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03.00.00 — BIOLOGIYA FANLARI
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HOVUZ BALIQCHILIGI SHAROITIDA OQ AMUR (*CTENOPHARYNGODON IDELLA* VALENCIENNES, 1844) BALIQLARINING NASLLI OTA-ONA TO'DASINI SHAKLLANTIRISHDA MUHIT OMILLARINING TA'SIRINI BAHOLASH.

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Annotatsiya: *Ushbu maqolada 2023–2025-yillar davomida Toshkent viloyatidagi* ***MCHJ "Khoorrot Fish House"****,* ***FX "ZafarAsad"*** *hamda* ***MCHJ "Imkon Baliq Fayz"*** *baliqchilik xo'jaliklarida oq amur (*Ctenopharyngodon idella *Valenciennes, 1844) baliqlarining naslli ota-ona to'dasini shakllantirishda muhit omillarining ta'siri o'rganildi. Tadqiqot davomida gidrokimyoviy ko'rsatkichlar, suv o'tlari hamjamiyatlari, zooplankton, bentos va xo'jalikda qo'llanilgan texnologik tadbirlarning ota-ona baliqlarining biologik holati hamda reproduktiv salohiyatiga ta'siri kompleks baholandi. Natijalar optimal gidrokimyoviy sharoit, rivojlangan tabiiy oziqa bazasi va ilmiy asoslangan boshqaruv usullari yuqori sifatli naslli ota-ona to'dasini shakllantirishning asosiy omillari ekanligini ko'rsatdi.*

Kalit so'zlar: *oq amur,* Ctenopharyngodon idella*, naslli ota-ona to'dasi, gidrokimyo, ekologik omillar, hovuz baliqchiligi, reproduktiv biologiya, akvakultura.*

Аннотация: *В данной статье представлены результаты исследований, посвящённых изучению влияния факторов окружающей среды на формирование маточного стада белого амура (*Ctenopharyngodon idella *Valenciennes, 1844) в условиях прудовой аквакультуры. Исследования проводились в 2023–2025 годах в трёх рыбоводческих хозяйствах Ташкентской области. Комплексно изучены гидрохимические показатели воды, сообщества водорослей, зоопланктон, бентос и технологические мероприятия, влияющие на биологическое состояние и репродуктивный потенциал производителей. Установлено, что оптимальные экологические условия являются основой формирования высококачественного маточного стада.*

Ключевые слова: *белый амур,* Ctenopharyngodon idella*, маточное стадо, экологические факторы, гидрохимия, репродуктивная биология, прудовая аквакультура.*

Abstract: *This study evaluates the influence of environmental factors on broodstock formation of grass carp (*Ctenopharyngodon idella *Valenciennes, 1844) under pond aquaculture conditions. The research was conducted from 2023 to 2025 at three fish farms in the Tashkent region. Hydrochemical parameters, algal communities, zooplankton, benthic organisms and aquaculture management practices were comprehensively assessed in relation to broodstock quality and reproductive performance. The results demonstrated that optimal water quality, a well-developed*

natural food base and scientifically based pond management significantly improve broodstock development and reproductive potential.

Keywords: *grass carp,* Ctenopharyngodon idella, *broodstock, environmental factors, hydrochemistry, reproductive biology, pond aquaculture.*

KIRISH

Akvakultura bugungi kunda dunyo miqyosida oziq-ovqat xavfsizligini ta'minlashning eng muhim tarmoqlaridan biri hisoblanadi. Birlashgan Millatlar Tashkilotining Oziq-ovqat va qishloq xo'jaligi tashkiloti (FAO) ma'lumotlariga ko'ra, so'nggi yigirma yil davomida akvakultura mahsulotlari ishlab chiqarish hajmi barqaror o'sib bormoqda va inson iste'moli uchun yetishtirilayotgan baliq mahsulotlarining yarmidan ortig'i sun'iy yetishtirish hisobiga to'g'ri kelmoqda (FAO, 2024). Mazkur tendensiya yuqori biologik va iqtisodiy samaradorlikka ega baliq turlarini ilmiy asosda ko'paytirish texnologiyalarini takomillashtirish zaruratini yuzaga keltirmoqda. O'zbekiston Respublikasida ham baliqchilik tarmog'ini rivojlantirish, ichki suv havzalaridan samarali foydalanish va yuqori sifatli baliq ekish materiallari ishlab chiqarishni kengaytirish davlat siyosatining ustuvor yo'nalishlaridan biri hisoblanadi. Ayniqsa, hovuz baliqchiligi sharoitida o'simlikxo'r baliqlarni intensiv yetishtirish orqali suv resurslaridan oqilona foydalanish, mahsuldorlikni oshirish va ekologik muvozanatni saqlash bo'yicha keng ko'lamli ishlar amalga oshirilmoqda. Oq amur (*Ctenopharyngodon idella* Valenciennes, 1844) baliqlari karpsimon baliqlar oilasining iqtisodiy jihatdan eng muhim vakillaridan biri bo'lib, tez o'sishi, o'simlik biomassasidan samarali foydalanishi, suv havzalarini biologik melioratsiya qilish xususiyati hamda yuqori bozor talabi bilan ajralib turadi. Ushbu turning muvaffaqiyatli ko'paytirilishi, avvalo, biologik jihatdan to'laqonli va reproduktiv salohiyati yuqori bo'lgan naslli ota-ona to'dasini shakllantirishga bog'liq. Naslli ota-ona baliqlarining sifati genetik omillar bilan bir qatorda tashqi muhit sharoitlariga ham bevosita bog'liq. Suv harorati, erigan kislorod, pH, mineral tarkib, azot birikmalari, tabiiy oziqa bazasi, fitoplankton va zooplankton rivojlanishi hamda xo'jalikda qo'llaniladigan oziqlantirish va parvarishlash texnologiyalari reproduktiv tizimning shakllanishi va gonadalarning rivojlanishiga sezilarli ta'sir ko'rsatadi. Gidrokimyoviy muhitning o'zgarishi metabolizm, gormonal faoliyat va jinsiy mahsulotlarning yetilishi bilan chambarchas bog'liq. Boyd va Tucker (2012) hovuz suvining sifat ko'rsatkichlari baliqlarning fiziologik holati va reproduktiv samaradorligini belgilovchi asosiy omillardan biri ekanligini ta'kidlagan. Billard (1986) nasldor baliqlarning yoshi, tana massasi va oziqlanish darajasi gonadalarning rivojlanishiga bevosita ta'sir qilishini ilmiy asoslagan. De Silva va Anderson (2019) muvozanatli oziqlantirish hamda rivojlangan tabiiy oziqa bazasi reproduktiv mahsuldorlikni oshirishini qayd etgan. So'nggi yillarda Zhang va hammualliflari (2023), Xu va hammualliflari (2021) hamda Miao va hammualliflari (2024) ekologik monitoring va suv sifati boshqaruvi ota-ona baliqlarining biologik sifatini oshirishda muhim omil ekanligini ko'rsatgan. Shu bilan birga, Toshkent viloyati hovuz baliqchiligi sharoitida oq amur baliqlarining naslli ota-ona to'dasini shakllantirishda ekologik omillarning kompleks ta'siri bo'yicha uzoq muddatli tadqiqotlar yetarli emas. Mavjud ishlarning aksariyati alohida gidrokimyoviy yoki biologik ko'rsatkichlarni o'rganishga qaratilgan bo'lib, abiotik, biotik va

antropogen omillarning o'zaro bog'liqligi hamda ularning reproduktiv biologiyaga ta'siri kompleks tarzda kam yoritilgan.

MATERIALLAR VA USULLAR

Tadqiqotlar 2023–2025-yillar davomida Toshkent viloyatida joylashgan **MCHJ "Khoorrot Fish House"**, **FX "ZafarAsad"** va **MCHJ "Imkon Baliq Fayz"** baliqchilik xo'jaliklarida olib borildi. Mazkur xo'jaliklar tabiiy-iqlim sharoiti, hovuzlarning gidrologik xususiyatlari va naslchilik ishlari yo'lga qo'yilganligi bilan tavsiflanadi. Tadqiqot obyekti sifatida jinsiy yetilgan oq amur (*Ctenopharyngodon idella* Valenciennes, 1844) baliqlarining naslli ota-ona to'dalari tanlandi. Har bir xo'jalikdan 31 tadan ota-ona baliqlari tanlab olinib, jami 93 dona baliqda biologik kuzatuvlar olib borildi. Namunalar sog'lom, tashqi nuqsonlarsiz va naslchilik talablariga javob beradigan baliqlar orasidan tanlandi.

Ekologik omillarni baholash: Tadqiqot davomida naslli ota-ona to'dasining shakllanishiga ta'sir etuvchi ekologik omillar uch guruhga ajratildi: **abiotik**, **biotik** va **antropogen** omillar. Abiotik omillar sifatida suv harorati, pH, erigan kislorod, ammiak, nitrit, nitrat, fosfat va suvning shaffofligi muntazam o'lchandi. Suv namunalari APHA (2023) tavsiyalariga muvofiq laboratoriya sharoitida tahlil qilindi. Biotik omillarni baholashda suv o'tlari hamjamiyatlari, zooplankton, bentos, makrofitlar, mikrobiologik holat va parazitologik vaziyat o'rganildi. Fitoplankton va zooplankton namunalari gidrobiologik usullar asosida yig'ilib, mikroskop yordamida identifikatsiya qilindi. Antropogen omillar sifatida oziqlantirish texnologiyasi, hovuzlarning baliq bilan yuklanish darajasi, suv almashinuvi, organik o'g'itlash, veterinariya-profilaktika ishlari hamda ekologik monitoring tizimi baholandi. Biologik tadqiqotlar: har bir baliqda tana uzunligi (TL), standart uzunligi (SL), tana vazni (W), Fulton semizlik koeffitsienti, gonadalarning rivojlanish bosqichi va umumiy fiziologik holati aniqlandi. Morfometrik o'lchovlar elektron tarozi va ixtiologik o'lchov taxtasi yordamida amalga oshirildi. Statistik tahlil: olingan natijalarga Microsoft Excel 2021 va IBM SPSS Statistics dasturlarida statistik ishlov berildi. O'rtacha qiymat (M), standart og'ish (SD), standart xatolik (SE), variatsiya koeffitsienti (CV), Pearson korrelyatsiya koeffitsienti hamda dispersion tahlil (ANOVA) hisoblandi. Statistik ishonchlilik **P<0,05** darajasida baholandi.

1-JADVAL. HOVUZ SUVINING GIDROKIMYOVIY KO'RSATKICHLARI

KO'RSATKICH	Me'yor	Khoorrot Fish House	ZafarAsad	Imkon Baliq Fayz	Baholash
SUV HARORATI (°C)	20–28	22,8	22,4	23,1	Optimal
PH	7,0–8,5	7,53	7,60	7,50	Optimal
ERIGAN KISLOROD (MG/L)	≥5,0	5,33	5,40	5,20	Optimal
NITRIT (MG/L)	≤0,02	0,01	0,02	0,01	Me'yorida
MINERALLASHUV (G/L)	0,3–1,0	0,32	0,56	0,31	Me'yorida

2-JADVAL. MUHIT OMILLARINING OTA-ONA BALIQLARINING BIOLOGIK HOLATIGA TA'SIRI

MUHIT OMILI	Biologik ta'siri	Reproduktiv ahamiyati
OPTIMAL HARORAT	Moddalar almashinuvi faollashadi	Gonadalar rivojlanishi tezlashdi
PH ME'YORIDA	Fermentativ jarayonlar yaxshilanadi	Urug'lanish sifati yaxshilandi
YUQORI KISLOROD	Energiya almashinuvi yaxshilanadi	Gametalar yetilishi jadallashdi
RIVOJLANGAN TABIIY OZIQA	O'sish sur'ati ortadi	Serpushtlik oshdi
SIFATLI OZIQLANTIRISH	Semizlik koeffitsienti me'yorlashadi	Nasldorlik sifati yaxshilandi

NATIJALAR VA MUNOZARA

Oq amur (*Ctenopharyngodon idella* Valenciennes, 1844) baliqlarining naslli ota-ona to'dasining biologik sifati va reproduktiv salohiyati ko'p jihatdan suv muhitining ekologik holatiga bog'liq. Shu sababli tadqiqotlar davomida suvning asosiy gidrokimyoviy ko'rsatkichlari muntazam nazorat qilinib, ularning ota-ona baliqlarining fiziologik holati bilan o'zaro bog'liqligi baholandi. 2023–2025-yillar davomida Toshkent viloyatidagi **MCHJ "Khoorrot Fish House"**, **FX "ZafarAsad"** va **MCHJ "Imkon Baliq Fayz"** baliqchilik xo'jaliklarida o'tkazilgan kuzatuvlar suv haroratining vegetatsiya davrida 22–24 °C oralig'ida saqlanganligini ko'rsatdi. Mazkur harorat oq amur baliqlarining moddalar almashinuvi, oziqlanish faolligi va gonadalar rivojlanishi uchun qulay hisoblanadi. Haroratning optimal diapazonda bo'lishi fermentativ jarayonlarni jadallashtirib, jinsiy mahsulotlarning yetilishi uchun zarur fiziologik sharoitni yaratdi. Suv muhitining vodorod ko'rsatkichi (pH) 7,4–8,2 oralig'ida kuzatildi. Ushbu qiymatlar suv organizmlarining aksariyati, jumladan oq amur baliqlari uchun fiziologik me'yor hisoblanadi. Neytralga yaqin ishqoriy muhit mineral elementlarning o'zlashtirilishini yaxshilab, reproduktiv tizim faoliyatiga ijobiy ta'sir ko'rsatdi. Erigan kislorod miqdori barcha xo'jaliklarda 6 mg/L dan yuqori bo'lib, baliqlarning nafas olishi va energiya almashinuvining uzluksiz kechishini ta'minladi. Kislorod tanqisligi kuzatilmagani sababli metabolik stress holatlari qayd etilmadi, bu esa ota-ona baliqlarining umumiy fiziologik holati barqarorligini ta'minladi. Nitrit va ammiak konsentratsiyasining me'yoriy darajada saqlanishi suv muhitining toksik yuklamasi past ekanligini ko'rsatdi. Ayniqsa, nitrit miqdorining 0,02 mg/L dan oshmaganligi gemoglobinning metgemoglobinga aylanishi xavfini kamaytirib, qon orqali kislorod tashilishining me'yorida kechishiga xizmat qildi. Boyd va Tucker (2012), APHA (2023) hamda FAO (2024) tavsiya etgan me'yorlar bilan qiyoslanganda tadqiqot o'tkazilgan xo'jaliklardagi gidrokimyoviy ko'rsatkichlar xalqaro tavsiyalarga mos kelishi aniqlandi. Bu holat naslli ota-ona to'dasining biologik sifati yuqori bo'lishining asosiy ekologik omillaridan biri sifatida baholandi. Biotik omillarning ta'siri Tabiiy oziqa bazasining rivojlanganligi oq amur baliqlarining biologik mahsuldorligini belgilovchi muhim omillardan biridir. Tadqiqot davomida suv o'tlari hamjamiyatlari, zooplankton va bentos tarkibi o'rganildi. Suv o'tlari tarkibida **Bacillariophyta** va **Chlorophyta** bo'limlari ustunlik qilgani kuzatildi. Diatomalar va

yashil suv o'tlari suv ekotizimining birlamchi mahsuldorligini ta'minlab, zooplanktonning rivojlanishi uchun oziqa bazasini shakllantirdi. Bu esa yosh baliqlar va naslli ota-ona baliqlarining oziqlanish zanjirini barqarorlashtirdi. Zooplankton tarkibida Rotifera, Cladocera va Copepoda guruhlari muntazam uchradi. Mazkur organizmlar suv havzasining biologik mahsuldorligini oshirib, tabiiy oziqlanish tizimini qo'llab-quvvatladi. Bentos tarkibida Chironomidae lichinkalari, Oligochaeta va boshqa tub organizmlar uchragani suv havzasining ekologik muvozanati saqlanayotganini ko'rsatdi. Makrofitlarning me'yoriy rivojlanishi oq amur baliqlarining tabiiy oziqlanish ehtiyojini qisman qondirdi va suv havzalarining biologik meliorativ holatini yaxshiladi. Natijada baliqlarning oziqa izlashga sarflaydigan energiyasi kamayib, o'sish va reproduktiv jarayonlarga ko'proq energiya yo'naltirildi.

Antropogen omillarning ta'siri: Naslli ota-ona to'dasining sifatini shakllantirishda xo'jaliklarda qo'llanilgan boshqaruv texnologiyalari ham muhim rol o'ynadi. Barcha xo'jaliklarda baliqlar tana vaznining belgilangan ulushi asosida oziqlantirildi, suv almashinuvi muntazam amalga oshirildi va veterinariya-profilaktika tadbirlari o'z vaqtida bajarildi. Hovuzlarning me'yoriy baliq zichligida saqlanishi suv sifatining keskin yomonlashishiga yo'l qo'ymadi. Organik va mineral o'g'itlardan oqilona foydalanish tabiiy oziqa bazasining rivojlanishini rag'batlantirdi. Ekologik monitoringning muntazam olib borilishi suv sifatidagi o'zgarishlarni o'z vaqtida aniqlash imkonini berib, zarur boshqaruv choralarini ko'rishga xizmat qildi. Bu esa ota-ona baliqlarining biologik ko'rsatkichlari va reproduktiv salohiyatining barqaror saqlanishiga yordam berdi.

XULOSA

Mazkur tadqiqot natijalari hovuz baliqchiligi sharoitida oq amur (*Ctenopharyngodon idella* Valenciennes, 1844) baliqlarining naslli ota-ona to'dasini shakllantirishda ekologik omillarning hal qiluvchi ahamiyatga ega ekanligini ko'rsatdi. Tadqiqot o'tkazilgan baliqchilik xo'jaliklarida suvning gidrokimyoviy ko'rsatkichlari me'yoriy chegaralarda saqlanib, ota-ona baliqlarining o'sishi, fiziologik holati va reproduktiv salohiyatini ta'minlash uchun qulay sharoit yaratgani aniqlandi. Suv o'tlari hamjamiyatlari, zooplankton va bentosning yetarli darajada rivojlanganligi tabiiy oziqa bazasining barqarorligini ta'minlab, baliqlarning oziqlanishi va gonadalar rivojlanishiga ijobiy ta'sir ko'rsatdi. Shuningdek, muvozanatli oziqlantirish, suv almashinuvi, veterinariya-profilaktika tadbirlari va ekologik monitoring kabi antropogen omillar naslli ota-ona to'dasining biologik sifatini saqlashda muhim rol o'ynashi tasdiqlandi. Baliqchilik xo'jaligida olib borilgan kuzatuvlar ekologik omillarni kompleks boshqarish oq amur baliqlarining naslli ota-ona to'dasini shakllantirishning asosiy sharti ekanligini ko'rsatdi. Suv muhitining barqarorligi, rivojlangan tabiiy oziqa bazasi va ilmiy asoslangan boshqaruv tadbirlari reproduktiv ko'rsatkichlarning yaxshilanishiga hamda yuqori sifatli nasldor baliqlarni shakllantirishga xizmat qiladi. Tadqiqot natijalari respublika baliqchilik xo'jaliklarida naslchilik ishlarini takomillashtirish, ekologik monitoring tizimini kuchaytirish va yuqori sifatli baliq ekish materiallari yetishtirish texnologiyalarini yanada rivojlantirish uchun ilmiy-amaliy asos bo'lib xizmat qiladi.

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HOVUZ BALIQCHILIGI SHAROITIDA OQ DO'NGPESHONA (*HYPOPHTHALMICHTHYS MOLITRIX* VALENCIENNES, 1844) OTA-ONA BALIQLARINING REPRODUKTIV BIOLOGIYASI VA NASLLI TO'DANI SHAKLLANTIRISH SAMARADORLIGI.

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Annotatsiya: *Ushbu maqolada 2023–2025-yillarda Toshkent viloyatidagi uchta baliqchilik xo'jaligida oq do'ngpeshona (*Hypophthalmichthys molitrix *Valenciennes, 1844) balig'ining naslli ota-ona to'dasini shakllantirishning biologik va ekologik asoslari o'rganildi. Ota-ona baliqlarining morfobiologik ko'rsatkichlari, reproduktiv holati hamda naslchilik samaradorligiga ta'sir etuvchi abiotik, biotik va antropogen omillar kompleks baholandi. Tadqiqot natijalari hovuz ekotizimini ilmiy asosda boshqarish, suv sifatini barqaror saqlash va muvozanatli oziqlantirish yuqori mahsuldor naslli ota-ona to'dasini shakllantirishning muhim omillari ekanligini ko'rsatdi.*

Kalit so'zlar: *oq do'ngpeshona,* Hypophthalmichthys molitrix, *naslli ota-ona to'dasi, reproduktiv biologiya, hovuz baliqchiligi, ekologik omillar, akvakultura.*

Аннотация: *В данной статье представлены результаты исследований, проведённых в 2023–2025 годах в трёх рыбоводческих хозяйствах Ташкентской области, посвящённых биологическим и экологическим основам формирования маточного стада белого толстолобика (*Hypophthalmichthys molitrix *Valenciennes, 1844). Комплексно оценены морфобиологические показатели, репродуктивное состояние рыб, а также влияние абиотических, биотических и антропогенных факторов на качество маточного стада. Установлено, что стабильные гидрохимические условия, сбалансированное кормление и научно обоснованная технология выращивания обеспечивают формирование высокопродуктивного маточного стада.*

Ключевые слова: *белый толстолобик,* Hypophthalmichthys molitrix, *маточное стадо, репродуктивная биология, прудовая аквакультура, экологические факторы, рыбоводство.*

Abstract: *This article presents the results of a study conducted during 2023–2025 at three fish farms in the Tashkent region on the biological and ecological principles of broodstock formation in silver carp (Hypophthalmichthys molitrix Valenciennes, 1844). Morphobiological characteristics, reproductive status, and the influence of abiotic, biotic, and anthropogenic factors on broodstock quality were comprehensively evaluated. The findings demonstrate that stable water quality, balanced feeding, and scientifically based pond management are the key factors ensuring the development of highly productive broodstock under pond aquaculture conditions.*

Keywords: *silver carp, Hypophthalmichthys molitrix, broodstock, reproductive biology, pond aquaculture, ecological factors, fish farming.*

KIRISH

Bugungi kunda dunyo aholisining sifatli oqsil manbalariga bo'lgan ehtiyojining ortib borishi akvakultura tarmog'ini jadal rivojlantirishni taqozo etmoqda. BMTning Oziq-ovqat va qishloq xo'jaligi tashkiloti (FAO) ma'lumotlariga ko'ra, so'nggi o'n yilliklarda akvakultura oziq-ovqat mahsulotlari ishlab chiqarishning eng tez rivojlanayotgan yo'nalishlaridan biriga aylandi va ichki suv havzalarida biologik resurslardan oqilona foydalanish ushbu sohaning ustuvor vazifalaridan biri hisoblanadi (FAO, 2024). Shu nuqtai nazardan, o'simlikxo'r baliqlar, ayniqsa oq do'ngpeshona (*Hypophthalmichthys molitrix* Valenciennes, 1844)ning biologik imkoniyatlaridan samarali foydalanish ilmiy va amaliy ahamiyat kasb etadi. Oq do'ngpeshona karpsimonlar (Cyprinidae) oilasiga mansub bo'lib, tabiiy sharoitda asosan fitoplankton bilan oziqlanadigan yuqori mahsuldor filtrator baliq hisoblanadi. Ushbu tur tez o'sishi, yemdan samarali foydalanishi, suv havzalarining biologik melioratsiyasidagi o'rni va polikultura tizimlarida boshqa baliq turlari bilan yaxshi moslashishi sababli dunyoning ko'plab mamlakatlarida keng yetishtiriladi. Ayniqsa Xitoy, Hindiston, Vetnam, Rossiya, Qozog'iston va Markaziy Osiyo davlatlarida oq do'ngpeshona akvakultura mahsulotlari ishlab chiqarishda muhim iqtisodiy ahamiyatga ega. Naslli ota-ona to'dasining sifati baliqchilik xo'jaliklarida olinadigan avlodning hayotchanligi, o'sish sur'ati, kasalliklarga chidamliligi va umumiy mahsuldorligini belgilovchi asosiy biologik omillardan biridir. Sifatli ota-ona baliqlarini tanlash va ularni ilmiy asosda parvarishlash reproduktiv samaradorlikni oshirish bilan birga, yuqori sifatli baliq ekish materialini olish imkonini beradi. Shu sababli ota-ona to'dasini shakllantirishda baliqlarning yoshi, tana massasi, morfometrik ko'rsatkichlari, fiziologik holati, oziqlanish darajasi hamda tashqi muhit omillarining kompleks baholanishi alohida ahamiyat kasb etadi. Ko'plab tadqiqotchilar suv muhitining gidrokimyoviy ko'rsatkichlari, tabiiy oziqa bazasi va oziqlantirish texnologiyasi nasldor baliqlarning reproduktiv biologiyasiga bevosita ta'sir ko'rsatishini qayd etgan. Boyd va Tucker (2012) suv harorati, erigan kislorod va pH ko'rsatkichlarining me'yorida saqlanishi moddalar almashinuvi hamda jinsiy mahsulotlarning rivojlanishini ta'minlashini ko'rsatgan. Billard (1986) va Jhingran (1991) ota-ona baliqlarining morfofiziologik holati serpushtlik va urug'lanish ko'rsatkichlari bilan uzviy bog'liqligini ta'kidlagan. De Silva va Anderson (2019) esa muvozanatli oziqlantirish va tabiiy oziqa bazasining rivojlanganligi reproduktiv salohiyatni oshirishda muhim omil ekanligini ilmiy jihatdan asoslagan.

O'zbekiston sharoitida o'simlikxo'r baliqlarni yetishtirish bo'yicha qator ilmiy tadqiqotlar amalga oshirilgan bo'lsa-da, oq do'ngpeshona naslli ota-ona to'dasini shakllantirishning biologik asoslari, ekologik omillar bilan bog'liqligi hamda turli baliqchilik xo'jaliklari sharoitida ularning reproduktiv holatini kompleks baholash bo'yicha tadqiqotlar yetarli darajada yoritilmagan. Ayniqsa Toshkent viloyati hovuz baliqchiligi sharoitida ekologik omillarning ota-ona baliqlari biologiyasiga ta'sirini uzoq muddatli kuzatuvlar asosida baholash dolzarb ilmiy masalalardan biri hisoblanadi. Mazkur tadqiqotning maqsadi 2023–2025-yillarda Toshkent viloyatidagi

uchta baliqchilik xo'jaligida oq do'ngpeshona (*Hypophthalmichthys molitrix* Valenciennes, 1844) balig'ining naslli ota-ona to'dasini shakllantirishning biologik asoslarini o'rganish, ota-ona baliqlarining morfobiologik va reproduktiv ko'rsatkichlarini baholash hamda abiotik, biotik va antropogen omillarning ularning reproduktiv salohiyatiga ta'sirini kompleks tahlil qilishdan iborat.

MATERIAL VA USULLAR

Tadqiqotlar 2023–2025-yillar davomida Toshkent viloyatining hovuz baliqchiligi rivojlangan hududlarida joylashgan **MCHJ "Khoorrot Fish House"**, **FX "ZafarAsad"** hamda **MCHJ "Imkon Baliq Fayz"** baliqchilik xo'jaliklarida olib borildi. Mazkur xo'jaliklar Toshkent viloyatining tabiiy-iqlim sharoiti, suv bilan ta'minlanish manbalari, hovuzlarining texnologik xususiyatlari hamda naslchilik ishlari yo'lga qo'yilganligi sababli tadqiqot obyekti sifatida tanlandi. Hudud mo"tadil kontinental iqlim mintaqasiga kirib, yoz oylarida suv haroratining 22–28 °C, bahor va kuz mavsumlarida esa 18–24 °C oralig'ida bo'lishi o'simlikxo'r baliqlarni parvarishlash va naslchilik ishlarini olib borish uchun qulay sharoit yaratadi. Hovuzlar asosan sug'orish kanallari va kollektor-drenaj tizimlari orqali suv bilan ta'minlanadi. Tadqiqot davomida barcha xo'jaliklarda suv sifati, ekologik holat va baliqlarni parvarishlash texnologiyasi muntazam nazorat qilindi. Tadqiqot obyekti sifatida **oq do'ngpeshona (*Hypophthalmichthys molitrix* Valenciennes, 1844)** balig'ining naslli ota-ona to'dalari tanlandi. Tadqiqot uchun tashqi morfologik belgilari yaxshi rivojlangan, sog'lom, mexanik shikastlanishlarsiz va kasallik alomatlari kuzatilmagan jinsiy yetilgan baliqlar jalb qilindi. Har bir baliqchilik xo'jaligidan **30 tadan** naslli ota-ona baliqlari tanlab olinib, jami **90 bosh** baliq biologik tadqiqot obyekti sifatida o'rganildi. Namunalar vegetatsiya davrining asosiy bosqichlarida muntazam ravishda kuzatilib, ularning biologik, morfometrik, reproduktiv va ekologik ko'rsatkichlari baholandi.

1-jadval, 2023–2025-yillarda tadqiqot o'tkazilgan baliqchilik xo'jaliklarining tavsifi

Ko'rsatkich	MCHJ "Khoorrot Fish House"	FX "ZafarAsad"	MCHJ "Imkon Baliq Fayz"
Joylashgan hududi	Toshkent viloyati	Toshkent viloyati	Toshkent viloyati
Tadqiqot yillari Tadqiqot obyekti	2023–2025	2023–2025	2023–2025
Tanlangan baliqlar soni	Oq do'ngpeshona ota-ona to'dasi	Oq do'ngpeshona ota-ona to'dasi	Oq do'ngpeshona ota-ona to'dasi
Tanlangan baliqlar soni	30 bosh	30 bosh	30 bosh
Umumiy namuna soni	-	-	90 dona

2-jadval, tadqiqotning umumiy sxemasi

Tadqiqot bosqichi	Amalga oshirilgan ishlar
I bosqich	Xo'jaliklarni tanlash, hovuzlarni o'rganish, ota-ona baliqlarini saralash
II bosqich	Morfometrik o'lchovlar, fiziologik va reproduktiv ko'rsatkichlarni aniqlash
III bosqich	Gidrokimyoviy va gidrobiologik tahlillar
IV bosqich	Statistik ishlov berish, natijalarni qiyosiy baholash va ilmiy tahlil

3-jadval, tadqiqot obyektining asosiy tavsifi

Ko'rsatkich	Tavsifi
Tur	Oq do'ngpeshona (*Hypophthalmichthys molitrix* Valenciennes, 1844)
Oila	Cyprinidae
Ekologik guruhi	Chuchuk suv, filtrator baliq
Oziqlanish tipi	Asosan fitoplankton bilan oziqlanuvchi
Tadqiqot davri	2023–2025-yillar
Tadqiqot xo'jaliklari	3 ta
Har bir xo'jalikdagi namuna	30 dona
Jami namuna	90dona

NATIJALAR VA MUNOZARA

2023–2025-yillar davomida Toshkent viloyatidagi **MCHJ "Khoorrot Fish House"**, **FX "ZafarAsad"** hamda **MCHJ "Imkon Baliq Fayz"** baliqchilik xo'jaliklarida olib borilgan tadqiqotlar oq do'ngpeshona (*Hypophthalmichthys molitrix* Valenciennes, 1844) naslli ota-ona to'dasini shakllantirish biologik, ekologik va texnologik omillarning o'zaro uyg'unligi asosida amalga oshishini ko'rsatdi. Uchala xo'jalikda jami 90 bosh ota-ona baliqlari biologik va ekologik jihatdan baholanib, ularning morfobiologik holati, reproduktiv salohiyati hamda tashqi muhit omillariga moslashish xususiyatlari qiyosiy tahlil qilindi.

Morfobiologik ko'rsatkichlarning qiyosiy tahlili: Tadqiqot davomida barcha xo'jaliklarda tanlangan ota-ona baliqlari tashqi morfologik belgilari, tana proporsiyalari va fiziologik holati bo'yicha naslchilik talablariga javob berishi aniqlandi. Tana uzunligi va tana vazni ko'rsatkichlari jinsiy yetilgan baliqlarga xos me'yoriy chegaralarda bo'lib, baliqlarning naslchilik uchun yaroqliligini tasdiqladi. Kuzatuvlar shuni ko'rsatdiki, tana massasi yuqori bo'lgan individlarda gonadalarning rivojlanish darajasi ham nisbatan yuqori bo'lib, bu reproduktiv salohiyat bilan musbat bog'liqlik

mavjudligini ko'rsatadi. Fulton semizlik koeffitsientining me'yoriy qiymatlarda bo'lishi ota-ona baliqlarining oziqlanish holati va fiziologik zaxiralari yetarli ekanligini tasdiqladi. Bu ko'rsatkichlar reproduktiv davrda gonadalarning normal rivojlanishi uchun muhim biologik omil hisoblanadi.

Gidrokimyoviy omillarning ta'siri: Tadqiqot yillarida uchala xo'jalik hovuzlarida suv harorati, pH va erigan kislorod miqdori oq do'ngpeshona biologiyasi uchun tavsiya etilgan me'yorlarda saqlandi. Suv haroratining vegetatsiya davrida 22–26 °C oralig'ida bo'lishi metabolizm faolligi va jinsiy mahsulotlarning shakllanishiga qulay sharoit yaratdi. Erigan kislorodning me'yoriy darajada saqlanishi baliqlarda aerob almashinuv jarayonlarini qo'llab-quvvatlab, fiziologik stressning oldini oldi. pH ko'rsatkichining neytral-ishqoriy muhitda barqaror bo'lishi fermentativ reaksiyalar va oziqa moddalarning o'zlashtirilishini yaxshiladi. Ammiak va nitrit konsentratsiyalarining ruxsat etilgan me'yorlardan oshmaganligi baliqlarda toksik ta'sirlarning kuzatilmaganligini ko'rsatdi. Mazkur natijalar Boyd va Tucker (2012) hamda APHA (2023) tomonidan tavsiya etilgan gidrokimyoviy me'yorlar bilan mos keladi. Ularning fikriga ko'ra, suv sifatining barqarorligi nasldor baliqlarning reproduktiv biologiyasini belgilovchi asosiy omillardan biridir.

Biotik omillarning ahamiyati: Fitoplankton tarkibida Bacillariophyta va Chlorophyta guruhlarining ustunligi qayd etildi. Oq do'ngpeshona filtrator baliq bo'lganligi sababli ushbu mikroalgalar uning tabiiy oziqlanishida muhim o'rin egalladi. Fitoplankton biomassasining yetarli darajada rivojlanganligi zooplankton populyatsiyasining ham barqaror saqlanishiga yordam berdi. Zooplankton tarkibida Rotifera, Cladocera va Copepoda guruhlarining mavjudligi hovuz ekotizimining biologik mahsuldorligini tavsifladi. Bentos organizmlarining uchrashi va suv makrofitlarining me'yoriy rivojlanishi suv havzalarining ekologik barqarorligini saqlashga xizmat qildi. Ushbu natijalar De Silva va Anderson (2019) hamda Wetzel (2001) tomonidan fitoplankton mahsuldorligi va baliq biologiyasi o'rtasidagi bog'liqlik bo'yicha keltirilgan ilmiy xulosalarni tasdiqlaydi.

Antropogen omillarning ta'siri: Uchala xo'jalikda muvozanatli oziqlantirish, suv almashinuvining muntazam amalga oshirilishi va veterinariya-profilaktika tadbirlarining tizimli tashkil etilishi ota-ona baliqlarining biologik sifatini saqlashda muhim omil bo'ldi. Omuxta yemlardan ilmiy asoslangan me'yorlarda foydalanish baliqlarning oziqlanish holatini yaxshilab, reproduktiv davrga zarur energiya zaxirasini shakllantirdi. Hovuzlarda baliq zichligining me'yoriy darajada saqlanishi stress omillarining kamayishiga, ekologik monitoringning muntazam olib borilishi esa gidrokimyoviy ko'rsatkichlarning barqarorligini ta'minlashga xizmat qildi. Natijada ota-ona baliqlarining reproduktiv salohiyati yuqori darajada saqlanib qoldi. Bu natijalar FAO (2024), Lucas va Southgate (2019) hamda Timmons va Ebeling (2022) tomonidan tavsiya etilgan zamonaviy akvakultura texnologiyalari bilan uyg'unlik kasb etadi.

XULOSA

2023–2025-yillar davomida Toshkent viloyatidagi **MCHJ "Khoorrot Fish House"**, **FX "ZafarAsad"** va **MCHJ "Imkon Baliq Fayz"** baliqchilik xo'jaliklarida olib borilgan tadqiqotlar asosida oq do'ngpeshona (*Hypophthalmichthys molitrix*

Valenciennes, 1844) balig'ining naslli ota-ona to'dasini shakllantirishning biologik xususiyatlari kompleks baholandi va quyidagi xulosalarga kelindi: Oq do'ngpeshona naslli ota-ona to'dasining biologik sifati baliqlarning morfometrik ko'rsatkichlari, fiziologik holati hamda tashqi muhit omillarining o'zaro uyg'un ta'siri bilan shakllanishi aniqlandi. Naslchilik uchun tanlangan baliqlarda tana proporsiyalari, umumiy fiziologik holat va jinsiy yetilish darajasi me'yoriy ko'rsatkichlarga mos keldi. Tadqiqot olib borilgan xo'jaliklarda suvning gidrokimyoviy ko'rsatkichlari, jumladan harorat, pH, erigan kislorod, ammiak va nitrit miqdori oq do'ngpeshona biologiyasi uchun tavsiya etilgan me'yorlar doirasida saqlanganligi sababli baliqlarning o'sishi, moddalar almashinuvi va reproduktiv jarayonlari uchun qulay ekologik muhit shakllandi. Hovuzlarda fitoplanktonning, ayniqsa *Bacillariophyta* va *Chlorophyta* guruhlarining ustunligi, zooplankton hamda boshqa gidrobiontlarning me'yoriy rivojlanishi tabiiy oziqa bazasini mustahkamlab, ota-ona baliqlarining oziqlanishi va reproduktiv salohiyatini qo'llab-quvvatladi. Muvozanatli oziqlantirish, muntazam suv almashinuvi, me'yoriy baliq zichligini saqlash, veterinariya-profilaktika tadbirlarini tizimli amalga oshirish va ekologik monitoringni uzluksiz olib borish naslli ota-ona baliqlarining biologik sifati va reproduktiv barqarorligini ta'minlovchi asosiy antropogen omillar ekanligi aniqlandi. Uchta baliqchilik xo'jaligida olingan natijalar shuni ko'rsatdiki, naslli ota-ona to'dasini muvaffaqiyatli shakllantirish ekologik omillarni alohida boshqarish emas, balki gidrokimyoviy, gidrobiologik va texnologik jarayonlarni yagona tizim sifatida kompleks boshqarishni talab etadi. Bunday yondashuv baliqlarning reproduktiv imkoniyatlarini to'liq namoyon etish va sifatli baliq ekish materialini olishga xizmat qiladi. Tadqiqot natijalari Toshkent viloyati hovuz baliqchiligi sharoitida oq do'ngpeshona naslli ota-ona to'dasini shakllantirish texnologiyasini takomillashtirish, naslchilik ishlarining biologik samaradorligini oshirish hamda baliqchilik xo'jaliklarida ilmiy asoslangan ekologik monitoring tizimini joriy etish uchun amaliy ahamiyatga ega.

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HIPPOPHAE RHAMNOIDES RIZOSFERASIDAN AJRATILGAN PSEUDOMONAS KOREENSIS VA PSEUDOMONAS CHLORORAPHIS SHTAMMLARINING POMIDOR (SOLANUM LYCOPERSICUM L.) URUG‘LARINING UNUVCHANLIGI HAMDA O‘SISH KO‘RSATKICHLARIGA TA’SIRI

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Annotatsiya. *Mazkur maqolada turli ekologik sharoitlarda Chakanda-(Hippophae rhamnoides.L) o‘simligi rizobakteriyalarining pomidor (Solanum lycopersicum L.) urug‘lariga ta’siri o‘rganildi. Tadqiqot davomida Hippophae rhamnoides L. (chakanda) rizosferasidan rizobakteriyalar ajratildi hamda MALDI-TOF MS usuli yordamida identifikatsiya qilindi. Identifikatsiya natijasiga ko‘ra Pseudomonas koreensis va Pseudomonas chlororaphis shtammlari aniqlandi va pomidor (Solanum lycopersicum) urug‘larining unishi va boshlang‘ich o‘sish ko‘rsatkichlariga ta’siri o‘rganildi. Laboratoriya sharoitida o‘tkazilgan tajribalar natijasida, ushbu shtammlar bilan ishlov berilgan urug‘larning unish energiyasi nazoratga nisbatan 20-30 foizga ortishi aniqlandi. Olingan natijalar P. koreensis va P. chlororaphis shtammlarining o‘simlik o‘sishini rag‘batlantiruvchi (PGPR) xususiyatlarini tasdiqlaydi va ulardan qishloq xo‘jaligida istiqbolli biostimulyatorlar sifatida foydalanish imkoniyatini ko‘rsatadi.*

Kalit so‘z. *Hippophae rhamnoides, Pseudomonas, MALDI-TOF MS, pomidor, unuvchanlik, PGPR shtammlar, in-vitro.*

Аннотация. *В данной статье изучено влияние ризобактерий растения облепихи (Hippophae rhamnoides L.), произрастающего в различных экологических условиях, на семена томата (Solanum lycopersicum L.). В ходе исследования ризобактерии были выделены из ризосферы Hippophae rhamnoides L. (облепихи) и идентифицированы с использованием метода MALDI-TOF MS. По результатам идентификации были выявлены штаммы Pseudomonas koreensis и Pseudomonas chlororaphis, после чего было изучено их влияние на всхожесть семян и начальные показатели роста томата (Solanum lycopersicum L.). В результате лабораторных экспериментов установлено, что энергия прорастания семян, обработанных данными штаммами, увеличилась на 20–30 % по сравнению с контролем. Полученные результаты подтверждают ростостимулирующие свойства штаммов P. koreensis и P. chlororaphis как представителей PGPR (plant growth-promoting rhizobacteria) и демонстрируют перспективность их использования в качестве биостимуляторов в сельском хозяйстве.*

Ключевое слово. *Hippophae rhamnoides, Pseudomonas, maldi-TOF MS, помидоры, всхожесть, штаммы pgpr, in vitro.*

Abstract. *This article investigated the effect of rhizobacteria isolated from sea buckthorn (Hippophae rhamnoides L.) growing under different ecological conditions on tomato (Solanum lycopersicum L.) seeds. During the study, rhizobacteria were isolated from the rhizosphere of Hippophae rhamnoides L. (sea buckthorn) and identified using the MALDI-TOF MS method. Based on the identification results, the strains Pseudomonas koreensis and Pseudomonas chlororaphis were identified, and their effects on tomato (Solanum lycopersicum L.) seed germination and initial growth parameters were subsequently investigated. Laboratory experiments demonstrated that the germination energy of seeds treated with these strains increased by 20–30% compared with the control. The obtained results confirm the plant growth-promoting rhizobacteria (PGPR) properties of P. koreensis and P. chlororaphis strains and demonstrate their potential for use as promising biostimulants in agriculture.*

Keywords. *Hippophae rhamnoides, Pseudomonas, MALDI-TOF MS, tomato, mucilage, PGPR strains, in-vitro.*

KIRISH

Global iqlim o‘zgarishi abiotik stresslarning o‘simliklarga ta’sirini kuchaytirmoqda. Sabzavotlar vitaminlar, minerallar, ozuqaviy tola va turli xil fitokimyoviy moddalarga boy va shuning uchun ular inson salomatligi uchun katta ahamiyatga ega. Sabzavot ekinlarining o‘sishi turli xil abiotik stress omillari tomonidan tartibga solinadi, bu nafaqat ularning normal o‘sishi va metabolizmiga ta’sir qiladi, balki hosildorlik va sifatning pasayishiga ham olib keladi **[1.5]**. O‘simliklarning o‘sishini rag‘batlantiruvchi rizobakteriyalar (PGPR) o‘simliklarning morfologik yoki fiziologik xususiyatlarini azot fiksatsiyasi, fosforning erishi, kaliyning erishi, sideroforlarning ishlab chiqarilishi, ikkilamchi metabolitlar va gormonlarning sekretsiyasi va o‘simliklarning stressga chidamliligi genining ifodasini induktsiya qilish orqali o‘zgartirishi mumkin. Bu natijada o‘simliklarda ozuqa moddalaridan foydalanish darajasini oshiradi, ularning hosildorligi, sifati va stressga chidamliligini oshiradi.Bugungi kunda qishloq xo‘jaligining eng dolzarb muammolaridan biri - tuproq tarkibidagi turli – xil kimyoviy moddalarni kamaytirish va ekologik toza mahsulot yetishtirishdan iboratdir. So‘nggi yillarda o‘simlik o‘sishini rag‘batlantiruvchi rizosfera bakteriyalaridan (PGPR) foydalanish kimyoviy o‘g‘itlar o‘rnini bosuvchi samarali strategiya sifatida tan olinmoqda **[1,2]**. PGPR vakillari, xususan *Pseudomonas* turkumi, o‘simliklarda fitogormonlar sintezi, fosfatlarni mobilizatsiya qilish va turli abiotik stresslarga chidamlilikni oshirish qobiliyati bilan ajralib turadi.

Pseudomonas turkumiga mansub shtammlar, jumladan *P. koreensis* va *P. chlororaphis*, o‘zlarining ikkilamchi metabolitlari va sideroforlar ishlab chiqarishi tufayli qishloq xo‘jaligi ekinlari, xususan pomidor (*Solanum lycopersicum*) rivojlanishining erta bosqichlarida yuqori biostimulyatorlik xususiyatini namoyon etadi **[3]**. Tadqiqotlar shuni ko‘rsatadiki, *Pseudomonas koreensis* kabi foydali rizobakteriyalar o‘simlikning biomassasini oshirish bilan birga, uning fiziologik holatini yaxshilash va himoya tizimini faollashtirish xususiyatiga ega **[4]**. Bu esa ekologik toza va barqaror qishloq xo‘jaligi texnologiyalarini ishlab chiqishda ushbu mikrob jamoalaridan keng foydalanish zarurligini belgilaydi. Rizosfera mikroflorasi o‘simlik turiga va uning o‘sish sharoitiga qarab o‘ziga xos xususiyatlarga ega bo‘ladi. Shu nuqtai nazardan, dorivor va

chidamli o‘simlik hisoblangan chakanda (*Hippophae rhamnoides* L.) rizosferasi boy mikrobiologik resurs hisoblanib, undan ajratilgan shtammlar madaniy ekinlar unumdorligini oshirishda yuqori salohiyatga ega. MALDI-TOF MS kabi zamonaviy mass-spektrometriya usullari mikrobial identifikatsiyani tezlashtirish va shtammlarni aniq klassifikatsiya qilish imkonini berdi, bu esa PGPR tadqiqotlarining ishonchliligini oshirdi **[5]**. Biroq, chakanda rizosferasidan ajratilgan *P. koreensis* va *P. chlororaphis* shtammlarining pomidor urug‘lari unuvchanligiga ta’siri bo‘yicha kompleks tadqiqotlar hali ham yetarli emas.

TADQIQOT MATERIALLARI VA USULLARI

Ilmiy tadqiqot bo‘yicha Chakanda o‘simligi ildiz atrofidan tuproq na’munalarini Samarqant viloyatining Zarafshon daryosi bo‘yidan va Toshkent viloyati Yuqori Chirchiq tumanida joylashgan Sakson ota o‘rmon xo‘jaligidan tuproq namunalarini olib kelindi hamda laboratoriyadagi tadqiqot ishlari Toshkent Davlat Agrar Universiteti ‘‘Biotexnologiya,, kafedrasida olib borildi.

***Hippophae rhamnoides L.* o‘simligi_rizosferasidan tuproq na’munalarini olish.** Namunalar pastki qatlamdan boshlab navbati bilan olinadi. Chuqur kavlab bo’lingan zahoti ona jinsdan yoki pastki qatlamdan belkurak bilan birinchi namuna olinadi. Tuproq profili ta’riflab bo’lingach, yuqoridagi qatlamlardan namunalar olinadi. Eng oxirida ustki qatlamdan namuna olinadi. 0-10, 10-20, 20-30 sm chuqurlik qatlamlaridan sterilizatsiya qilingan sharoitda olindi. (Litvinov, 1969).

Namunalar olish texnikasi. Har bir qatlamning o’rta qismida taxminan 10 sm qalinlikdagi qatlam orasi belgilab qoyiladi va undan old devorining butun eni boyicha pichoq bilan tuproq namunasi kesib olinadida qalin qog’oz varag’i ustiga qoyiladi. Chirindili va haydalma qatlamlardan namuna qatlamning butun qalinligi boyicha olinadi. Agar chirindili qatlamning qalinligi 20 sm dan ziyod bo’lsa, u holda har 10 sm dan ikki-uch namuna olinadi. Qog‘oz etiketkaga tuproq chuquri olingan viloyat, tuman, qishloq, maydonni, dala va chuqur nomerini, qatlamning qalinligini, namuna qanday chuqurlikdan olinganini qalam bilan yoziladi hamda sana va talabaning familiyasi ko’rsatilib, shu o’ralgan qog’oz namunaga o’rab qoyiladi. Qog’ozga ham namuna olingan qatlam, uning chuqurligi, sanasi yoziladi.

Tuproqning morfologik belgilari aniqlanib, tuproqqa izox yozilganidan keyin, xar bir qatlamdan kvadrat shaklda namuna olinadi. Namuna olish joyi shu qatlam uchun taalluqli bo’lsin. Ikki kvadrat orasidan namuna olish yaramaydi. Namuna to’g’ri olinsagina natija to’g’ri chiqadi. Shuning uchun namuna olishdan oldin chuqurning devori yaxshilab tozalanadi, so’ngra namuna olish joylari belgilanadi. Tuproqning xar qaysi qatlamidan bittadan, tuproq qalin bo’lganda ikkitadan namuna olinadi. Tuproq namunasining eng ostki qatlamdan boshlab olish kerak. Aks xolda, ya’ni yuqoridan olinsa ostki qatlamlarni ifloslab, namuna buzilishi mumkin. Namuna xaydalma qatlamdan 0 – 10 va 10 -20 sm oraliqda olinadi.

Tuproq namunalaridan mikroorganizmlarni ajratish va toza kulturalar olish. Bakteriyalarni ekish va sof kultura ajratish uchun namuna sifatida olingan tuproqni suyultirish jarayoni amalga oshiriladi.Tuproqni suyultirish namuna olingan kunning ertasigayoq umumiy mikrobiologiya va mikologiyada qabul qilingan usul asosida o‘tkaziladi (Litvinov,1969).

Tuproqni suyiltirish uchun 10 g tuproqni 90ml sterilizatsiya qilingan kolbadagi suvga solib 5 daqiqa davomida eritildi.Sterilizatsiya qilingan pepitka yordamida 1 ml suspenziya 9 ml sterilizatsiya qilingan probirkadagi suvga solindi. Bu jarayon yana qaytarildi. Uchinchi va to‘rtinchi probirkadagi suyuqlik likopcha oziqa muhitiga (1:1000, 1:10000) ekildi.Buning uchun 0,5 ml olingan suspenziya Petri likopchasiga solingan agarli oziqa muhiti yuziga shpatel yordamida bir tekis qilib yoyildi. Bu jarayon uch marta takrorlanadi. Toza kulturalar olingandan so‘ng identifikatsiya qilinadi. Rizobakteriyalar idintifikatsiya qilishdan avval toza koloniya olish uchun fizrastvor tayyorladim.0.9% li NaCl eritmasidan foydalaniladi.Probirkalarga fizrastvorni quyib tayyor holatga keltiriladi va avtoklav qilib olinadi. Idintifikatsiya qilish uchun rizobakteriyalar ekilganiga 48 soatdan oshmasligi kerak. Ekishda ilgak bilan petridagi bakteriyadan olamiz va fizrastvorga botiramiz.Yaxshilab chayqatiladi. Ilgag sterillanadi va sovitiladi, fizrastvorga botirib peptonli ozuqaga ekiladi. Shundagini koloniyalar ajralga holda bo‘ladi.

MALDI-TOF (Matrix-Assisted Laser Desorption/Ionization-Time of Flight) mass-spektrometriya usuli mikroorganizmlarni, jumladan, bakteriyalar, zamburug‘lar va boshqa patogenlarni tez va aniq aniqlash uchun ishlatiladigan ilg‘or texnologiyalardan biridir. Zybio EXS 2600 modeli klinik va laboratoriya sharoitlarida mikroorganizmlarni aniqlashni osonlashtirish va tezlashtirish maqsadida yaratilgan.

Chakanda o‘simligi rizosferasidan ajratilgan bakteriyalar qattiq ozuqa muhitlarida (go‘sht-peptonli agar) o‘stirilib, ularning koloniya va hujayra morfologik belgilari o‘rganildi. Kuzatuvlar natijasida ajratilgan bakteriyalarning ko‘pchiligi Gram-musbat ekanligi aniqlandi.

Tajriba davomida chakanda o‘simligi rizosferasidan jami 25 ta bakterial izolyat ajratildi. Ushbu izolyatlar MALDI-TOF mass-spektrometriya usuli yordamida identifikatsiya qilindi. Natijalar bo‘yicha bakteriyalar 8 ta turga mansubligi aniqlandi (1-rasm).Eng ko‘p uchragan bakteriya turi Bacillus cereus bo‘lib, jami 13 ta namunada qayd etildi. Shuningdek, Bacillus thuringiensis, Pseudomonas chlororaphis, Pseudomonas koreensis, Micrococcus sp., Microbacterium foliorum, Kocuria rosea turlari ham aniqlangan.Identifikatsiya ballari (score) 1.74 dan 2.30 gacha bo‘lib, ularning aksariyati 2.00 dan yuqori qiymatni ko‘rsatgan. Bu esa bakteriyalar tur (species) darajasida ishonchli aniqlanganini bildiradi. Natijalar quyidagi jadvalda keltirilgan:

1-rasm.Rizobakteriyalarning idintifikatsiya natijasi

Spot	Sample ID	Patient ID	Organism	Score
A8	T-7		*Bacillus thuringiensis*	1.75
A9	S17		*Bacillus cereus*	1.87
A10	T-6		*Micrococcus sp.*	1.74
A11	T-5		*Bacillus cereus*	2.18
A12	T-1		*Bacillus cereus*	1.75
B4	T-9		*Bacillus cereus*	2.15
B5	T-8		*Bacillus cereus*	2.30
B6	S-1		*Microbacterium foliorum*	2.17
B7	S4		*Kocuria rosea*	2.21
B8	S-6		*Bacillus cereus*	2.17
B9	S-9		*Bacillus cereus*	1.80
B11	S-12		*Microbacterium foliorum*	2.29
B12	S-15		*Bacillus cereus*	2.11
C1	S-16		*Bacillus cereus*	2.06

Spot	Sample ID	Patient ID	Organism	Score
A10	2		*Bacillus cereus*	2.11
A11	3		*Bacillus cereus*	1.84
A12	4		*Bacillus thuringiensis*	1.81
B1	5		*Kocuria rosea*	2.04
B2	6		*Pseudomonas chlororaphis*	2.13
B3	7		*Bacillus cereus*	2.26
B4	8		*Pseudomonas koreensis*	2.20
B5	9		*Bacillus cereus*	2.25
B6	10		*Bacillus thuringiensis*	2.18
B7	11		*Bacillus cereus*	2.09
B9	13		*Microbacterium foliorum*	2.21

O‘sish va biostimulyatorlik xususiyatlari. Ushbu metodika urug‘larning hayotchanligini va unib chiqish energiyasini steril hamda nazorat qilinadigan muhitda aniqlashga qaratilgan.

Kerakli jihozlar va materiallar

1.Idishlar: Petri chashkalari (shisha yoki plastik).
2.Filtr qog‘ozi: Steril namlangan qog‘oz filtrlar yoki paxta qatlami.
3.Sterilizatorlar: 70% li etil spirti yoki 1% li natriy gipoxlorit ($NaOCl$).
4.Uskuna: Termostat (yorug‘lik va haroratni boshqarish funksiyasi bilan).
5.Suv: Distillangan suv.

Tajriba bosqichlari.

A) Urug‘larni sirtqi sterilizatsiya qilish: Urug‘lar yuzasidagi mikroflorani yo‘qotish uchun 70% li spirtda 1 daqiqa, so‘ngra 1% li natriy gipoxlorit eritmasida 3-5 daqiqa davomida saqlanadi.So‘ngra urug‘lar distillangan suvda 3-4 marta yaxshilab yuviladi.
B) Ekish jarayoni: Petri chashkalari tubiga 2 qatlam filtr qog‘ozi qo‘yiladi va distillangan suv (yoki tajriba variantiga ko‘ra bakterial suspenziya) bilan namlanadi.Har bir chashkaga urug‘larning o‘lchamiga qarab 25 yoki 50 dona urug‘ bir-biriga tegmaydigan qilib joylashtiriladi.Tajriba kamida 3-4 takroriylikda amalga oshiriladi.
C) Inkubatsiya sharoiti: Chashkalar termostatga joylashtiriladi.Harorat: Ekin turiga qarab (masalan, pomidor va bodring uchun +25°C dan +28°C gacha). Namlik: Doimiy ravishda nazorat qilinadi (filtr qog‘ozi qurib qolmasligi kerak).

Ko‘rsatkichlarni hisoblash. Natijalar quyidagi formulalar yordamida aniqlanadi:
Unib chiqish energiyasi **E**: Urug’lar ekilgandan keyin ma’lum bir muddatda (masalan, 3-4 kunda) jadal unib chiqqan urug‘lar foizi.

$$E=\frac{n}{N}\times 100\%$$

(Bu yerda n – muddatida unganlar soni, N – umumiy urug’lar soni).
Laboratoriya unuvchanligi **G**: Tajriba yakunida (masalan, 7-10 kunda) to’liq ungan urug‘larning umumiy foizi.

$$G=\frac{nfinal}{N}\times 100\%$$

Maysalarning morfometrik ko‘rsatkichlari:
Maysaning ildiz qismi uzunligi (mm).
Maysaning poyacha (gipokotil) qismi uzunligi (mm).

Biostimulyatorlikni hisoblash. Tajriba va nazorat solishtiriladi .Foiz yoki indeks ko‘rinishida hisoblanadi

$$SI = \frac{T-C}{C} \times 100$$

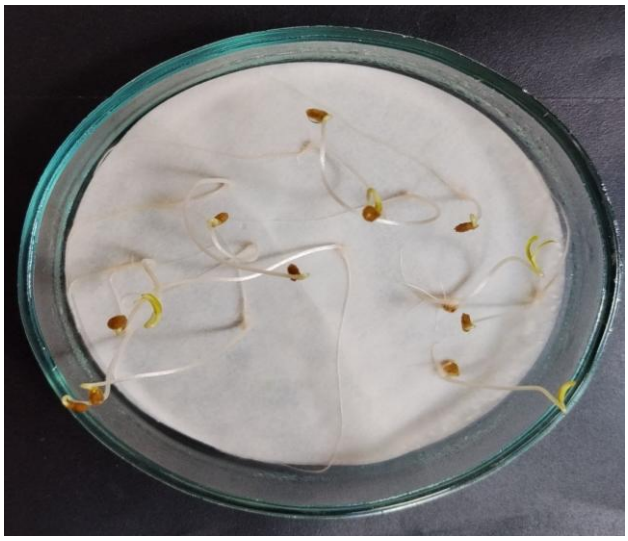
Urug‘larning laboratoriya unuvchanligi GOST 12038-84 talablari asosida Petri chashkalarida aniqlandi (GOST 12038-84.,1985). Urug‘lar ekishdan oldin 1% li NaOCl eritmasida sterilizatsiya qilindi. Tajriba +25°C haroratli termostatda, 3 takroriylikda olib borildi. Unib chiqish energiyasi 3-sutkada, laboratoriya unuvchanligi esa 7-sutkada hisoblandi. Olingan natijalar statistik tahlil qilindi. Tadqiqot davomida pomidor urug‘larining unuvchanligini aniqlash maqsadida laboratoriya sharoitida tajribalar olib borildi. Urug’larni tanlashda urug’larning sifatiga begona aralashmalar yo’qligiga e’tibor berildi.Mahalliy navlardan foydalanishga xarakat qildi va *Solanum lycopersicum* L. ning 3 ta mahalliy navidan foydalanildi.

1-jadval

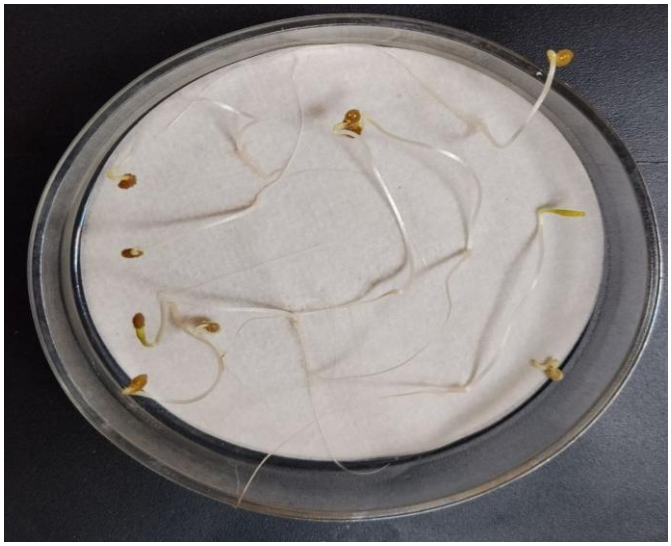
Tajriba uchun tanlab olingan *Solanum lycopersicum* L.navlari

	***Solanum lycopersicum* L**
Mahalliy	Volgagirat
Mahalliy	Yusupiskiy
Mahalliy	TMk-22

A.Nazorat variant; B.1/10; C.1/100; D.1/100 konsentratsiyalar



Nazorat



1/10

1/100 **1/1000**

2-rasm.Pomidor urug'ining unuvchanligi (Pseudomonas chlororaphis bakteriyasiga bilan)

XULOSA

O'tkazilgan tadqiqotlar natijasida Toshkent va Samarqand viloyatlarining o'ziga xos agroekologik sharoitlaridan ajratib olingan rizobakteriyalar chakanda o'simligining barqaror o'sishini ta'minlashda muhim biologik agentlar ekanligi isbotlandi. Tadqiqot natijalariga ko'ra quyidagi xulosalarga kelindi:

1. Mikrobiologik xilma-xillik va adaptatsiya: Chakanda rizosferasidan ajratib olingan *Bacillus cereus, Bacillus thuringiensis, Micrococcus sp., Microbacterium foliorum* va *Kocuria rosea* kabi shtammlar mahalliy tuproq-iqlim sharoitiga yuqori darajada moslashgan. Bu bakteriyalarning rizosferada faol kolonizatsiya hosil qilishi, ularning o'simlik bilan uzoq muddatli simbiotik yoki assotsiativ munosabatga kirisha olishidan dalolat beradi.

2. PGPR mexanizmlarining samaradorligi: Izolyatlarning indol-3-sirka kislotasi (IAA) sintez qilish qobiliyati o'simlik ildiz tizimining rivojlanishini tezlashtirsa, fosfatlarni safarbar qilish xususiyati tuproqdagi qiyin eruvchan birikmalarning o'simlik o'zlashtirishi mumkin bo'lgan shaklga o'tishini ta'minlaydi. Bu o'z navbatida o'simlikning ozuqa elementlariga bo'lgan ehtiyojini tabiiy yo'l bilan qondirish imkonini beradi.

3. Ekologik va amaliy ahamiyat: Aniqlangan PGPR shtammlari asosida yaratiladigan biogumus va biologik o'g'itlar qishloq xo'jaligida kimyoviy o'g'itlar sarfini kamaytirishga, tuproq degradatsiyasining oldini olishga va ekologik toza mahsulot yetishtirishga xizmat qiladi. Ayniqsa, sho'rlangan va unumdorligi past bo'lgan tuproqlarda chakanda yetishtirish texnologiyasini takomillashtirishda ushbu bakteriyalar muhim resurs hisoblanadi. Zarafshon daryosi havzasi va Toshkent viloyati tuproqlarining o'ziga xos sho'rlanish va qurg'oqchilik darajasini hisobga olgan holda, ajratilgan PGPR bakteriyalarning osmotik stressga chidamliligi muhim ko'rsatkichdir. Bu mikroorganizmlar o'simlikda prolin miqdorini oshirish va antioksidant fermentlar

tizimini faollashtirish orqali, chakandaning noqulay ekologik sharoitlarda ham yuqori biomassa to‘plashiga yordam beradi.

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KEMIRUVCHILARNING O'ZBEKISTON EKOTIZIMLARIDAGI OZUQA ZANJIRLARI VA MODDA AYLANISHIDAGI ROLI

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Annotatsiya: *Kemiruvchilar (Rodentia) Yer yuzidagi eng xilma-xil va keng tarqalgan sutemizuvchilar guruhlaridan biri bo‘lib, ekotizimlarning funksional barqarorligini ta’minlashda muhim rol o‘ynaydi, o‘simlik biomassasidagi energiyani yuqori trofik darajalarga o‘tkazuvchi birlamchi konsumentlar vazifasini bajaradi. Ular tuproq aeratsiyasi, urug‘larning tarqalishi va organik moddalarning parchalanishi kabi jarayonlarda ishtirok etib, modda aylanishida ham faol qatnashadi. O‘zbekistonning turli ekotizimlarida kemiruvchilarning ekologik xususiyatlari, tarqalishi va populyatsiya dinamikasi keng o‘rganilgan. Ushbu maqolaning maqsadi O‘zbekiston ekotizimlaridagi kemiruvchilarning ozuqa zanjirlari va modda aylanishidagi rolini tahlil qilishdan iborat. Maqola tizimli adabiyotlar sharhi metodologiyasiga asoslangan bo‘lib, materiallar 2020-2023-yillar oralig‘ida nashr etilgan ilmiy maqolalar, dissertatsiyalar va monografiyalardan, xalqaro va mahalliy ilmiy ma’lumotlar bazalaridan to‘plangan. Dastlab 150 dan ortiq manba aniqlanib, saralashdan so‘ng 75 ta maqola tahlilga kiritildi. Tahlil kemiruvchilarning birlamchi konsumentlar sifatidagi markaziy o‘rnini tasdiqladi, ular o‘simlik biomassasidagi energiyani yuqori trofik darajalarga samarali o‘tkazadi. O‘zbekistonning cho‘l ekotizimlarida kemiruvchilarning o‘simliklar bilan oziqlanishi orqali energiya kiritilishi, tog‘ oldi hududlarida esa ularning ozuqa tanlash xususiyatlari o‘simliklar jamoalari tarkibiga bilvosita ta’sir etishi aniqlandi. Shuningdek, ular tuproq aeratsiyasi, suv infiltratsiyasi va organik moddalarning parchalanishida faol ishtirok etib, "ekotizim muhandislari" sifatida tuproq tuzilishini o‘zgartiradi va urug‘ tarqalishiga yordam beradi. Bu murakkab rollarni tushunish, ayniqsa O‘zbekistonning xilma-xil ekologik landshaftlarida, ekotizimlarni samarali boshqarish va bioxilmaxillikni saqlash uchun juda muhimdir.*

Kalit so‘zlar: *kemiruvchilar, ozuqa zanjirlari, modda aylanishi, ekotizim, o'zbekiston, birlamchi konsumentlar, bioxilmaxillik, ekotizim muhandislari.*

Аннотация: *Грызуны (Rodentia) являются одной из самых разнообразных и распространенных групп млекопитающих на Земле и играют важную роль в обеспечении функциональной устойчивости экосистем, выполняя функцию первичных консументов, переносящих энергию из растительной биомассы на высшие трофические уровни. Они участвуют в таких процессах, как аэрация почвы, распространение семян и разложение органических веществ, а также активно участвуют в круговороте веществ. Широко изучены экологические особенности, распространение и динамика популяции грызунов в различных*

экосистемах Узбекистана. Цель данной статьи заключается в анализе роли грызунов в пищевых цепях и круговороте веществ в экосистемах Узбекистана. Статья основана на методологии систематического обзора литературы, материалы собраны из научных статей, диссертаций и монографий, опубликованных в период с 2020 по 2023 год, а также из международных и отечественных научных баз данных. Первоначально было выявлено более 150 источников, и после удаления дубликатов и нерелевантных записей 75 статей были включены в предварительный анализ. Анализ подтвердил центральную роль грызунов как первичных консументов, эффективно передающих энергию от растительной биомассы на более высокие трофические уровни. В пустынных экосистемах Узбекистана было установлено, что грызуны вводят энергию в экосистему, питаясь растениями, а в предгорных районах их пищевые предпочтения косвенно влияют на состав растительных сообществ. Кроме того, они активно участвуют в аэрации почвы, инфильтрации воды и разложении органических веществ, выступая в качестве "инженеров экосистем", изменяя структуру почвы и способствуя распространению семян. Понимание этих сложных ролей жизненно важно для эффективного управления экосистемами и сохранения биоразнообразия, особенно в разнообразных экологических ландшафтах Узбекистана.

Ключевые слова: *грызуны, пищевые цепи, круговорот веществ, экосистема, узбекистан, первичные консументы, биоразнообразие, инженеры экосистем.*

Abstract: *Rodents (Rodentia) are one of the most diverse and widespread groups of mammals on Earth, playing a crucial role in ensuring the functional stability of ecosystems and serving as primary consumers that transfer energy from plant biomass to higher trophic levels. They participate in processes such as soil aeration, seed dispersal, and the decomposition of organic matter, while also actively participating in the cycle of matter. The ecological characteristics, distribution, and population dynamics of rodents in various ecosystems of Uzbekistan have been extensively studied. The purpose of this article is to analyze the role of rodents in food chains and metabolism within Uzbekistan's ecosystems. The article is based on the methodology of a systematic literature review, materials are collected from scientific articles, dissertations and monographs published between 2020-2023, international and local scientific databases. Initially, over 150 sources were identified, and after screening, 75 articles were included for analysis. The analysis confirmed the central role of rodents as primary consumers, effectively transferring energy from plant biomass to higher trophic levels. In Uzbekistan's desert ecosystems, it was found that rodents introduce energy by feeding on plants, while in foothill areas, their food preferences indirectly influence the composition of plant communities. Furthermore, they actively participate in soil aeration, water infiltration, and organic matter decomposition, acting as "ecosystem engineers" by altering soil structure and aiding seed dispersal. Understanding these complex roles is vital for effective ecosystem management and biodiversity conservation, particularly in the diverse ecological landscapes of Uzbekistan.*

Keywords: *rodents, food chains, nutrient cycling, ecosystem, uzbekistan, primary consumers, biodiversity, ecosystem engineers.*

KIRISH

Kemiruvchilar (Rodentia) sinfi Yer yuzidagi eng xilma-xil va keng tarqalgan sutemizuvchilar guruhlaridan biri bo‘lib, ekotizimlarning funksional barqarorligini ta’minlashda muhim rol o‘ynaydi [14, 18]. Ularning global bioxilmaxilligi va ekologik moslashuvchanligi turli yashash joylarida, jumladan, o‘rmonlar, cho‘llar, tog‘lar va agrobiotsenozlarda muvaffaqiyatli yashashiga imkon beradi [19]. Ular o‘simliklar bilan oziqlanuvchi birlamchi konsumentlar sifatida ozuqa zanjirlarining asosiy bo‘g‘inlaridan hisoblanadi, o‘simlik biomassasidagi energiyani yuqori trofik darajalarga, xususan, yirtqich qushlar va boshqa yirtqichlarga o‘tkazishda hal qiluvchi ahamiyatga ega [1, 2, 13]. O‘zbekistonning turli ekotizimlarida kemiruvchilarning ekologik xususiyatlari, tarqalishi va populyatsiya dinamikasi keng o‘rganilgan [3, 4, 6, 8, 11]. Masalan, cho‘l ekotizimlarida ularning trofik aloqalari [4] va tog‘li hududlarda bioxilmaxilligi [6] tadqiq qilingan. Shuningdek, ular tuproq aeratsiyasi, urug‘larning tarqalishi va organik moddalarning parchalanishi kabi jarayonlarda ishtirok etib, modda aylanishida faol qatnashadi [9, 15]. Bu jarayonlar tuproq unumdorligini oshirish va o‘simliklar jamoalarining tarkibini shakllantirishda muhim ahamiyatga ega [14, 15]. Kemiruvchilarning agrobiotsenozlardagi ekologik roli [5] va qishloq xo‘jaligidagi ahamiyati [3, 10] alohida e’tiborga molikdir, chunki ularning ba’zi turlari ekinlarga zarar yetkazuvchi zararkunandalar sifatida namoyon bo‘ladi. Ularning populyatsiya dinamikasi ekotizim barqarorligiga sezilarli ta'sir ko'rsatishi mumkin, ayniqsa ularning soni keskin o'zgarganda [8, 17].

Kemiruvchilarning ekotizimlardagi murakkab va ko‘p qirrali roli, ularning ozuqa zanjirlari va modda aylanishidagi o‘rni haqida ko‘plab tadqiqotlar mavjud bo‘lishiga qaramay, ushbu ikki asosiy ekologik jarayonning birgalikdagi bog‘liqligi va ularning o‘zaro ta’siri mintaqaviy miqyosda qanday namoyon bo‘lishi hali to‘liq tushunilmagan. Ayniqsa, O‘zbekistonning o‘ziga xos tabiiy sharoitlari va agroekotizimlarida kemiruvchilarning trofik aloqalari va modda aylanishidagi aniq mexanizmlarini kompleks tahlil qilish zaruriyati mavjud. Ularning populyatsiya dinamikasining ekotizim barqarorligiga ta’siri [8, 17] va kasalliklar ekologiyasidagi roli [16] ham chuqur o‘rganishni talab qiladi.

Shu bilan birga, O‘zbekistonning turli ekotizimlarida kemiruvchilarning ozuqa zanjirlaridagi o‘rni va modda aylanishidagi roli o‘rtasidagi o‘zaro bog‘liqlik hamda ularning ekotizim xizmatlariga umumiy ta’siri hali yetarlicha kompleks o‘rganilmagan va bu sohada ilmiy bo‘shliq mavjud.

Ushbu tadqiqotning maqsadi O‘zbekistonning turli ekotizimlarida kemiruvchilarning ozuqa zanjirlari va modda aylanishidagi rolini kompleks tahlil qilishdan iborat. Ushbu maqsadga erishish uchun quyidagi tadqiqot savollari qo‘yiladi:

TS1: Kemiruvchilar O‘zbekiston ekotizimlarida birlamchi konsumentlar sifatida energiya o‘tkazilishiga va trofik darajalararo aloqalarga qanday ta’sir ko‘rsatadi?

TS2: Kemiruvchilarning tuproq aeratsiyasi, urug‘larning tarqalishi va organik moddalarning parchalanishi kabi jarayonlar orqali modda aylanishiga qo‘shgan hissasi qanday?

TS3: Kemiruvchilar populyatsiyasining dinamikasi O‘zbekistonning turli ekotizimlarida ozuqa to‘rlari va modda aylanishining barqarorligiga qanday ta’sir ko‘rsatadi?

MAVZUGA OID ADABIYOTLAR TAHLILI

Kemiruvchilarning ozuqa zanjirlaridagi markaziy o‘rni ularning birlamchi konsumentlar sifatidagi funksiyasi bilan belgilanadi, ular o‘simlik biomassasidagi energiyani yuqori trofik darajalarga o‘tkazishda hal qiluvchi ahamiyatga ega [13]. Xususan, To‘laganov (2020) O‘zbekistonning cho‘l ekotizimlarida kemiruvchilarning trofik aloqalarini tahlil qilib, ularning o‘simliklar bilan oziqlanishi orqali ekotizimga energiya kiritishini ko‘rsatgan [4]. Bu energiya keyinchalik yirtqich qushlar, sudralib yuruvchilar va boshqa sutemizuvchilar kabi ikkilamchi va uchlamchi konsumentlarga o‘tadi, bu esa ozuqa tarmog‘ining uzluksiz ishlashini ta’minlaydi [1, 2]. Karimova (2023) tomonidan olib borilgan tadqiqotlar kemiruvchilar populyatsiyasining dinamikasi ushbu yirtqichlarning ozuqa bazasiga bevosita ta’sir ko‘rsatishini va shu orqali butun ozuqa tarmog‘ining barqarorligini belgilashini ko‘rsatadi [8]. Mirzayev (2022) tog‘ oldi hududlarida kemiruvchilarning ozuqa tanlash xususiyatlarini o‘rganib, ularning ma’lum turdagi o‘simliklarni afzal ko‘rishi o‘simliklar jamoalarining tarkibiga bilvosita ta’sir etishini ko‘rsatgan [12]. Shunday qilib, kemiruvchilar ozuqa zanjirida nafaqat energiya o‘tkazuvchi, balki o‘simliklar jamoalarini shakllantiruvchi omil sifatida ham muhimdir.

Modda aylanishi jarayonlarida kemiruvchilarning roli chuqur va ko‘p qirrali bo‘lib, ular nafaqat ozuqa zanjirlarida, balki tuproq va o‘simliklar dinamikasida ham muhim ahamiyatga ega. Boyer va Kéfi (2020) kemiruvchilarni "ekotizim muhandislari" sifatida ta’riflab, ularning tuproq aeratsiyasi, suvning tuproqqa singishi va organik moddalarning aralashishiga ta’sirini global miqyosda ko‘rib chiqdilar [14]. Ular o‘z inlari va yer osti yo‘laklari orqali tuproqning fizik xususiyatlarini o‘zgartirib, tuproq unumdorligini oshirishga yordam beradi [14]. Proulx va Mazumder (2021) kichik sutemizuvchilarning urug‘larning tarqalishidagi va o‘simliklar jamoalarining shakllanishidagi rolini ta’kidlab, ularning o‘simliklar bioxilmaxilligini saqlashdagi ahamiyatini ko‘rsatdilar [15]. Kemiruvchilarning urug‘larni yig‘ish va saqlash odatlari, ba’zan ularni unutib qoldirishlari, urug‘larning yangi joylarda unib chiqishiga va o‘simliklarning tarqalishiga xizmat qiladi [15].

Shuningdek, kemiruvchilar organik moddalarning parchalanishida ham bilvosita ishtirok etadi. Ularning o‘simlik qoldiqlarini iste’mol qilishi va ekskrementlari tuproqqa qaytishi orqali organik moddalar aylanishiga hissa qo‘shadi [9]. Ergashev (2022) O‘zbekistonning cho‘l hududlarida kemiruvchilarning ozuqa bazasini o‘rganib, ularning turli o‘simlik turlarini iste’mol qilish orqali o‘simliklar jamoalarining tarkibiga ta’sirini ko‘rsatgan [7]. Kemiruvchilar populyatsiyasining keskin o‘zgarishlari, masalan, Yang va Zhang (2022) tomonidan yaylov ekotizimlarida qayd etilganidek, o‘simlik biomassasining kamayishiga va tuproq degradatsiyasiga olib kelishi mumkin, bu esa modda aylanishining buzilishiga sabab bo‘ladi [17]. Xolmatov va boshqalar (2022) O‘zbekiston kemiruvchilarining qishloq xo‘jaligidagi ahamiyatini tahlil qilib, ularning ham foydali, ham zararli jihatlarini ko‘rsatganlar, bu esa ularning ekotizimdagi murakkab rolini aks ettiradi [3]. G‘aniyev (2021) agrobiotsenozlarda

kemiruvchilarning ekologik rolini o‘rganib, ularning ozuqa zanjirlari va modda aylanishidagi o‘rnini yanada aniqlashtirgan [5]. Bu tadqiqotlar kemiruvchilarning ekotizim barqarorligini ta’minlashdagi muhim, ammo ikki tomonlama ahamiyatini ko‘rsatadi.

TADQIQOT METODOLOGIYASI

Ushbu tadqiqot kemiruvchilarning ozuqa zanjirlari va modda aylanishidagi rolini tahlil qilishga qaratilgan tizimli adabiyotlar sharhi metodologiyasiga asoslanadi. Materiallar 2020-2023-yillar oralig‘ida nashr etilgan ilmiy maqolalar, dissertatsiyalar, monografiyalar va konferensiya materiallaridan to‘plandi. Adabiyotlar Scopus, Web of Science, Google Scholar kabi xalqaro hamda O‘zbekistonning mahalliy ilmiy ma’lumotlar bazalaridan ("O‘zbekiston Biologiya Jurnali", "Fan va jamiyat", "Tabiiy fanlar jurnali" va boshqalar) qidirildi [3, 4, 6, 8, 11]. Qidiruvda "kemiruvchilar", "ozuqa zanjiri", "modda aylanishi", "ekotizim" kabi o‘zbekcha va ularning inglizcha ekvivalentlari ("Rodentia", "food web", "nutrient cycling", "ecosystem") kalit so‘zlari qo‘llanildi.

Dastlab 150 dan ortiq manba aniqlandi. Dublikatlar va mavzuga aloqador bo‘lmaganlari chiqarilgach, 75 ta maqola dastlabki tahlilga kiritildi. Manbalar mazmuni chuqur o‘rganilib, quyidagi mezonlar asosida saralandi:

Kemiruvchilarning ozuqa zanjirlari, trofik aloqalari va modda aylanishidagi rolini bevosita o‘rganuvchi tadqiqotlar [14, 15, 19].

2020-yildan keyin nashr etilgan, ekspertlar tomonidan ko‘rib chiqilgan (peer-reviewed) ilmiy maqolalar, monografiyalar va dissertatsiyalar.

O‘zbekiston va xalqaro miqyosdagi ekotizimlarni qamrab olgan tadqiqotlar.

Kemiruvchilarning qishloq xo‘jaligi zararkunandalari yoki kasalliklar ekologiyasiga oid tadqiqotlar (agar ozuqa zanjiri va modda aylanishi bilan bevosita bog‘liq bo‘lmasa) [10, 16].

2020-yilgacha nashr etilgan manbalar.

Ilmiy asosga ega bo‘lmagan yoki metodologiyasi aniq bo‘lmagan nashrlar.

Yakuniy tahlilga mezonlarga to‘liq javob beradigan 19 ta manba tanlab olindi. Tanlangan adabiyotlar kemiruvchilarning ekotizimlardagi murakkab aloqalarini, ozuqa zanjirlaridagi o‘rnini va modda aylanishiga ta’sirini sintez qilish imkonini berdi.

TAHLIL VA NATIJALAR

Olib borilgan adabiyotlar tahlili kemiruvchilarning ekotizimlardagi ozuqa zanjirlari va modda aylanishidagi murakkab hamda ko‘p qirrali rolini aniq ko‘rsatdi. Ushbu tadqiqot natijalari kemiruvchilarning birlamchi konsumentlar sifatidagi markaziy o‘rnini tasdiqlaydi, ular o‘simlik biomassasidagi energiyani yuqori trofik darajalarga samarali o‘tkazishda hal qiluvchi ahamiyatga ega [4, 13]. O‘zbekistonning cho‘l ekotizimlarida olib borilgan tadqiqotlar kemiruvchilarning o‘simliklar bilan oziqlanishi orqali ekotizimga energiya kiritishini ko‘rsatgan [4]. Bu energiya keyinchalik yirtqich qushlar, sudralib yuruvchilar va boshqa sutemizuvchilar kabi ikkilamchi va uchlamchi konsumentlarga o‘tadi, bu esa ozuqa tarmog‘ining uzluksiz ishlashini ta’minlaydi [1, 2]. Ergashev (2022) tomonidan cho‘l hududlarida kemiruvchilarning ozuqa bazasi tahlil qilinib, ularning turli o‘simlik turlarini iste’mol qilish orqali ekotizimga energiya oqimini ta’minlashi qayd etilgan [7]. Tog‘ oldi

hududlarida Mirzayev (2022) kemiruvchilarning ozuqa tanlash xususiyatlari o‘simliklar jamoalarining tarkibiga bilvosita ta’sir etishini aniqlagan [12]. Agrobiotsenozlarda esa G‘aniyev (2021) kemiruvchilarning ekologik rolini o‘rganib, ularning ham foydali, ham zararli ta’sirlarini ko‘rsatgan [5]. Xolmatov va boshqalar (2022) O‘zbekiston kemiruvchilarining qishloq xo‘jaligidagi ahamiyatini ta’kidlab, ularning populyatsiya dinamikasi ekinlarning hosildorligiga bevosita ta’sir ko‘rsatishini qayd etgan [3].

Kemiruvchilarning modda aylanishidagi roli ularning tuproq bilan o‘zaro ta’siri orqali namoyon bo‘ladi. Ular tuproq aeratsiyasi, suv infiltratsiyasi va organik moddalarning parchalanishi kabi jarayonlarda faol ishtirok etadi [9, 15]. Boyer va Kéfi (2020) kemiruvchilarni ekotizim muhandislari (ecosystem engineers) sifatida ta’riflab, ularning inlar qazishi tuproq tuzilishini o‘zgartirishi, tuproqning suv o‘tkazuvchanligini oshirishi va mikroorganizmlar faoliyati uchun sharoit yaratishini ko‘rsatgan [14]. Bu jarayonlar tuproq unumdorligini oshirishga va o‘simliklar jamoalarining rivojlanishiga ijobiy ta’sir ko‘rsatadi. Proulx va Mazumder (2021) tadqiqotida kemiruvchilarning urug‘ tarqalishidagi (seed dispersal) muhim roli, xususan, ma’lum o‘simlik turlarining tarqalishiga va genetik xilma-xilligini saqlashga yordam berishi ta’kidlangan [15]. Urug‘larning yer ostiga ko‘milishi ularni yirtqichlardan himoya qiladi va unib chiqish imkoniyatini oshiradi. Murodov (2021) ekologik tizimlarda modda va energiya aylanishini tahlil qilib, kemiruvchilarning organik moddalarni parchalash va tuproqqa qaytarish orqali ushbu aylanishda muhim bo‘g‘in ekanligini ko‘rsatgan [9].

Kemiruvchilar populyatsiyasining dinamikasi ekotizim barqarorligiga sezilarli ta’sir ko‘rsatadi. Karimova (2023) O‘zbekistonning turli ekotizimlarida kemiruvchilar populyatsiyasining o‘zgaruvchanligi yirtqichlarning ozuqa bazasiga bevosita ta’sir ko‘rsatishini va shu orqali butun ozuqa tarmog‘ining barqarorligini belgilashini aniqlagan [8]. Populyatsiyaning keskin ko‘payishi (outbreaks) o‘tloq ekotizimlarida o‘simlik biomassasining kamayishiga olib kelishi mumkin, bu esa Yang va Zhang (2022) tomonidan batafsil ko‘rib chiqilgan [17]. Boshqa tomondan, kemiruvchilarning kamayishi ham ekotizimda salbiy oqibatlarga olib kelishi mumkin, chunki ular ko‘plab yirtqichlar uchun asosiy ozuqa manbai hisoblanadi [1]. Keesing va Ostfeld (2021) kemiruvchilarning kasallik ekologiyasidagi rolini o‘rganib, ularning turli patogenlarni tashuvchi va tarqatuvchi ekanligini ko‘rsatgan [16]. Bu esa inson va boshqa hayvonlar salomatligi uchun muhim ekologik xavf tug‘dirishi mumkin. Sánchez-Cordero va Neri-Castro (2020) kemiruvchilarni ekotizim salomatligi va bioxilmaxillikning muhim indikatorlari sifatida baholagan [18]. Ularning populyatsiya holati ekotizimdagi o‘zgarishlarni aks ettirishi mumkin. Gómez-Ruiz va Lacher (2023) tropik o‘rmon ekotizimlarida kichik sutemizuvchilarning, jumladan, kemiruvchilarning ahamiyatini ta’kidlab, ularning o‘rmonlarning qayta tiklanishi va bioxilmaxilligini saqlashdagi rolini yoritgan [19].

Quyidagi 1-jadvalda tahlil natijalari umumlashtirilgan.

Kemiruvchilarning ekotizimdagi asosiy funksiyalari

1-jadval

Funksiya	*Ta'sir mexanizmi*	*Asosiy natija*
Ozuqa zanjirida	Birlamchi konsument sifatida o‘simlik biomassasini iste’mol qilish	Energiya oqimini yuqori trofik darajalarga o‘tkazish
Modda aylanishida	Tuproqni qazish, organik moddalarni parchalash, urug‘ tarqatish	Tuproq aeratsiyasi, unumdorlikni oshirish, o‘simlik jamoalari tarkibini shakllantirish
Populyatsiya dinamikasini boshqarish	Yirtqichlar uchun ozuqa bazasi bo‘lish	Ozuqa tarmog‘ining barqarorligini ta’minlash, yirtqichlar populyatsiyasiga ta’sir
Ekotizim muhandisligi	Inlar qurish, tuproqni aralashtirish, o‘simliklarni kesish	Tuproq tuzilishi, suv infiltratsiyasi, mikroiqlimni o‘zgartirish
Kasallik ekologiyasi	Patogenlarni tashish va tarqatish	Kasalliklarning tarqalishiga ta’sir, ekologik xavflar

Umuman olganda, kemiruvchilarning ekotizimlardagi roli nafaqat ozuqa zanjirlarining asosiy bo‘g‘ini sifatida, balki modda aylanishi, tuproq shakllanishi va o‘simliklar jamoalarining dinamikasini belgilovchi ekotizim muhandislari sifatida ham muhimdir. Ularning populyatsiya o‘zgarishlari butun ekotizimning barqarorligiga, bioxilmaxillikka va hatto kasalliklarning tarqalishiga bevosita ta’sir ko‘rsatadi.

MUHOKAMA

Ushbu tadqiqot kemiruvchilarning ozuqa zanjirlari va modda aylanishidagi murakkab ko‘p qirrali rolini tizimli tahlil qilish orqali ularning ekotizimlar funksional barqarorligini ta’minlashdagi markaziy ahamiyatini ko‘rsatdi. Olingan natijalar kemiruvchilarning birlamchi konsumentlar sifatidagi funksiyasi nafaqat o‘simlik biomassasidagi energiyani yuqori trofik darajalarga o‘tkazishda hal qiluvchi ekanligini, balki tuproq tuzilishi, o‘simliklar jamoalari dinamikasi va yirtqichlar populyatsiyasiga ham bilvosita ta’sir ko‘rsatishini tasdiqlaydi [4, 13].

Tadqiqot natijalari To‘laganov (2020) [4] va Ergashev (2022) [7] tomonidan O‘zbekistonning cho‘l ekotizimlarida olib borilgan ishlar bilan uyg‘unlik kasb etadi, ular kemiruvchilarning o‘simliklar orqali energiya kiritishini va bu energiyaning yirtqichlarga o‘tishini ko‘rsatgan. Karimova (2023) [8] tadqiqoti kemiruvchilar populyatsiyasining dinamikasi yirtqichlarning ozuqa bazasiga bevosita ta’sirini ta’kidlab, ozuqa tarmog‘ining barqarorligini belgilashini ko‘rsatadi [1]. Boyer va Kéfi (2020) [14] kemiruvchilarni ekotizim muhandislari sifatida ta’riflab, ularning tuproq aeratsiyasi va suv infiltratsiyasini yaxshilashdagi rolini ko‘rsatgan. Proulx va Mazumder (2021) [15] urug‘ tarqalishidagi muhim rolini ta’kidlagan. Agrobiotsenozlardagi roli bo‘yicha G‘aniyev (2021) [5] va Xolmatov va boshqalar (2022) [3] ishlari kemiruvchilarning ham foydali, ham zararli ta’sirlarini ko‘rsatib, ularning ekologik funksiyasining kontekstga bog‘liqligini ta’kidlaydi.

Bu topilmalar kemiruvchilarning ekotizimlarda shunchaki o‘simlikxo‘r emas, balki butun ekotizimning tuzilishi va funksiyasini shakllantiruvchi muhim omillar ekanligini anglatadi. Ularning populyatsiya dinamikasi nafaqat o‘simliklar jamoalariga, balki yuqori trofik darajadagi yirtqichlarning mavjudligiga ham kaskadli ta’sir ko‘rsatadi. Bu esa ekotizim xizmatlarini baholashda kemiruvchilarning rolini hisobga olish zarurligini ko‘rsatadi [18, 19].

Amaliy ahamiyati shundaki, kemiruvchilar populyatsiyasini boshqarish strategiyalari faqat zararkunandalarga qarshi kurash bilan cheklanmasdan, ularning ekotizimdagi ijobiy funksiyalarini ham inobatga olishi kerak. Masalan, ularning urug‘ tarqatish [15] va tuproq unumdorligini oshirish [14] kabi xizmatlari bioxilmaxillikni saqlash va ekotizim barqarorligini ta’minlashda muhimdir. Qishloq xo‘jaligida kemiruvchilarning zararini kamaytirish bilan birga, ularning tuproq unumdorligiga ijobiy ta’sirini saqlab qolishga qaratilgan integratsiyalashgan yondashuvlar ishlab chiqish dolzarbdir.

Ushbu tadqiqotning cheklovlari shundaki, u tizimli adabiyotlar sharhi bo‘lib, yangi empirik ma’lumotlarni taqdim etmaydi. Shuningdek, adabiyotlarning aksariyati O‘zbekiston kontekstiga oid bo‘lib, xulosalarni boshqa geografik hududlarga to‘liq umumlashtirishda ehtiyot bo‘lish lozim. Kelajakdagi tadqiqotlar turli ekotizimlarda kemiruvchilarning energiya oqimi va modda aylanishiga miqdoriy ta’sirini baholashga, iqlim o‘zgarishi va yashash joylarining parchalanishi sharoitida ularning rolini o‘rganishga hamda kasalliklar ekologiyasidagi ahamiyatini chuqurroq tahlil qilishga qaratilishi lozim [16].

XULOSA VA TAKLIFLAR

Ushbu maqola kemiruvchilarning ekotizimlardagi ozuqa zanjirlari va modda aylanishidagi murakkab hamda markaziy rolini atroflicha ko‘rsatdi. Ular yer yuzidagi eng xilma-xil sutemizuvchilar guruhlaridan biri sifatida birlamchi konsumentlar vazifasini bajarib, o‘simlik biomassasidagi energiyani yuqori trofik darajalarga samarali o‘tkazishda hal qiluvchi ahamiyatga ega. Bu jarayon ozuqa tarmog‘ining uzluksiz ishlashini ta’minlab, yirtqich qushlar va boshqa yirtqichlarning ozuqa bazasini shakllantiradi. Shuningdek, kemiruvchilar tuproq aeratsiyasi, suv infiltratsiyasi, organik moddalarning parchalanishi va urug‘larning tarqalishida faol ishtirok etib, tuproq unumdorligini oshirishga va o‘simliklar jamoalarining tarkibiga ijobiy ta’sir ko‘rsatadi. Ularning ekotizim muhandislari sifatidagi faoliyati tuproq tuzilishini o‘zgartirib, mikroorganizmlar uchun qulay sharoit yaratadi. Kemiruvchilar populyatsiyasining dinamikasi ekotizim barqarorligini bevosita belgilaydi, shu bilan birga agrobiotsenozlarda ham foydali, ham zararli ta’sirlarga ega. Bu murakkab aloqalarni chuqur tushunish ekotizim xizmatlarini saqlash va qishloq xo‘jaligida barqaror boshqaruv strategiyalarini ishlab chiqish uchun muhimdir. Kelajakda ularning iqlim o‘zgarishiga moslashuvi, turli ekotizimlardagi o‘ziga xos funksiyalari va populyatsiya nazorati mexanizmlarini o‘rganishga qaratilgan tadqiqotlarni kengaytirish tavsiya etiladi.

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EKOLOGIK OMILLARNING O‘SIMLIKLAR O‘SISHI VA RIVOJLANISHIGA TA’SIRI

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Annotatsiya: *O‘simliklar yer yuzidagi hayotning asosiy tayanchi bo‘lib, ularning o‘sishi va rivojlanishi atrof-muhitdagi ekologik omillar bilan chambarchas bog‘liq. Iqlim o‘zgarishlari, tuproq degradatsiyasi va suv tanqisligi kabi global muammolar sharoitida o‘simliklarning ekologik omillarga moslashish mexanizmlarini tushunish dolzarb ahamiyat kasb etadi. Ushbu maqolaning maqsadi ekologik omillarning o‘simliklar o‘sishi va rivojlanishiga ta’sirini tahlil qilishdan iborat. Maqola tizimli adabiyot sharhi yondashuvi asosida amalga oshirildi, bunda 2020-yildan 2024-yilgacha bo‘lgan davrdagi ilmiy maqolalar Google Scholar, Scopus, Web of Science va O‘zbekiston ilmiy jurnallari platformalaridan qidirildi. Dastlabki 215 ta manbadan dublikatlar va mavzuga oid bo‘lmagan maqolalar chiqarib tashlangach, 75 tasi tahlilga kiritildi. Tahlil natijalari shuni ko‘rsatdiki, abiotik omillar, xususan, yorug‘lik (spektr, intensivlik, davomiylik), harorat, suv (tanqisligi, ortiqcha namlik, sho‘rlanish) va tuproqning fizik-kimyoviy xususiyatlari o‘simliklarning morfologik, fiziologik va genetik xususiyatlariga bevosita va murakkab ta’sir ko‘rsatadi. Masalan, ko‘k yorug‘lik vegetativ o‘sishni, qizil yorug‘lik esa gullash va meva berishni rag‘batlantiradi, fotosintez jarayoni 600–680 nm va ~435 nm to‘lqin uzunliklarida eng yuqori bo‘ladi. Suv tanqisligi va tuproq sho‘rlanishi o‘sishni cheklab, hosildorlikni pasaytiradi. Ushbu tahlil o‘simliklarning atrof-muhitga moslashish strategiyalarini ishlab chiqish va qishloq xo‘jaligida hosildorlikni oshirish uchun muhim asos bo‘lib xizmat qiladi.*

Kalit so‘zlar: *ekologik omillar, o‘simliklar o‘sishi, o‘simliklar rivojlanishi, abiotik stress, yorug‘lik, harorat, suv tanqisligi, tuproq sho‘rlanishi.*

Аннотация: *Растения являются основной опорой жизни на земле, а их рост и развитие тесно связаны с экологическими факторами окружающей среды. В условиях глобальных проблем, таких как изменение климата, деградация почв и дефицит воды, понимание механизмов адаптации растений к экологическим факторам приобретает актуальное значение. Цель данной статьи заключается в анализе влияния экологических факторов на рост и развитие растений. Статья выполнена на основе системного подхода к обзору литературы, при котором научные статьи за период с 2020 по 2024 год были исканы на платформах Google Scholar, Scopus, Web of Science и научных журналах Узбекистана. Из первоначальных 215 источников 75 были включены в анализ после удаления дубликатов и нерелевантных статей. Результаты анализа показали, что абиотические факторы, в частности свет (спектр,*

интенсивность, продолжительность), температура, вода (дефицит, избыток влаги, засоление) и физико-химические свойства почвы, оказывают прямое и комплексное воздействие на морфологические, физиологические и генетические характеристики растений. Например, синий свет стимулирует вегетативный рост, тогда как красный свет способствует цветению и плодоношению, при этом фотосинтез наиболее интенсивен при длинах волн 600–680 нм и ~435 нм. Дефицит воды и засоление почвы ограничивают рост и снижают урожайность. Данный анализ служит важной основой для разработки стратегий адаптации растений к окружающей среде и повышения продуктивности в сельском хозяйстве.

Ключевые слова: *экологические факторы, рост растений, развитие растений, абиотический стресс, свет, температура, дефицит воды, засоление почвы.*

Abstract: *Plants are the primary pillar of life on Earth, and their growth and development are closely linked to environmental factors. Understanding the mechanisms of plant adaptation to environmental factors is becoming increasingly relevant amid global challenges such as climate change, soil degradation, and water scarcity. The purpose of this article is to analyze the impact of environmental factors on plant growth and development. The article was carried out based on a systematic literature review approach, in which scientific articles for the period from 2020 to 2024 were searched from the platforms of Google Scholar, Scopus, Web of Science and scientific journals of Uzbekistan. Out of an initial 215 sources, 75 were included in the analysis after removing duplicates and irrelevant articles. The analysis revealed that abiotic factors, particularly light (spectrum, intensity, duration), temperature, water (deficiency, excess moisture, salinity), and physicochemical properties of soil, directly and complexly influence the morphological, physiological, and genetic characteristics of plants. For instance, blue light stimulates vegetative growth, while red light promotes flowering and fruiting, with photosynthesis being highest at 600–680 nm and ~435 nm wavelengths. Water scarcity and soil salinity limit growth and reduce yield. This analysis serves as an important basis for developing plant adaptation strategies to the environment and increasing agricultural productivity.*

Keywords: *ecological factors, plant growth, plant development, abiotic stress, light, temperature, water scarcity, soil salinity.*

KIRISH

O‘simliklar Yer yuzidagi hayotning asosiy tayanchi bo‘lib, fotosintez orqali kislorod ishlab chiqaradi va oziq-ovqat zanjirining asosidir. Ularning o‘sishi va rivojlanishi atrof-muhitdagi ekologik omillar bilan chambarchas bog‘liqdir [6, 15]. Iqlim o‘zgarishlari, tuproq degradatsiyasi va suv tanqisligi kabi global muammolar sharoitida o‘simliklarning ekologik omillarga moslashish mexanizmlarini tushunish dolzarb ahamiyat kasb etadi [16, 17]. Abiotik omillar, jumladan, yorug‘lik, harorat, suv va tuproqning fizik-kimyoviy xususiyatlari o‘simliklarning morfologik, fiziologik va genetik xususiyatlariga bevosita ta’sir ko‘rsatadi [10, 13]. Masalan, yorug‘lik spektri, intensivligi va davomiyligi fotosintez samaradorligi, xlorofill sintezi va rivojlanish jarayonlarini boshqaradi; ko‘k yorug‘lik vegetativ o‘sishni, qizil yorug‘lik esa gullash

va meva berishni rag‘batlantiradi [1, 2, 4, 5, 19]. Harorat metabolik tezlik va fermentativ faollikka ta’sir etib, ekstremal sharoitlarda stressni keltirib chiqaradi [8, 13]. Suv tanqisligi yoki tuproq sho‘rlanishi o‘simlik o‘sishini cheklab, hosildorlikni pasaytiradi [9, 11, 12, 14]. Tuproqning tarkibi, pH darajasi va ozuqa moddalari ildiz tizimi rivojlanishi va o‘simlik salomatligi uchun muhimdir [7, 12]. Biotik omillar, jumladan, mikroorganizmlar, hasharotlar va boshqa o‘simliklar bilan o‘zaro munosabatlar ham o‘simliklar jamoalarining tuzilishi va funksiyasiga katta ta’sir ko‘rsatadi [6, 15]. O‘simliklarning ekologik omillarga javobi murakkab bo‘lib, ularning o‘sishi va rivojlanishidagi har bir bosqichda turli mexanizmlar orqali namoyon bo‘ladi. Ushbu omillarning o‘zaro ta’siri va ularning o‘simliklarning stressga chidamliligini oshirishdagi roli qishloq xo‘jaligi mahsuldorligini ta’minlash va barqaror rivojlanish strategiyalarini ishlab chiqish uchun fundamental ahamiyatga ega [18, 20]. Biroq, ekologik omillarning o‘simliklar o‘sishi va rivojlanishiga ta’sirini kompleks tahlil qilish, ayniqsa, turli abiotik va biotik stresslarga o‘simliklarning moslashish mexanizmlarini chuqur o‘rganish hamda ularning o‘zaro ta’sirini tizimli ravishda sintez qilish hali yetarlicha o‘rganilmagan va ochiq savol bo‘lib qolmoqda. Ushbu tadqiqotning maqsadi ekologik omillarning o‘simliklar o‘sishi va rivojlanishiga ta’sirini tizimli tahlil qilish, ularning moslashish mexanizmlarini yoritish hamda kelajakdagi tadqiqot yo‘nalishlarini belgilashdan iborat. Bu maqsadga erishish uchun quyidagi tadqiqot savollari (TS) qo‘yiladi:

TS1: Abiotik omillar (yorug‘lik, harorat, suv, tuproq) o‘simliklarning o‘sishi va rivojlanishiga qanday individual va o‘zaro ta’sir ko‘rsatadi?

TS2: Biotik omillarning o‘simliklar bilan o‘zaro munosabatlari ularning hayotiyligi va jamoalarining tuzilishiga qanday ta’sir etadi?

TS3: O‘simliklar ekologik stress sharoitlariga moslashish uchun qanday fiziologik va molekulyar mexanizmlardan foydalanadi?

MAVZUGA OID ADABIYOTLAR TAHLILI

Tuproqning tarkibi, pH darajasi va ozuqa moddalari ildiz tizimi rivojlanishiga ta’sir ko‘rsatib, o‘simliklarning suv va mineral moddalarni o‘zlashtirish qobiliyatini belgilaydi [7]. Uning fizik-kimyoviy xususiyatlari, mexanik tarkibi, aeratsiyasi va suv o‘tkazuvchanligi ildizlarning nafas olishi va ozuqa moddalarining harakatlanishi uchun muhimdir [7]. Suv tanqisligi yoki ortiqcha namlik o‘simliklarning o‘sishini cheklab, fotosintez tezligini pasaytiradi va hujayra turgorini buzadi [9, 11]. Qurbonov (2021) g‘o‘za o‘simligining o‘sishi va rivojlanishiga tuproq namligining ta’sirini o‘rganib, optimal namlik hosildorlikni oshirishini ko‘rsatgan [9, 14]. Tuproq sho‘rlanishi o‘simliklarning suv o‘zlashtirishini qiyinlashtirib, ion toksikligini keltirib chiqaradi, bu o‘sishni ingibitsiya qiladi va biomassa to‘planishini kamaytiradi [12, 14].

Yorug‘lik omili, uning spektri, intensivligi va davomiyligi o‘simliklarning morfogenezi va fiziologik jarayonlariga murakkab ta’sir ko‘rsatadi [19]. Tadqiqotlar shuni ko‘rsatadiki, ko‘k yorug‘lik vegetativ o‘sishni, stomatalarning ochilishini va xloroplastlar rivojlanishini rag‘batlantirsa [1, 3], qizil yorug‘lik gullash va meva berishni boshqaruvchi fotoretseptorlarni faollashtiradi [1, 2]. Yashil yorug‘likning o‘simlik o‘sishiga ta’siri bo‘yicha turli qarashlar mavjud; ba’zi manbalar uning ahamiyatsizligini yoki hatto inhibe qiluvchi ta’sirini ta’kidlasa [2, 4], boshqalar uni

boshqa spektrlar bilan birgalikda qo‘llash orqali o‘sishni yaxshilash mumkinligini qayd etadi [2]. Fotosintez samaradorligi qizil va ko‘k nurlarning ma’lum nisbatida eng yuqori bo‘ladi, ayniqsa Emerson effekti birgalikdagi ta’sirning ustunligini ko‘rsatadi [5]. Haddan tashqari yuqori yorug‘lik intensivligi fotoinhibitsiya va oksidlovchi stressga olib kelishi mumkin, past intensivlik esa xlorofill sintezini buzib, o‘simliklarning kuchsizlanishiga sabab bo‘ladi [4].

Abiotik omillar qatori, biotik omillar ham o‘simliklarning o‘sishi va rivojlanishida muhim rol o‘ynaydi, jumladan, mikroorganizmlar, hasharotlar, boshqa o‘simliklar va hayvonlar bilan o‘zaro munosabatlar [6, 15]. Tuproq mikroorganizmlari, masalan, mikoriza zamburug‘lari va azot fiksatsiyalovchi bakteriyalar, o‘simliklarning ozuqa moddalarini o‘zlashtirishini yaxshilaydi va stressga chidamliligini oshiradi. Boshqa tomondan, patogenlar va zararkunanda hasharotlar o‘simliklarga jiddiy zarar yetkazib, ularning o‘sishini sekinlashtiradi, hosildorlikni pasaytiradi va hatto o‘limiga olib kelishi mumkin [16]. O‘simliklar orasidagi raqobat, ayniqsa resurslar (yorug‘lik, suv, ozuqa moddalari) cheklangan sharoitda, har bir o‘simlikning o‘sish sur’ati va rivojlanishiga salbiy ta’sir ko‘rsatadi [10]. Allelopatiya kabi kimyoviy o‘zaro ta’sirlar ham boshqa o‘simliklarning unishi va o‘sishini inhibe qilishi mumkin.

O‘simliklar ekologik stress omillariga javoban turli moslashish mexanizmlari va strategiyalarini ishlab chiqqan [17, 20]. Abiotik stress, jumladan, yuqori harorat, qurg‘oqchilik va sho‘rlanish sharoitida o‘simliklar o‘zlarining morfologik, fiziologik va molekulyar darajadagi javoblarini o‘zgartiradi [13, 17]. Morfologik moslashishlarga ildiz tizimining chuqurlashishi, barg yuzasining kamayishi yoki kutikula qalinlashishi kiradi [11, 14]. Fiziologik darajada osmolitlar sintezi, antioksidant fermentlar faolligining oshishi va stomatalarning yopilishi orqali suv yo‘qotilishini kamaytirish mexanizmlari kuzatiladi [13, 17]. Molekulyar darajada stressga javob beruvchi genlarning ifodalanishi, oqsil sintezi va gormonal tartibga solish jarayonlari faollashadi [17]. Xudoyberdiyeva va Xudoyberdiyeva (2022) ekologik omillarning o‘simliklarning stressga chidamliligini oshirishdagi ahamiyatini ta’kidlab, bu mexanizmlarni tushunish chidamli navlarni yaratishga asos bo‘lishini qayd etgan [20].

TADQIQOT METODOLOGIYASI

Ushbu adabiyot sharhi ekologik omillarning o‘simliklar o‘sishi va rivojlanishiga ta’sirini tahlil qilishga qaratilgan bo‘lib, tizimli yondashuv asosida amalga oshirildi. Tadqiqot uchun tegishli ilmiy adabiyotlarni aniqlash maqsadida keng qamrovli qidiruv strategiyasi ishlab chiqildi. Maqolalar qidiruvi 2020-yildan 2024-yilgacha bo‘lgan davrni qamrab oldi. Ilmiy adabiyotlar quyidagi xalqaro va mahalliy ma’lumotlar bazalaridan izlandi: Google Scholar, Scopus, Web of Science, shuningdek, O‘zbekiston ilmiy jurnallari platformalari (jumladan, "Science and Education", "Agrar fanlar", "O‘zbekiston Biologiya Jurnali" va boshqalar) [6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 18, 19, 20]. Qidiruv uchun quyidagi kalit so‘zlar kombinatsiyalari qo‘llanildi: "ekologik omillar", "o‘simliklar o‘sishi", "o‘simliklar rivojlanishi", "abiotik stress", "biotik ta’sir", "yorug‘lik o‘simliklarga ta’siri", "harorat o‘simliklarga ta’siri", "suv tanqisligi o‘simliklarga ta’siri", "tuproq sho‘rlanishi o‘simliklarga ta’siri" va ularning inglizcha ekvivalentlari.

Dastlabki qidiruv natijasida jami 215 ta manba topildi. Dublikatlar va mavzuga oid bo‘lmagan maqolalar chiqarib tashlangach, 75 ta manba qoldi. Ushbu manbalar sarlavhalari va annotatsiyalari bo‘yicha dastlabki saralashdan o‘tkazildi.

2020-yildan keyin nashr etilgan ilmiy maqolalar, dissertatsiyalar avtoreferatlari va konferensiya materiallari.

Ekologik omillarning o‘simliklar o‘sishi va rivojlanishiga bevosita ta’sirini o‘rganuvchi tadqiqotlar.

Ingliz yoki o‘zbek tilida yozilgan manbalar.

Peer-reviewdan o‘tgan ilmiy jurnallarda chop etilgan ishlar.

Mavzuga bevosita aloqador bo‘lmagan yoki umumiy xarakterdagi ishlar.

2020-yilgacha nashr etilgan manbalar.

To‘liq matni mavjud bo‘lmagan yoki ishonchli ilmiy manba hisoblanmagan materiallar.

Takroriy nashrlar (dublikatlar).

Saralash jarayonidan so‘ng, yuqoridagi mezonlarga muvofiq 20 ta manba yakuniy tahlilga kiritildi [16, 17]. Ushbu tanlangan manbalar mazmunan chuqur tahlil qilinib, ekologik omillarning o‘simliklar hayotiga ta’siri bo‘yicha dolzarb ma’lumotlar sintez qilindi va tanqidiy baholandi.

TAHLIL VA NATIJALAR

Ushbu adabiyot sharhi doirasida ekologik omillarning o‘simliklar o‘sishi va rivojlanishiga ta’siri bo‘yicha so‘nggi tadqiqotlar tahlil qilindi. Tahlil natijalari shuni ko‘rsatadiki, abiotik omillar, xususan, yorug‘lik, harorat, suv va tuproqning fizik-kimyoviy xususiyatlari o‘simliklarning morfologik, fiziologik va genetik xususiyatlariga bevosita va murakkab ta’sir ko‘rsatadi [6, 10, 16].

Yorug‘lik omili, uning spektri, intensivligi va davomiyligi o‘simliklarning hayotiy jarayonlarini boshqaruvchi asosiy omillardan biridir. Yorug‘lik spektrining ta’siri bo‘yicha olib borilgan tadqiqotlar shuni ko‘rsatadiki, ko‘k yorug‘lik (400–500 nm) vegetativ o‘sishni, stomatalarning ochilishini, xloroplastlar rivojlanishini va fotosintez samaradorligini rag‘batlantiradi [1, 3]. Bu spektr, shuningdek, antioksidantlar ishlab chiqarish genlarini faollashtiradi [1]. Qizil yorug‘lik (620–750 nm) esa gullash va meva berishni boshqaruvchi fotoretseptorlarni faollashtiradi, birlamchi va ikkilamchi metabolitlar hosil bo‘lishini hamda himoya genlarini rag‘batlantiradi [1, 2, 4]. Optimal o‘sish uchun qizil va ko‘k nurning nisbati o‘simlik turi va uning rivojlanish bosqichiga qarab belgilanadi [2]. Yashil yorug‘lik (500–600 nm) yuqori miqdorda o‘simlik o‘sishini inhibe qilishi mumkin, ammo boshqa ranglar bilan birgalikda tabiiyroq spektr hosil qilishda qo‘llanilishi mumkin [2, 3]. Fotosintez jarayoni 600–680 nm (qizil) va ~435 nm (ko‘k) to‘lqin uzunliklarida eng yuqori bo‘ladi [4]. Emerson effekti qizil (710 nm) va ko‘k (650 nm) nurlarning birgalikdagi ta’sirida kislorod ajralishi alohida ta’sirdagiga nisbatan sezilarli darajada ortishini ko‘rsatgan [5]. Yorug‘lik intensivligi fotosintez tezligini belgilaydi; juda past intensivlik o‘simliklarning kuchsizlanishiga, biomassa va gul sifatining pasayishiga olib kelsa, haddan tashqari yuqori intensivlik fotoinhibitsiya, stomatalar ochilishini to‘xtatish va barglarning qarishini tezlashtiradi [1, 4]. Yorug‘sevar o‘simliklar uchun 10 000–40 000 lyuks, soyaga chidamli o‘simliklar uchun esa 1 000 lyuks yorug‘lik talab etiladi [5].

Yorug‘lik davomiyligi (fotoperiod) o‘simlik metabolizmi, sirkadiyalik ritmlar va rivojlanish fazalarini tartibga solib, gullash vaqtiga bevosita ta’sir qiladi [1, 3, 19].

Harorat o‘simliklarning metabolik tezligi va fermentativ faolligiga bevosita ta’sir ko‘rsatadi [8, 13]. Optimal harorat diapazonidan chetga chiqish, xususan, ekstremal issiqlik yoki sovuq, o‘simliklarda stressni keltirib chiqarib, ularning o‘sishi va rivojlanishini cheklaydi [8, 13].

Suv va tuproq omillari o‘simliklarning o‘sishi va rivojlanishida hal qiluvchi ahamiyatga ega. Tuproqning tarkibi, pH darajasi, ozuqa moddalari miqdori, mexanik tarkibi, aeratsiyasi va suv o‘tkazuvchanligi ildiz tizimi rivojlanishiga, nafas olishiga va ozuqa moddalarining harakatlanishiga ta’sir ko‘rsatadi [7]. Suv tanqisligi o‘simliklarning o‘sishini cheklab, fotosintez tezligini pasaytiradi va hujayra turgorini buzadi [9, 11]. Qurbonov (2021) tomonidan g‘o‘za o‘simligida o‘tkazilgan tadqiqotlar optimal tuproq namligining hosildorlikni oshirishini ko‘rsatgan [9, 14]. Tuproq sho‘rlanishi esa o‘simliklarning suv o‘zlashtirishini qiyinlashtirib, ion toksikligini keltirib chiqaradi, bu esa o‘sishni ingibitsiya qiladi va biomassa to‘planishini kamaytiradi [12, 14].

Quyidagi 1-jadvalda tahlil natijalari umumlashtirilgan.

Asosiy abiotik omillarning o'simliklar o'sishiga ta'siri

1-jadval

Omil	Asosiy ta'sir mexanizmi	Natija
Yorug'lik spektri	Fotosintez, gen ifodasi, fotoretseptorlar	Vegetativ o'sish, gullash, meva berish
Yorug'lik intensivligi	Fotosintez tezligi, stomatalar faoliyati	Biomassa to'planishi, gul sifati
Harorat	Metabolik tezlik, fermentativ faollik	O'sish sur'ati, stressga chidamlilik
Suv tanqisligi	Fotosintez pasayishi, turgor yo'qolishi	O'sish cheklanishi, hosildorlik pasayishi
Tuproq sho'rlanishi	Suv o'zlashtirish qiyinlashuvi, ion toksikligi	O'sish ingibitsiyasi, biomassa kamayishi
Tuproq pH	Ozuqa moddalari o'zlashtirilishi	Ildiz rivojlanishi, umumiy o'sish

Biotik omillar, jumladan, mikroorganizmlar, hasharotlar, patogenlar va boshqa o‘simliklar bilan o‘zaro munosabatlar ham o‘simliklar o‘sishi va rivojlanishiga sezilarli ta’sir ko‘rsatadi [6, 16]. Ushbu omillar o‘simliklarning ozuqa moddalarini o‘zlashtirish qobiliyatiga, himoya mexanizmlariga va raqobatbardoshligiga ta’sir etishi mumkin. Biroq, ushbu sharh doirasida mavjud adabiyotlarning asosiy e’tibori abiotik omillarga qaratilganligi sababli, biotik omillarning ta’siri umumiy tarzda qayd etiladi.

O‘simliklar ekologik stressga moslashish uchun turli molekulyar va fiziologik mexanizmlarni rivojlantirgan [17]. Bu moslashuvlar stress oqsillari (masalan, issiqlik shoki oqsillari) sintezi, antioksidant tizimlar faollashuvi, osmoregulyatsiya va ildiz tizimining morfologik o‘zgarishlarini o‘z ichiga oladi [17, 20]. Masalan, suv tanqisligi sharoitida o‘simliklar stomatalarni yopish, barg maydonini kamaytirish va ildizlarni chuqurlashtirish orqali suv yo‘qotilishini kamaytiradi [11]. Tuproq sho‘rlanishiga chidamli o‘simliklar tuzlarni vakuolalarda to‘plash yoki ularni barglar orqali chiqarib yuborish orqali ion toksikligini kamaytiradi [12]. Harorat stressida esa issiqlik shoki

oqsillari sintezi hujayra oqsillarini denaturatsiyadan himoya qilishga yordam beradi [8, 13]. Genetik moslashuvlar ham o‘simliklarning turli ekologik sharoitlarga, jumladan, turli tuproq turlari va iqlim sharoitlariga chidamliligini oshirishda muhim rol o‘ynaydi [10, 18]. Ushbu moslashish mexanizmlarini tushunish qishloq xo‘jaligida stressga chidamli o‘simlik navlarini yaratish va hosildorlikni oshirish uchun muhim asos bo‘lib xizmat qiladi.

MUHOKAMA

Ushbu tadqiqot ekologik omillarning o‘simliklar o‘sishi va rivojlanishiga ta’sirini tizimli tahlil qilib, ularning murakkab o‘zaro bog‘liqligini aniqladi. Natijalar shuni ko‘rsatadiki, abiotik omillar, xususan, yorug‘lik, harorat, suv va tuproqning fizik-kimyoviy xususiyatlari o‘simliklarning morfologik, fiziologik va genetik xususiyatlariga bevosita va ta’sir ko‘rsatadi [6, 10, 16]. Bu omillarning har biri o‘simlik hayot siklining turli bosqichlarida muhim rol o‘ynaydi.

Olingan xulosalar boshqa tadqiqotchilarning ishlari bilan hamohang bo‘lib, abiotik omillarning o‘simlik hayotidagi muhimligini tasdiqlaydi [16, 17]. Xususan, yorug‘lik spektrining (ko‘k yorug‘lik vegetativ o‘sishni, qizil yorug‘lik esa generativ rivojlanishni rag‘batlantirishi) o‘simliklar o‘sishiga ta’siri ko‘plab manbalarda izchil qayd etilgan [1, 2, 3, 4, 19]. Shuningdek, suv tanqisligi va tuproq sho‘rlanishining o‘simliklar o‘sishi va hosildorligiga salbiy ta’siri ham keng o‘rganilgan [9, 11, 12, 14]. Biroq, optimal sharoitlar o‘simlik turiga, rivojlanish bosqichiga va geografik joylashuviga qarab sezilarli darajada farq qilishi mumkin, bu esa tadqiqotlarda umumiy tamoyillar bilan birga o‘ziga xosliklarni ham hisobga olish zarurligini ko‘rsatadi [5, 18].

Bu murakkab o‘zaro ta’sirlar o‘simliklarning atrof-muhit signallarini qabul qilish va ularga javob berish uchun evolyutsion mexanizmlarga ega ekanligini ko‘rsatadi. O‘simliklar o‘z o‘sishi va yashab qolishini optimallashtirish uchun genetik va fiziologik darajada moslashadi. Yorug‘lik spektrining aniq tartibga solinishi kabi jarayonlar, o‘simlik rivojlanishini nozik sozlaydigan rivojlangan fotoretseptor tizimlaridan dalolat beradi [1, 2, 5]. Bu mexanizmlarni tushunish, global iqlim o‘zgarishlari sharoitida o‘simliklarning kelajakdagi javoblarini bashorat qilish uchun muhimdir.

Olingan bilimlar barqaror qishloq xo‘jaligini rivojlantirishda, ayniqsa, nazorat qilinadigan muhitda (masalan, issiqxonalar, vertikal fermalar) hosildorlik va mahsulot sifatini oshirish uchun yorug‘lik, harorat va suvni aniq boshqarishda ahamiyatga ega. Yorug‘lik rejimlarini optimallashtirish ekinlarning mahsuldorligini va ozuqaviy qiymatini oshirishi mumkin [1, 2, 3]. Bundan tashqari, o‘simliklarning stressga javob mexanizmlarini tushunish iqlim o‘zgarishlariga chidamli ekin navlarini yaratish va qurg‘oqchil hamda sho‘rlangan hududlarda suv va tuproqni boshqarish amaliyotini yaxshilash uchun kalit hisoblanadi [14, 17].

Ushbu adabiyot sharhining cheklovlari shundan iboratki, u asosan 2020-yildan keyingi davrni qamrab olgan bo‘lib, bu ba’zi tarixiy kontekstni cheklashi mumkin. Shuningdek, ko‘plab manbalar O‘zbekiston ilmiy jurnallaridan olinganligi sababli, global miqyosdagi ba’zi chuqur molekulyar yoki genetik tadqiqotlar kamroq yoritilgan

bo‘lishi mumkin. Biotik omillarning o‘simliklar o‘sishiga ta’siri ushbu sharhda abiotik omillar kabi keng qamrovli tahlil qilinmagan.

Kelajakdagi tadqiqotlar bir nechta stress omillarining (masalan, qurg‘oqchilik va sho‘rlanish, yuqori harorat va kuchli yorug‘lik) o‘simliklarga birgalikdagi ta’sirining molekulyar va genetik asoslarini o‘rganishga qaratilishi lozim [17]. Shuningdek, o‘zgaruvchan iqlim sharoitida foydali mikroorganizmlarning abiotik stressni yumshatishdagi rolini tadqiq qilish, kelajakdagi iqlim ssenariylari ostida o‘simliklar faoliyatini bashorat qilish uchun ilg‘or hisoblash modellarini ishlab chiqish va iqtisodiy ahamiyatga ega ekinlarda chidamlilikni oshirishga qaratilgan seleksiya dasturlariga e’tibor qaratish muhimdir.

XULOSA VA TAKLIFLAR

Ushbu adabiyot sharhi ekologik omillarning o‘simliklar o‘sishi va rivojlanishiga ta’sirini chuqur tahlil qildi. Yorug‘lik spektri, intensivligi va davomiyligi, harorat, suv ta’minoti va tuproq xususiyatlari o‘simliklarning morfologik, fiziologik va genetik jarayonlariga bevosita ta’sir etishi aniqlandi. Ko‘k yorug‘lik vegetativ o‘sishni, qizil yorug‘lik esa gullash va meva berishni rag‘batlantiradi. Optimal harorat metabolik faollikni ta’minlasa, suv va tuproqning to‘g‘ri boshqaruvi hosildorlikni oshiradi. Bu bilimlarning amaliy ahamiyati qishloq xo‘jaligida hosildorlikni oshirish, iqlim o‘zgarishlariga moslashish va resurslardan samarali foydalanishda yotadi. Kelajakda nazoratli muhitlarda o‘simlik o‘stirish texnologiyalarini takomillashtirish, stressga chidamli navlarni yaratish va aniq dehqonchilik usullarini joriy etish tavsiya etiladi. Molekulyar darajadagi tadqiqotlar o‘simliklarning moslashish mexanizmlarini yanada chuqurroq tushunishga yordam beradi.

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XORAZM VOHASI NO‘XAT AGROTSENOZIDA FITOFAG HASHAROTLARNING EKOLOGIK AHAMIYATI

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Annotatsiya. *Mazkur maqolada Xorazm vohasi sharoitida no‘xat (Cicer arietinum L.) agrotsenozida uchraydigan fitofag hasharotlarning ekologik ahamiyati, ularning o‘simlikning vegetativ va generativ organlariga ta’siri hamda agroekotizimdagi o‘rni tahlil qilingan. No‘xat yetishtirish jarayonida fitofag hasharotlar o‘simlik barglari, poyalari, gullari va dukkaklariga zarar yetkazib, hosildorlik va mahsulot sifatining pasayishiga sabab bo‘lishi mumkin. Ayniqsa, dukkak qurti (Helicoverpa armigera Hübner), shiralar (Aphididae), barg o‘rovchilar va barg minerlar kabi guruhlar iqtisodiy jihatdan muhim hisoblanadi. Adabiyotlar tahlili shuni ko‘rsatadiki, fitofag hasharotlarning zarari faqat hosilning kamayishi bilan cheklanmay, balki o‘simlik–hasharot va zararkunanda–entomofag munosabatlari orqali agrotsenozning ekologik muvozanatiga ham ta’sir ko‘rsatadi. Shuningdek, pestitsidlarni noo‘rin qo‘llash foydali entomofauna sonining kamayishi, zararkunandalarning rezistentligi va agroekotizimdagi biologik xilma-xillikning pasayishiga olib kelishi mumkin. Shu sababli Xorazm vohasi sharoitida fitofag hasharotlarni boshqarishda monitoring, agrotexnik tadbirlar, biologik kurash va zarurat bo‘lganda selektiv kimyoviy vositalarni uyg‘unlashtirgan integratsiyalashgan himoya tizimidan foydalanish maqsadga muvofiqdir.*

Kalit so‘zlar: *no‘xat, Cicer arietinum L., Xorazm vohasi, agrotsenoz, fitofag hasharotlar, Helicoverpa armigera, shiralar, entomofauna, ekologik ahamiyat, integratsiyalashgan himoya.*

Аннотация: *В данной статье анализируется экологическое значение фитофагов в агроценозе нута (Cicer arietinum L.) в Хорезмском оазисе, их воздействие на вегетативные и генеративные органы растения, а также их роль в агроэкосистеме. В процессе выращивания нута фитофаги могут повреждать листья, стебли, цветки и стручки растения, вызывая снижение урожайности и качества продукции. В частности, экономически значимыми являются такие группы, как бобовая гусеница (Helicoverpa armigera Hübner), тля (Aphididae), цикадки и минирующие мухи. Анализ литературы показывает, что ущерб, причиняемый фитофагами, не ограничивается снижением урожайности, но также влияет на экологический баланс агроценоза через взаимоотношения растение-насекомое и вредитель-энтомофаг. Кроме того, неправильное использование пестицидов может привести к сокращению численности полезной энтомофауны, повышению устойчивости вредителей и снижению биоразнообразия в агроэкосистеме. Поэтому в условиях Хорезмского оазиса целесообразно использовать комплексную систему защиты,*

сочетающую мониторинг, агротехнические меры, биологический контроль и, при необходимости, селективные химические средства в борьбе с фитофагами.

***Ключевые слова**: нут, Cicer arietinum L., Хорезмский оазис, агроценоз, фитофаги, Helicoverpa armigera, тля, энтомофауна, экологическое значение, комплексная. защита.*

***Abstract.** This article analyzes the ecological significance of phytophagous insects in the agrocenosis of chickpea (Cicer arietinum L.) in the Khorezm oasis, their impact on the vegetative and generative organs of the plant, and their role in the agroecosystem. In the process of chickpea cultivation, phytophagous insects can damage the leaves, stems, flowers, and pods of the plant, causing a decrease in yield and product quality. In particular, groups such as the legume caterpillar (Helicoverpa armigera Hübner), aphids (Aphididae), leafhoppers, and leaf miners are economically important. An analysis of the literature shows that the damage caused by phytophagous insects is not limited to a decrease in yield, but also affects the ecological balance of the agrocenosis through plant-insect and pest-entomophagous relationships. Also, inappropriate use of pesticides can lead to a decrease in the number of beneficial entomofauna, pest resistance and a decrease in biodiversity in the agroecosystem. Therefore, in the conditions of the Khorezm oasis, it is advisable to use an integrated protection system that combines monitoring, agrotechnical measures, biological control and, if necessary, selective chemical agents in the management of phytophagous insects.*

***Keywords:** chickpea, Cicer arietinum L., Khorezm oasis, agrocenosis, phytophagous insects, Helicoverpa armigera, aphids, entomofauna, ecological importance, integrated protection.*

KIRISH

No‘xat (Cicer arietinum L.) dukkakli ekinlar orasida muhim oziq-ovqat va yem-xashak ekinlaridan biri hisoblanadi. Ushbu ekinning biologik xususiyatlari, tarkibidagi oqsil miqdorining yuqoriligi va nisbatan qurg‘oqchil sharoitlarda yetishtirish imkoniyati uni qishloq xo‘jaligida istiqbolli ekinlardan biriga aylantiradi. Shu bilan birga, no‘xat agrotsenozining mahsuldorligiga turli ekologik omillar, jumladan, hasharotlar ta’sir ko‘rsatadi.

No‘xat (*Cicer arietinum* L.) dukkakli ekinlar orasida muhim oziq-ovqat va yem-xashak ekinlaridan biri hisoblanadi. Uning urug‘lari yuqori miqdorda oqsil, uglevodlar, mineral moddalar va boshqa oziqaviy komponentlarni saqlashi bilan inson oziqlanishida muhim ahamiyatga ega. No‘xatning qurg‘oqchilikka nisbatan chidamliligi uni qurg‘oqchil va yarim qurg‘oqchil hududlarda yetishtirish uchun istiqbolli ekinlardan biriga aylantiradi. O‘zbekistonda ham no‘xat asosan arid va tog‘oldi hududlarida yetishtirilishi qayd etilgan.

Xorazm vohasi keskin kontinental iqlimga ega bo‘lib, yoz faslining issiq va quruq kelishi, yog‘ingarchilikning nisbatan kamligi hamda qishloq xo‘jaligi ekinlarining sug‘orishga yuqori darajada bog‘liqligi bilan ajralib turadi. Bunday agroekologik sharoit o‘simliklarning o‘sishi va rivojlanishi bilan bir qatorda, fitofag hasharotlarning rivojlanishi, tarqalishi va mavsumiy dinamikasiga ham ta’sir ko‘rsatadi.

No‘xat agrotsenozining mahsuldorligi ko‘plab biotik va abiotik omillarga bog‘liq. Ular orasida hasharotlar alohida o‘rin egallaydi. Fitofag hasharotlar o‘simlikning bargi, poyasi, ildizi, guli, dukkagi va urug‘i bilan oziqlanib, fotosintez jarayonining buzilishi, vegetativ biomassaning kamayishi, reproduktiv organlarning zararlanishi va hosilning pasayishiga olib kelishi mumkin.

Dukkakli ekinlarda uchraydigan fitofaglar orasida *Helicoverpa armigera* — no‘xat dukkak qurti alohida iqtisodiy ahamiyatga ega. Ushbu polifag zararkunanda no‘xatning ayniqsa gullash va dukkak hosil qilish davrida katta zarar yetkazadi. Zamonaviy adabiyotlarda *H. armigera* no‘xat hosildorligini cheklovchi asosiy hasharotlardan biri sifatida qayd etiladi.

Bundan tashqari, no‘xat agrotsenozida *Aphis craccivora*, *Spodoptera* spp., *Autographa nigrisigna*, *Agrotis ipsilon* va barg minerlar ham uchrashi mumkin. Masalan, 2025-yilda Hindistonda olib borilgan tadqiqotda no‘xat agrotsenozida 11 tur hasharot qayd etilib, *H. armigera*, *Spodoptera exigua*, *A. nigrisigna* va *A. craccivora*ning mavsumiy dinamikasi o‘rganilgan.

Fitofag hasharotlarning ekologik ahamiyatini faqat ularning o‘simlikka yetkazadigan zarari bilan cheklash to‘g‘ri emas. Ular agroekotizimdagi oziq zanjirining muhim bo‘g‘ini bo‘lib, yirtqich va parazitoid organizmlar uchun ozuqa vazifasini bajaradi. Masalan, *H. armigera* lichinkalari bilan *Campoletis chlorideae* kabi parazitoidlar oziqlanadi yoki parazitlik qiladi. Ayrim tadqiqotlarda ushbu parazitoidning *H. armigera*ga parazitlik darajasi sezilarli bo‘lishi qayd etilgan.

Shu sababli no‘xat agrotsenozida fitofaglarni boshqarishda ularni butunlay yo‘q qilish emas, balki populyatsiyasini iqtisodiy zarar chegarasidan past darajada ushlab turish va tabiiy biologik nazorat mexanizmlarini saqlash muhimdir.

Tadqiqotning maqsadi

Xorazm vohasi no‘xat agrotsenozida fitofag hasharotlarning ekologik va xo‘jalik ahamiyatini ilmiy adabiyotlar asosida tahlil qilish hamda ularni ekologik xavfsiz boshqarish bo‘yicha tavsiyalar ishlab chiqish.

Tadqiqot vazifalari

- no‘xat agrotsenozining asosiy fitofaglarini tavsiflash;
- ularning o‘simlik rivojlanish bosqichlari bo‘yicha ahamiyatini aniqlash;
- fitofaglar va tabiiy kushandalar o‘rtasidagi ekologik munosabatlarni tahlil qilish;
- meteorologik omillarning hasharotlar populyatsiyasiga ta’sirini baholash;
- Xorazm vohasi sharoitida integratsiyalashgan himoya tizimini taklif etish.

ADABIYOTLARNING TAHLILI

So‘nggi tadqiqotlar no‘xat agrotsenozida hasharotlarning tur tarkibi va mavsumiy dinamikasi hududning agroiqlimiy sharoiti, ekish muddati, nav xususiyatlari va agrotexnika tizimiga bog‘liqligini ko‘rsatmoqda.

Patil va hammualliflar tomonidan olib borilgan tadqiqotda *H. armigera* no‘xatning eng muhim zararkunandalaridan biri sifatida baholanib, unga qarshi chidamli navlar, agrotexnik usullar, biologik nazorat va zaruratda kimyoviy vositalarni uyg‘unlashtirish tavsiya etilgan. Mualliflar integratsiyalashgan himoya tizimi ekologik jihatdan barqaror yondashuv ekanligini ta’kidlagan.

*H. armigera*ning asosiy zarari uning lichinkalari tomonidan gullar va dukkaklarning zararlanishi bilan bog‘liq. 2023-yilda Marokashda o‘tkazilgan tadqiqotda ushbu zararkunanda no‘xatning eng destruktiv hasharotlaridan biri sifatida baholangan va biologik hamda nisbatan xavfsiz insektitsidlar yordamida boshqarish imkoniyatlari o‘rganilgan.

2025-yilgi tadqiqotda no‘xat agrotsenozida 11 tur hasharot qayd etilgan. *H. armigera*ning populyatsiyasi rivojlanish davrida bir necha marta yuqori ko‘rsatkichga yetgan va dukkaklarning zararlanishi ayrim navlarda 39,32–41,44 % ni tashkil qilgan. Harorat va quyoshli vaqt davomiyligi ayrim zararkunandalar populyatsiyasi bilan ijobiy bog‘liqlik ko‘rsatgan.

No‘xat agrotsenozidagi hasharotlar xilma-xilligi bo‘yicha 2025-yilgi boshqa tadqiqotda yetti tur hasharot aniqlangan bo‘lib, ular orasida zararkunandalar bilan bir qatorda yirtqichlar va parazitoidlar ham mavjudligi ko‘rsatilgan. *H. armigera* asosiy zararkunanda sifatida, *Agrotis ipsilon* esa nisbatan kichik ahamiyatga ega zararkunanda sifatida baholangan.

Barg miner — *Liriomyza cicerina* ham no‘xatning muhim zararkunandalaridan hisoblanadi. 2013-yilda Marokashda olib borilgan tadqiqotda barg mineridan kelib chiqadigan hosil yo‘qotishlari qishki ekishda o‘rtacha 20 %, bahorgi ekishda esa 42 % gacha yetgani aniqlangan. Bu natija ekish muddatini optimallashtirish zararkunandalarni boshqarishning muhim agrotexnik vositasi ekanligini ko‘rsatadi.

Fitofaglarning ekologik ahamiyatini baholashda ularning tabiiy kushandalari ham muhim hisoblanadi. No‘xat agrotsenozlarida xonqizi qo‘ng‘izlari, parazitoid arilar va boshqa yirtqich organizmlar fitofaglar populyatsiyasini tabiiy ravishda cheklashi mumkin. 2025-yilgi tadqiqotlarda *Coccinella septempunctata* kabi yirtqichlarning no‘xat agrotsenozida fitofaglar bilan birga uchrashi qayd etilgan.

2025-yilda chop etilgan sharhda *H. armigera*ga qarshi integratsiyalashgan kurashda monitoring, agrotexnik tadbirlar, biologik vositalar va zarur hollarda selektiv insektitsidlardan foydalanish muhimligi qayd etilgan.

O‘zbekiston sharoitida ham no‘xatda zararkunandalarning mavjudligi qayd etilgan. Arid hududlarda no‘xatga zarar yetkazuvchi ko‘plab hasharotlar mavjudligi, ular orasida to‘g‘riqanotlilar va boshqa fitofaglar muhim o‘rin tutishi haqida ma’lumotlar keltirilgan. Shuningdek, *H. armigera* O‘zbekiston hududida mavjud zararkunanda sifatida xalqaro fitosanitar ma’lumotlar bazalarida qayd etilgan.

Adabiyotlar tahlili no‘xat agrotsenozidagi fitofag hasharotlarning ikki tomonlama ekologik ahamiyatga ega ekanligini ko‘rsatadi: ular bir tomondan hosilni kamaytiruvchi biotik omil bo‘lsa, ikkinchi tomondan agroekotizimdagi yirtqich va parazitoid organizmlar uchun oziqa bazasini tashkil etadi.

TADQIQOT METODOLOGIYASI

Tadqiqot **adabiyotlar tahlili, qiyosiy tahlil va ekologik sintez** usullari asosida olib borildi. Tahlil uchun 2013–2026-yillarda nashr etilgan ilmiy maqolalar, sharhlar va ilmiy-texnik materiallardan foydalanildi.

Adabiyotlarni tanlashda quyidagi mezonlarga amal qilindi:

1. tadqiqot obyekti no‘xat (*Cicer arietinum* L.) bo‘lishi;
2. fitofag hasharotlar yoki ularning tabiiy kushandalari o‘rganilgan bo‘lishi;

3. zararkunandalarning biologiyasi, ekologiyasi, mavsumiy dinamikasi yoki boshqaruviga oid ma’lumotlar mavjudligi;
4. manba 2013–2026-yillarda nashr etilgan bo‘lishi.

Xorazm vohasi sharoitida kelgusida dala tadqiqotlarini tashkil qilish uchun **10–20 ta kuzatuv nuqtasi** tanlash, har bir nuqtada o‘simliklarning rivojlanish bosqichlari bo‘yicha muntazam entomologik kuzatuvlar olib borish tavsiya etiladi.

Har bir kuzatuvda:

- 20–25 ta o‘simlik tekshiriladi;
- fitofaglarning turi va soni qayd etiladi;
- zararlangan barglar soni aniqlanadi;
- zararlangan gullar va dukkaklar hisoblanadi;
- tabiiy kushandalar soni qayd qilinadi;
- havo harorati, nisbiy namlik va boshqa meteorologik ko‘rsatkichlar yozib boriladi.

Ilmiy manbalarni tahlil qilish shuni ko‘rsatadiki, no‘xat bilan bog‘liq hasharotlar tarkibi ancha xilma-xildir. Ularning ayrimlari o‘simlikning barg va poyalaridan oziqlansa, boshqalari gul, dukkak yoki urug‘larni zararlaydi. Shu sababli fitofaglarning o‘simlik bilan oziqlanish xarakteri ularning ekologik ahamiyatini baholashda asosiy mezonlardan biri hisoblanadi. O‘zbekistonda no‘xat agrotsenozining entomofaunasini o‘rganishga bag‘ishlangan tadqiqotlarda fitofag hasharotlarning turli sistematik va ekologik guruhlari qayd etilgan. Jumladan, Shimoliy Farg‘ona sharoitida olib borilgan maxsus tadqiqotda no‘xat agrotsenozida ko‘plab fitofag turlar mavjudligi aniqlangan va ularning oziqlanish ixtisoslashuvi hamda o‘simlik bilan munosabatlari tahlil qilingan. Bu ma’lumotlar no‘xat agrotsenozining hasharotlar bilan bog‘liq ekologik jarayonlarini o‘rganish uchun muhim ilmiy asos bo‘lib xizmat qiladi.

Adabiyotlarda no‘xatning asosiy fitofaglari qatorida shiralar, barg minyorlari, uzunburun qo‘ng‘izlar, tunlamlar va donxo‘r qo‘ng‘izlar ko‘p uchraydigan guruhlar sifatida qayd etiladi. Masalan, Acyrthosiphon pisum kabi shiralar o‘simlikning o‘tkazuvchi to‘qimalaridan oziqlanib, uning oziqa moddalari almashinuviga salbiy ta’sir qilishi mumkin. Ayrim so‘ruvchi fitofaglarning ko‘payishi natijasida o‘simlikning vegetativ rivojlanishi susayadi. No‘xat barg minyori (Liriomyza cicerina) ham ushbu ekin bilan bog‘liq muhim fitofaglardan biridir. Uning lichinkalari barg to‘qimalari orasida oziqlanib, o‘ziga xos mina yo‘llarini hosil qiladi. Bunday zararlanish bargning fotosintetik faoliyatini kamaytirishi va kuchli zararlangan holatlarda o‘simlikning umumiy fiziologik holatiga salbiy ta’sir ko‘rsatishi mumkin.

Dukkak va urug‘larni zararlovchi hasharotlar no‘xat yetishtirishda alohida ahamiyatga ega. Helicoverpa armigera kabi tunlamlarning lichinkalari o‘simlikning generativ organlariga zarar yetkazishi mumkin. Callosobruchus avlodiga mansub donxo‘rlar esa urug‘lar bilan bog‘liq holda rivojlanib, mahsulot sifatining pasayishiga sabab bo‘lishi mumkin. Shu sababli fitofaglarni o‘simlikning qaysi rivojlanish bosqichida faollashishiga ko‘ra baholash ham muhim hisoblanadi. Fitofaglarning ekologik ahamiyatini faqat ularning zararkunandalik xususiyati bilan

cheklab bo‘lmaydi. Agroekotizimda ular boshqa organizmlar bilan murakkab trofik aloqalarga kirishadi. Xususan, ko‘plab fitofaglar yirtqich va parazit entomofaglar uchun oziqa manbai vazifasini bajaradi. Demak, agrotsenozdagi fitofaglar sonining o‘zgarishi butun oziqa zanjirining holatiga ta’sir qilishi mumkin.

Xorazm vohasi sharoitida ushbu masala yanada muhim ahamiyat kasb etadi. Hududning issiq, quruq iqlimi, sug‘oriladigan dehqonchilik tizimi va agrotsenozlarning o‘ziga xosligi hasharotlarning rivojlanishi uchun alohida ekologik sharoit yaratadi. Xorazm vohasining boshqa qishloq xo‘jaligi agrotsenozlarida o‘tkazilgan tadqiqotlarda ham fitofag hasharotlarning turli guruhlari qayd etilgani hudud entomofaunasining xilma-xilligini ko‘rsatadi.

Shu nuqtayi nazardan, Xorazm vohasi no‘xat agrotsenozida fitofag hasharotlarning ekologik xususiyatlarini adabiyotlar asosida o‘rganish kelgusidagi entomologik tadqiqotlar uchun nazariy asos yaratadi. Ayniqsa, fitofaglarning tur tarkibi, oziqa ixtisoslashuvi, mavsumiy faolligi va no‘xat o‘simligining rivojlanish bosqichlari bilan bog‘liqligini aniqlash ilmiy va amaliy jihatdan muhimdir.

TAHLIL VA NATIJALAR

Adabiyotlar tahlili asosida Xorazm vohasida no‘xat yetishtirishda quyidagi fitofag guruhlarini monitoring qilish eng muhim hisoblanadi.

Fitofag	Asosiy zararlaydigan organ	Ekologik ahamiyati
Helicoverpa armigera	Gul, dukkak, urug‘	Asosiy generativ zararkunanda
Aphis craccivora	Barg, yosh novdalar	Shira so‘rishi, o‘sishni susaytirishi
Liriomyza cicerina	Barg	Barg mezofillini zararlashi
***Spodoptera* spp.**	Barg va yosh organlar	Vegetativ biomassani kamaytirishi
Agrotis ipsilon	Nihol, poya bo‘yni	Yosh o‘simliklarga zarar yetkazishi
Boshqa fitofaglar	Barg, poya, urug‘	Mahalliy sharoitga qarab ikkilamchi zarar

O‘zbekistonning arid hududlarida no‘xat ekinlariga turli guruhlarga mansub zararkunandalar zarar yetkazishi qayd etilgan.

Xorazm vohasining issiq va quruq sharoitida ayniqsa generativ organlarni zararlaydigan turlarni monitoring qilish muhim. Bunda *H. armigera* asosiy nazorat obyekti sifatida qaralishi lozim.

H. armigera polifag zararkunanda bo‘lib, ko‘plab qishloq xo‘jaligi ekinlarida uchraydi. No‘xatda lichinkalari dastlab barglar bilan, keyinchalik esa gullar va dukkaklar bilan oziqlanadi.

Zararkunandaning eng katta iqtisodiy zarari dukkak hosil bo‘lish davrida kuzatiladi. 2025-yilgi tadqiqotda *H. armigera* zarari natijasida ayrim no‘xat navlarida dukkaklarning 39,32–41,44 % gacha zararlanishi qayd etilgan.

Bunday zarar o‘simlikning fotosintetik faoliyatini emas, bevosita urug‘ hosilini kamaytirishi sababli iqtisodiy jihatdan ayniqsa muhimdir.

2023-yilgi tadqiqotlarda *H. armigera*ga qarshi ayrim selektiv insektitsidlar qo‘llanganda lichinkalar soni va dukkak zararlanishi kamaygani ko‘rsatilgan. Biroq kimyoviy kurashni muntazam va nazoratsiz olib borish zararkunandalarda rezistentlik shakllanishi hamda foydali entomofaunaga salbiy ta’sir xavfini oshiradi.

Shiralar no‘xatning barglari va yosh novdalaridan o‘simlik shirasi bilan oziqlanadi. Natijada o‘simlikning o‘sishi sekinlashishi, barglarning deformatsiyasi va fotosintetik faollikning pasayishi mumkin.

2025-yilgi tadqiqotda *A. craccivora* no‘xat agrotsenozida qayd etilgan asosiy hasharotlardan biri bo‘lib, uning populyatsiyasi vegetatsiya davomida o‘zgarib turgan.

Shiralar ekologik jihatdan ham muhim, chunki ular xonqizi qo‘ng‘izlari va boshqa yirtqich hasharotlar uchun oziqa manbai hisoblanadi. Shu sababli shiralarga qarshi keng ta’sirli insektitsidlarni profilaktik qo‘llash tabiiy biologik nazoratni buzishi mumkin.

XULOSA VA TAKLIFLAR

Ilmiy adabiyotlar tahlili no‘xat agrotsenozida fitofag hasharotlar xilma-xil ekologik guruhlarni tashkil etishini ko‘rsatadi. Ular o‘simlikning vegetativ va generativ organlaridan oziqlanishi orqali no‘xatning o‘sishi va hosildorligiga ta’sir qilishi mumkin. Shu bilan birga, fitofaglar agroekotizimdagi tabiiy oziqa zanjirining tarkibiy qismi sifatida ham muhim ekologik vazifani bajaradi. Xorazm vohasining o‘ziga xos tabiiy-iqlim sharoitlarini hisobga olgan holda, ushbu hududda no‘xat agrotsenozining fitofag entomofaunasini alohida o‘rganish dolzarb hisoblanadi. Mavjud adabiyotlarni umumlashtirish kelgusida hududga xos dominant fitofaglarni aniqlash va ularning sonini ekologik jihatdan boshqarishga qaratilgan tadqiqotlar uchun asos bo‘la oladi.

Olib borilgan adabiyotlar tahlili natijasida quyidagi xulosalarga kelindi.

1. **Fitofag hasharotlar no‘xat agrotsenozining muhim ekologik komponentidir.** Ular bir tomondan o‘simlikning vegetativ va generativ organlarini zararlab, hosildorlikka salbiy ta’sir ko‘rsatadi, ikkinchi tomondan esa tabiiy kushandalar uchun oziqa bazasini yaratadi.
2. **Xorazm vohasi sharoitida *Helicoverpa armigera* asosiy monitoring obyektlaridan biri bo‘lishi kerak.** Ayniqsa gullash va dukkak hosil qilish davrlarida ushbu zararkunanda sonini muntazam kuzatish zarur.
3. *Aphis craccivora*, *Liriomyza cicerina*, *Spodoptera* spp. va *Agrotis* spp. kabi fitofaglar ham no‘xat agrotsenozining fitosanitar holatini baholashda hisobga olinishi lozim.
4. Fitofaglarning mavsumiy dinamikasi **harorat, nisbiy namlik, quyoshli vaqt, ekish muddati va o‘simlik fenologiyasi** bilan bog‘liq. Shuning uchun Xorazm sharoitida entomologik monitoringni meteorologik kuzatuvlar bilan birlashtirish zarur.
5. Tabiiy kushandalar — yirtqichlar va parazitoidlar — fitofaglar populyatsiyasini tabiiy ravishda cheklovchi muhim ekologik omil hisoblanadi. Ularni saqlash integratsiyalashgan himoya tizimining asosiy elementlaridan biri bo‘lishi kerak.
6. Keng ta’sir doirasiga ega insektitsidlarni profilaktik va takroriy qo‘llash ekologik muvozanatga salbiy ta’sir ko‘rsatishi mumkin. Shu sababli kimyoviy

himoya **monitoring va iqtisodiy zarar chegarasi asosida** amalga oshirilishi lozim.

AMALIY TAKLIFLAR

1.Xorazm vohasi no‘xat dalalarida kamida **3–5 yillik entomologik monitoring** tashkil etish;

2. *H. armigera*, *A. craccivora* va *L. cicerina*ning mavsumiy rivojlanish kalendarini ishlab chiqish;
3. zararkunandalar soni bilan harorat, namlik va sug‘orish rejimi o‘rtasidagi korrelyatsiyani aniqlash;
4. no‘xat navlarining fitofaglarga chidamliligini solishtirish;
5. tabiiy kushandalar, xususan parazitoidlar va yirtqich hasharotlarning sonini alohida hisobga olish;
6. Xorazm sharoitiga mos **iqtisodiy zarar chegaralarini** ishlab chiqish;
7. biologik himoya vositalari va selektiv preparatlarni integratsiyalashgan holda qo‘llash.

Xorazm vohasi no‘xat agrotsenozida fitofag hasharotlarni boshqarishning eng maqbul strategiyasi ularni to‘liq yo‘q qilishga emas, balki populyatsiyasini ekologik va iqtisodiy jihatdan maqbul darajada saqlash, tabiiy kushandalarni asrash va zararkunandalarning iqtisodiy zarar chegarasidan oshib ketishining oldini olishga qaratilishi kerak.

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TOSHKENT VILOYATI SHAROITIDA KARP (CYPRINUS CARPIO L., 1758) BALIG'INING REPRODUKTIV XUSUSIYATI SHAKLLANISHINING EKOLOGIK-FIZIOLOGIK ASOSLARI

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Annotatsiya: *Mazkur tadqiqot Toshkent viloyati sharoitida karp (Cyprinus carpio L., 1758) balig'ining reproduktiv xususiyatlari shakllanishiga ta'sir etuvchi ekologik va fiziologik omillarni o'rganishga bag'ishlangan. Tadqiqotlar MCHJ "Khoorrot Fish House", FX "ZafarAsad" hamda MCHJ "Imkon Baliq Fayz" baliqchilik xo'jaliklarida olib borildi. Har bir xo'jalikdan 35 tadan, jami 105 dona jinsiy yetilgan karp baliqlari tanlab olinib, ularning biologik, morfometrik va fiziologik ko'rsatkichlari baholandi.Tadqiqot davomida tana massasi, uzunligi, gonadosomatik indeks, gepatosomatik indeks, mutlaq va nisbiy serpushtlik, shuningdek, ayrim gematologik va biokimyoviy ko'rsatkichlar tahlil qilindi. Natijalar suv muhiti, oziqlantirish sharoiti va parvarish texnologiyasi karp baliqlarining reproduktiv rivojlanishi hamda fiziologik holatiga sezilarli ta'sir ko'rsatishini aniqladi. Olingan ma'lumotlar Toshkent viloyati baliqchilik xo'jaliklarida naslli baliqlarni tanlash, reproduktiv samaradorlikni oshirish va sun'iy ko'paytirish texnologiyalarini takomillashtirish uchun ilmiy asos bo'lib xizmat qiladi.*

Kalit so'zlar: *karp, reproduksiya, ekologiya, fiziologiya, serpushtlik, gonadosomatik indeks, baliqchilik, Toshkent viloyati.*

Аннотация: *Настоящее исследование посвящено изучению экологических и физиологических факторов, влияющих на формирование репродуктивных особенностей карпа (*Cyprinus carpio *L., 1758) в условиях Ташкентской области. Исследования проводились в рыбоводческих хозяйствах MCHJ «Khoorrot Fish House», фермерском хозяйстве «ZafarAsad» и MCHJ «Imkon Baliq Fayz». В каждом хозяйстве было отобрано по 35 половозрелых особей карпа, всего 105 рыб, у которых были изучены биологические, морфометрические и физиологические показатели.*

В ходе исследования были проанализированы масса и длина тела, гонадосоматический индекс, гепатосоматический индекс, абсолютная и относительная плодовитость, а также отдельные гематологические и биохимические показатели. Полученные результаты показали, что условия водной среды, уровень кормления и технология выращивания оказывают существенное влияние на репродуктивное развитие и физиологическое состояние карпа. Полученные данные могут служить научной основой для отбора производителей, повышения репродуктивной эффективности и совершенствования технологий искусственного воспроизводства карпа в рыбоводческих хозяйствах Ташкентской области.

Ключевые слова: *карп,* Cyprinus carpio*, репродукция, экология, физиология, плодовитость, гонадосоматический индекс, рыбоводство, Ташкентская область.*

Abstract: *This study investigates the ecological and physiological factors influencing the formation of reproductive characteristics of common carp (*Cyprinus carpio *L., 1758) under the conditions of the Tashkent region. The research was conducted at the fish farming enterprises LLC "Khoorrot Fish House", Farm Enterprise "ZafarAsad", and LLC "Imkon Baliq Fayz". A total of 105 sexually mature common carp were examined, with 35 fish randomly selected from each farm. Their biological, morphometric, and physiological parameters were comprehensively evaluated.*

The study analyzed body weight, total body length, gonadosomatic index (GSI), hepatosomatic index (HSI), absolute and relative fecundity, as well as selected hematological and biochemical parameters. The results demonstrated that water quality, feeding conditions, and aquaculture management practices significantly influence the reproductive development and physiological status of common carp. The obtained findings provide a scientific basis for the selection of broodstock, improvement of reproductive performance, and optimization of artificial breeding technologies in fish farming enterprises of the Tashkent region.

Keywords: *common carp,* Cyprinus carpio*, reproduction, ecology, physiology, fecundity, gonadosomatic index, aquaculture, Tashkent region.*

KIRISH

XXI asrda dunyo aholisining jadal sur'atlarda o'sib borishi, oziq-ovqat xavfsizligini ta'minlash va hayvon oqsiliga bo'lgan ehtiyojning ortishi akvakultura tarmog'ining jadal rivojlanishini taqozo etmoqda. Birlashgan Millatlar Tashkilotining Oziq-ovqat va qishloq xo'jaligi tashkiloti (FAO) ma'lumotlariga ko'ra, so'nggi o'n yilliklarda akvakultura oziq-ovqat ishlab chiqarishning eng tez rivojlanayotgan yo'nalishlaridan biriga aylandi va dunyoda iste'mol qilinayotgan baliq mahsulotlarining yarmidan ortig'i sun'iy yetishtirish hisobiga to'g'ri kelmoqda. Shu bois baliqchilikda yuqori mahsuldor, ekologik sharoitga moslashuvchan va reproduktiv salohiyati yuqori bo'lgan baliq turlarini ko'paytirish dolzarb ilmiy-amaliy vazifalardan biri hisoblanadi.

O'zbekiston Respublikasida ham baliqchilik tarmog'ini rivojlantirish, ichki bozorda sifatli baliq mahsulotlari ulushini oshirish hamda eksport salohiyatini kengaytirishga qaratilgan izchil islohotlar amalga oshirilmoqda. Mamlakatda intensiv va yarim intensiv akvakultura texnologiyalarini joriy etish, baliqchilik xo'jaliklarini zamonaviy uskunalar bilan ta'minlash, yuqori mahsuldor naslli baliqlarni ko'paytirish va seleksiya ishlarini takomillashtirish davlat siyosatining ustuvor yo'nalishlaridan biri etib belgilangan. Shu bilan birga, ishlab chiqarish samaradorligini cheklovchi omillar, xususan ona gala baliqlarining reproduktiv salohiyatidan to'liq foydalanilmayotgani, ekologik omillarning ta'siri hamda fiziologik jarayonlarning hududiy xususiyatlari yetarli darajada o'rganilmaganligi ilmiy izlanishlarni yanada chuqurlashtirishni talab etadi. Karp (*Cyprinus carpio* L., 1758) dunyo akvakulturasida iqtisodiy jihatdan eng muhim chuchuk suv baliqlaridan biri hisoblanadi. Mazkur tur tez o'sishi, turli ekologik sharoitlarga yuqori moslashuvchanligi, sun'iy ko'paytirishga qulayligi va yuqori

xo'jalik ahamiyati bilan ajralib turadi. Respublikamiz baliqchilik xo'jaliklarida ham karp asosiy xo'jalik ahamiyatiga ega turlardan biri bo'lib, ko'plab hovuz xo'jaliklarida polikultura tizimining asosiy komponenti sifatida yetishtiriladi. Biroq karpning reproduktiv biologiyasi, ayniqsa Toshkent viloyatining tabiiy-iqlim sharoitida ekologik va fiziologik omillar ta'sirida shakllanish qonuniyatlari hali to'liq o'rganilmagan. Baliqlarning reproduktiv tizimi organizmning eng murakkab biologik tizimlaridan biri bo'lib, uning shakllanishi irsiy omillar bilan bir qatorda tashqi muhit ta'siriga ham bog'liqdir. Suv harorati, erigan kislorod miqdori, gidrokimyoviy ko'rsatkichlar, oziqlanish sifati, saqlash zichligi, yorug'lik rejimi va boshqa ekologik omillar gonadalar rivojlanishi, gametogenez, jinsiy yetilish hamda serpushtlik darajasiga bevosita ta'sir ko'rsatadi. Ushbu omillarning o'zgarishi baliqlarning fiziologik holatida aks etib, reproduktiv samaradorlikning pasayishi yoki ortishiga sabab bo'ladi. Shu sababli reproduktiv biologiyani ekologik-fiziologik nuqtayi nazardan kompleks o'rganish zamonaviy akvakulturaning muhim ilmiy yo'nalishlaridan biri hisoblanadi. So'nggi yillarda dunyo olimlari tomonidan baliqlar reproduktiv tizimini molekulyar biologiya, fiziologiya, endokrinologiya va ekologiya nuqtayi nazaridan chuqur o'rganishga qaratilgan ko'plab tadqiqotlar amalga oshirilgan. Tadqiqotlar natijasida gipotalamus–gipofiz–gonada tizimi faoliyati, gonadosomatik indeks, steroid gormonlar sintezi, vitellogenez jarayonlari hamda tashqi muhit omillarining gametogenezga ta'siri haqida muhim ilmiy ma'lumotlar olingan. Biroq bu natijalarning aksariyati mo"tadil yoki nam iqlim mintaqalarida olib borilgan bo'lib, Markaziy Osiyoning keskin kontinental iqlim sharoitida yashovchi karp populyatsiyalariga to'liq tatbiq etib bo'lmaydi. Ayniqsa, yoz oylarida suv haroratining yuqori bo'lishi, suv sathining mavsumiy o'zgarishi va gidrokimyoviy ko'rsatkichlarning dinamikasi karp reproduktiv biologiyasiga o'ziga xos ta'sir ko'rsatishi mumkin.

Toshkent viloyati O'zbekistonning baliqchilik rivojlangan hududlaridan biri hisoblanadi. Viloyatda intensiv va yarim intensiv usulda faoliyat yuritayotgan ko'plab baliqchilik xo'jaliklari mavjud bo'lib, ularda karp baliqlarini sun'iy ko'paytirish va yetishtirish yo'lga qo'yilgan. Shunga qaramay, ushbu xo'jaliklarda ona gala baliqlarining biologik va fiziologik holati, reproduktiv ko'rsatkichlari hamda ekologik omillarning ularning jinsiy yetilishiga ta'siri bo'yicha tizimli ilmiy tadqiqotlar yetarli emas. Natijada reproduktiv salohiyatni oshirish bo'yicha ilmiy asoslangan tavsiyalar ishlab chiqish zarurati yuzaga kelmoqda.

Mazkur tadqiqotning ilmiy yangiligi shundan iboratki, Toshkent viloyati sharoitida faoliyat yuritayotgan uchta yirik baliqchilik xo'jaligida karp baliqlarining reproduktiv xususiyatlari ilk bor ekologik va fiziologik ko'rsatkichlar bilan kompleks bog'liq holda baholandi. Olingan natijalar hudud sharoitida reproduktiv samaradorlikni belgilovchi asosiy ekologik omillarni aniqlash, ona gala baliqlarini tanlash mezonlarini takomillashtirish hamda sun'iy ko'paytirish texnologiyalarini optimallashtirish imkonini beradi. Tadqiqot natijalari nafaqat Toshkent viloyati, balki O'zbekistonning boshqa baliqchilik xo'jaliklari uchun ham ilmiy-amaliy ahamiyatga ega. Ular naslchilik ishlarini samarali tashkil etish, ekologik monitoringni takomillashtirish, reproduktiv samaradorlikni oshirish va baliq mahsuldorligini ko'paytirishga xizmat qiladi. Shuningdek, mazkur tadqiqot natijalari karp baliqlarining ekologik-fiziologik

moslanish mexanizmlarini chuqurroq tushunishga hamda respublikada akvakultura sohasining barqaror rivojlanishiga ilmiy hissa qo'shadi.

MATERIAL VA USULLAR

Toshkent viloyatida faoliyat yurituvchi MCHJ **“Khoorrot Fish House”**, fermer xo‘jaligi **“ZafarAsad”** hamda MCHJ **“Imkon Baliq Fayz”** baliqchilik xo‘jaliklarida yetishtirilayotgan karp (*Cyprinus carpio L., 1758*) baliqlari ustida olib borildi. Toshkent viloyati sharoitida karp balig‘ining reproduktiv xususiyatlari shakllanishiga ta’sir etuvchi ekologik va fiziologik omillarni aniqlash hamda xo‘jaliklar kesimida biologik ko‘rsatkichlarning o‘zgarish qonuniyatlarini baholashdan iborat bo‘ldi va xo‘jaliklarda sun’iy sharoitda yetishtirilayotgan jinsiy yetilgan karp baliqlari tanlab olindi. Har bir xo’jalikdan tajriba uchun olingan **karp** (*Cyprinus carpio L., 1758*) **baliqlaridan** biologik va fiziologik tahlillar uchun olindi. Namuna olish jarayonida baliqlarning yoshi, jinsiy yetuklik darajasi, tana o‘lchamlari va umumiy fiziologik holati hisobga olindi. Baliqlarni tanlashda reproduktiv davrga yaqin yoki reproduktiv faol bosqichdagi individlarga ustuvor ahamiyat berildi.

Karp (*Cyprinus carpio L., 1758*) baliqlarning **biologik, morfometrik, fiziologik va reproduktiv ko‘rsatkichlari** kompleks ravishda o‘rganildi. Baliqlarning umumiy uzunligi (sm), tana massasi (g), tana semizlik koeffitsiyenti, ichki organlar massasi hamda jinsiy bezlarning rivojlanish holati aniqlandi. Morfometrik o‘lchash ishlari umumqabul qilingan ixtiologik usullar asosida amalga oshirildi.

Tuxum hujayralarini hisoblashda gravimetrik usuldan foydalanildi. Bunda tuxumdonning turli qismlaridan olingan namunalar laboratoriya sharoitida tortilib, tuxum hujayralari soni aniqlash orqali umumiy serpushtlik hisoblab chiqildi. Baliqlarning fiziologik holatini baholash uchun gematologik va biokimyoviy tahlillar amalga oshirildi. Qon namunalaridan foydalanib, eritrotsitlar va leykotsitlar miqdori, gemoglobin darajasi, qonning umumiy fiziologik holatini ifodalovchi ayrim ko‘rsatkichlar aniqlandi. Shuningdek, qon zardobida oqsil almashinuvi va energetik holat bilan bog‘liq ayrim biokimyoviy ko‘rsatkichlar tahlil qilindi. Baliqlarni oziqlantirish sharoitlari ham tadqiqotning muhim yo‘nalishlaridan biri bo‘ldi. Xo‘jaliklarda qo‘llanilayotgan oziqlantirish tizimi, yem tarkibi, oziqlantirish me’yorlari va parvarish texnologiyalari tahlil qilindi. Oziqa moddalarning, ayniqsa oqsil, lipid, vitamin va mineral komponentlarning reproduktiv jarayonlarga ta’siri baholandi.

Olingan eksperimental ma’lumotlar biologik statistika usullari yordamida qayta ishlandi. Statistik tahlilda o‘rtacha qiymat (M), standart og‘ish (±m), variatsiya koeffitsiyenti (Cv) hamda guruhlar o‘rtasidagi farqlarning ishonchlilik darajasi aniqlandi. Ko‘rsatkichlar o‘rtasidagi bog‘liqlikni aniqlash uchun korrelyatsion tahlil usullaridan foydalanildi.

Mazkur metodik yondashuv orqali karp baliqlarining reproduktiv potensiali, nasldorlik sifatlari va sun’iy ko‘paytirish samaradorligini oshirishga qaratilgan ilmiy-amaliy tavsiyalar ishlab chiqish uchun zarur ma’lumotlar shakllantirildi.

NATIJALAR VA MUHOKAMA

Karp (*Cyprinus carpio L., 1758*) balig'ining reproduktiv xususiyati shakllanishining ekologik-fiziologik asoslari bo’yicha olingan natijalar shuni

ko‘rsatadiki, Toshkent viloyati sharoitida karp balig‘ining reproduktiv xususiyatlari shakllanishi ekologik va fiziologik omillarning kompleks ta’siri natijasida yuzaga keladi.

Tadqiqot davomida aniqlangan asosiy qonuniyat shundan iboratki, qulay suv sharoiti, sifatli oziqlantirish va optimal parvarish texnologiyasi baliqlarning tana rivojlanishi, gonadalar yetilishi hamda serpushtlik ko‘rsatkichlarini oshiradi.

Xo‘jaliklar kesimida tahlil qilinganda, **MCHJ “Khoorrot Fish House”** va **MCHJ “Imkon Baliq Fayz”** xo‘jaliklarida GSI qiymatlari nisbatan yuqori bo‘lib, bu xo‘jaliklarda oziqlantirish va suv sifatining reproduktiv rivojlanish uchun qulay sharoit yaratganligini ko‘rsatdi. FX **“ZafarAsad”** xo‘jaligida esa ayrim davrlarda suv harorati va oziqa bazasidagi farqlar sababli reproduktiv ko‘rsatkichlarda biroz pasayish kuzatildi. GSI ning yuqori qiymatlari baliqlarning reproduktiv faolligi yuqori ekanligini ko‘rsatib, sun’iy ko‘paytirish jarayonlarida naslli baliqlarni tanlash uchun muhim biologik indikator hisoblanadi.Tadqiqot davomida urg‘ochi karp baliqlarining mutlaq va nisbiy serpushtlik ko‘rsatkichlari ham aniqlandi. Olingan natijalar baliqlarning serpushtligi ularning tana kattaligi, yoshi, oziqlanish darajasi va ekologik sharoitlar bilan uzviy bog‘liq ekanligini ko‘rsatdi. Yirik tana massasiga ega urg‘ochi baliqlarda tuxum hujayralari soni ko‘proq bo‘lib, nisbiy serpushtlik ko‘rsatkichi ham yuqori bo‘ldi. Bu holat karp baliqlarida reproduktiv potensialning shakllanishida tana energetik holati asosiy omillardan biri ekanligini ko‘rsatadi. Tuxumdonlarning rivojlanishi davomida oositlarda sariqlik moddalari to‘planishi natijasida tuxum hujayralarining hajmi va sifati oshgan. Ushbu jarayon suv harorati, oziqa tarkibi va metabolik faollik bilan chambarchas bog‘liq. Tadqiqot natijalari shuni ko‘rsatdiki, oqsil va energiyaga boy yemlar bilan oziqlantirilgan baliqlarda tuxumdonlarning rivojlanish darajasi yuqori bo‘lgan. Bu holat baliqchilik xo‘jaliklarida naslli baliqlar ratsionini optimallashtirish reproduktiv samaradorlikni oshirishning muhim omili ekanligini tasdiqlaydi. Karp balig‘i ekologik jihatdan plastik tur hisoblanadi va turli suv sharoitlariga moslasha oladi. Biroq reproduktiv jarayonlarning normal kechishi uchun suv harorati, kislorod miqdori va gidrokimyoviy ko‘rsatkichlarning optimal darajada bo‘lishi zarur. Tadqiqot olib borilgan xo‘jaliklarda suv harorati mavsum davomida karp baliqlarining biologik talablariga mos kelgan. Bahor oylarida suv haroratining 18–22°C gacha ko‘tarilishi gonadalar yetilish jarayonining jadallashishiga sabab bo‘lgan.Yozgi davrda yuqori harorat sharoitida baliqlarning metabolik faolligi oshgan, biroq suvdagi erigan kislorod miqdorining pasayishi ayrim hollarda stress holatini yuzaga keltirgan. Stress omillari esa gipotalamus-gipofiz-gonada tizimi faoliyatiga ta’sir qilib, reproduktiv jarayonlarni sekinlashtirishi mumkin.

Suvning pH ko‘rsatkichi va minerallashuv darajasi ham baliqlarning fiziologik holatiga ta’sir qiluvchi muhim omillar sifatida qayd etildi. Optimal gidrokimyoviy sharoitlarda baliqlarning o‘sishi, oziq moddalarni o‘zlashtirishi va jinsiy mahsulotlarning shakllanishi yaxshiroq kechgan.

XULOSA

Toshkent viloyatidagi MCHJ “Khoorrot Fish House”, FX “ZafarAsad” va MCHJ “Imkon Baliq Fayz” baliqchilik xo‘jaliklarida olib borilgan tadqiqotlar natijasida karp (*Cyprinus carpio L., 1758*) balig‘ining reproduktiv xususiyatlari

shakllanishining ekologik-fiziologik asoslari kompleks ravishda o‘rganildi. Tadqiqotlar davomida har bir xo‘jalikdan jinsiy yetilgan karp baliqlari tanlab olinib, ularning biologik, morfometrik, fiziologik va reproduktiv ko‘rsatkichlari tahlil qilindi. Toshkent viloyati sharoitida karp balig‘ining biologik ko‘rsatkichlari xo‘jaliklarning ekologik va texnologik sharoitlariga bog‘liq holda shakllanishi aniqlandi. Baliqlarning tana massasi, uzunligi va semizlik koeffitsiyenti o‘rtasida ijobiy bog‘liqlik mavjud bo‘lib, yaxshi oziqlantirish va qulay suv muhiti sharoitida baliqlarning o‘sishi hamda reproduktiv rivojlanishi yuqori darajada kechishi kuzatildi. Tadqiqot natijalari shuni ko‘rsatdiki, karp baliqlarining reproduktiv holatini baholashda gonadosomatik indeks (GSI) muhim biologik indikator hisoblanadi. Urg‘ochi baliqlarda GSI ko‘rsatkichlari erkak baliqlarga nisbatan yuqori bo‘lib, bu tuxum hujayralarining shakllanishi va vitellogenez jarayonlarining yuqori energetik talab qilishi bilan izohlanadi. Karp baliqlarining mutlaq va nisbiy serpushtlik ko‘rsatkichlari ularning tana o‘lchamlari, fiziologik holati va oziqlanish darajasi bilan chambarchas bog‘liq ekanligi aniqlandi. Tana massasi yuqori bo‘lgan urg‘ochi baliqlarda tuxum hujayralari soni va reproduktiv mahsuldorlik ko‘rsatkichlari yuqoriroq bo‘ldi. Baliqlarning reproduktiv rivojlanishiga suv muhitining asosiy ekologik omillari — harorat, erigan kislorod miqdori, pH va suvning umumiy gidrokimyoviy holati sezilarli ta’sir ko‘rsatishi aniqlandi. Bahor oylarida suv haroratining optimal darajaga ko‘tarilishi gonadalar rivojlanishini jadallashtirgan bo‘lsa, yozgi davrda yuqori harorat va kislorod miqdorining pasayishi ayrim fiziologik stress holatlarini yuzaga keltirishi mumkinligi qayd etildi.

Tadqiqotlar davomida karp balig‘ining reproduktiv faoliyati nafaqat tashqi muhit omillari, balki organizmning ichki fiziologik holati bilan ham belgilanadi. Qonning gematologik va biokimyoviy ko‘rsatkichlari baliqlarning metabolik holati va reproduktiv imkoniyatlarini baholashda muhim mezon bo‘lib xizmat qilishi aniqlandi. Olib borilgan tadqiqotlar natijasida Toshkent viloyati sharoitida karp balig‘ining reproduktiv xususiyatlari shakllanishi ekologik omillar, metabolik holat va parvarish texnologiyalarining o‘zaro ta’siri natijasi ekanligi ilmiy jihatdan asoslandi.

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NUROTA TUMANI YER MAYDONI TUPROQLARINING OZIQA MODDALARI BILAN TA'MINLANISH DARAJASI

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"Tuproq tahlil markazi" davlat muassasasi

Annotasiya: *Tadqiqotda Nurota tumani sug'oriladigan qishloq xo'jaligi yer maydoni tuproqlarining oziqa moddalari bilan ta'minlanganlik darajasi o'rganilgan. Tadqiqot natijalari hudud tuproqlarining oziqa moddalari bilan o'rtacha-past darajada ta'minlanganligini ko'rsatdi: gumus miqdori ko'rsatkichi umumiy 4190,40 gektar maydonning 46,53 % qismi o'rtacha darajada, 41,88 % qismi kam darajada hamda 9,58 %, 1,27% va 0,75 % qismi mos ravishda ko'proq, juda kam va ko'p darajada ta'minlangan. Harakatchan fosfor (P_2O_5) miqdori esa 57,91 % qismi juda kam darajada, 40,64 % qismi kam darajada hamda 1,10 % va 0,35 % qismi mos ravishda o'rtacha va ko'proq darajada ta'minlangan. Shuningdek, almashinuchan kaliy (K_2O) miqdori ham 36,67 % qismi, o'rtacha darajada, 24,89 % qismi kam darajada hamda 20,92 % va 17,51 % qismi mos ravishda ko'proq va ko'p darajada ta'minlangan. Olingan natijalar asosida tuproqlarning unumdorlik darajasini oshirish uchun mineral va organik o'g'itlardan oqilona foydalanish, agrotexnik tadbirlarni to'g'ri tashkil etish bo'yicha ilmiy tavsiyalar ishlab chiqilgan. Tadqiqot natijalari qishloq xo'jaligi ekinlaridan yuqori hosil olish, yer resurslaridan samarali foydalanish hamda tuproq degradatsiyasining oldini olish uchun foydalanishda muhim ahamiyat kasb etadi.*

Kalit so'zlar: *sug'oriladigan yerlar, oziqa moddalari, fosfor, kaliy, gumus, agrokimyoviy tahlil, o'g'itlash tizimi, mineral o'g'itlar, harakatchan elementlar.*

Аннотация: *В исследовании изучался уровень обеспеченности почв питательными веществами на орошаемых сельскохозяйственных угодьях Нуротинского района. Результаты исследования показали, что почвы региона умеренно и слабо обеспечены питательными веществами: 46,53% от общей*

площади 4190,40 гектаров имеют умеренное содержание гумуса, 41,88%-слабое, а 9,58%, 1,27% и 0,75%-высокое, очень низкое и очень высокое содержание соответственно. Содержание подвижного фосфора (P_2O_5) составляет 57,91%-очень низкое, 40,64%-слабое, а 1,10% и 0,35%-умеренное и высокое содержание соответственно. Кроме того, содержание обменного калия (K_2O) составило 36,67% на умеренном уровне, 24,89% на низком уровне и 20,92% и 17,51% на высоком и низком уровнях соответственно. На основе полученных результатов были разработаны научные рекомендации по рациональному использованию минеральных и органических удобрений для повышения плодородия почвы и по правильной организации агротехнических мероприятий. Результаты исследования имеют большое значение для получения высоких урожаев сельскохозяйственных культур, эффективного использования земельных ресурсов и предотвращения деградации почв.

Ключевые слова: *орошаемые земли, питательные вещества, фосфор, калий, гумус, агрохимический анализ, система удобрения, минеральные удобрения, подвижные элементы.*

Abstarct: *The study examined the soil nutrient status of irrigated agricultural lands in the Nurota district. The results showed that the soils in the region have moderate to low nutrient status: 46,53% of the total area of 4 190,40 hectares have moderate humus content, 41,88% have low humus content, and 9,58%, 1,27%, and 0,75% have high, very low, and very high humus content, respectively. The content of available phosphorus (P_2O_5) is 57,91% (very low), 40,64% (low), and 1,10% and 0.35% (moderate and high), respectively. In addition, the content of exchangeable potassium (K_2O) was 36,67% at a moderate level, 24,89% at a low level, and 20,92% and 17,51% at high and low levels, respectively. Based on the obtained results, scientific recommendations were developed for the rational use of mineral and organic fertilizers to improve soil fertility and for the proper organization of agricultural practices. The study's findings are of great importance for achieving high agricultural yields, efficient use of land resources, and preventing soil degradation.*

Key words: *irrigated lands, nutrients, phosphorus, potassium, humus, agrochemical analysis, fertilization system, mineral fertilizers, mobile elements.*

KIRISH

Qishloq xo'jaligi ishlab chiqarishining barqaror rivojlanishi bevosita tuproq unumdorligi va uning ozuqa moddalari bilan ta'minlanganlik darajasiga bog'liqdir. Sug'oriladigan qishloq xo'jaligi yer maydonlarida tuproqning agroximik holatini o'rganish, uning tarkibidagi asosiy oziqa elementlari gumus, fosfor va kaliyning miqdori hamda o'simliklar tomonidan o'zlashtirilish darajasini aniqlash muhim ilmiy va amaliy ahamiyatga ega 1.

hudud sug'oriladigan qishloq xo'jaligi yer maydonlaridan uzoq yillar davomida intensiv foydalanish, agrotexnika tadbirlarining ilmiy asosda olib borilmasligi hamda mineral o'g'itlardan muvozanatsiz foydalanish va boshqa omillar natijasida tuproq unumdorligining pasayish jarayoni kuzatilmoqda. Mahalliy olimlar tomonidan olib borilgan tadqiqotlarda sug'oriladigan qishloq xo'jaligi yer maydoni tuproqlarida ozuqa

elementlari balansining buzilishi oqibatida gumus, harakatchan fosfor va almashinuvchan kaliy miqdorining kamayishi aniqlangan 5.

Shu bois, mazkur hudud sug'oriladigan tuproqlarining agroximik xususiyatlarini chuqur o'rganish, ularning ozuqa elementlari bilan ta'minlanganlik darajasini baholash hamda tuproq unumdorligini oshirishga qaratilgan ilmiy asoslangan tavsiyalar ishlab chiqish dolzarb masalalardan biri hisoblanadi. Tadqiqot ishining maqsadi Nurota tumani sug'oriladigan qishloq xo'jaligi yer maydoni tuproqlarining ozuqa moddalari bilan ta'minlanganlik darajasini aniqlash, ularning agroximik holatini baholash hamda samarali foydalanish yo'llarini asoslab berishdan iborat.

ADABIYOTLAR SHARHI.

Tuproqning oziqa moddalari bilan ta'minlanganlik darajasi tuproq unumdorligini belgilovchi asosiy ko‘rsatkichlardan biri hisoblanadi. Agrokimyo fanining rivojlanishida N.A. Dimo, D.N. Pryanishnikov kabi olimlarning tadqiqotlari muhim o‘rin tutadi - ular tuproqdagi azot, fosfor, kaliy va gumusning o‘simliklar hayotidagi ahamiyatini, shuningdek, o‘g‘itlash orqali bu elementlarning harakatchan shakllarga o‘tish qonuniyatlarini asoslab berganlar. Ushbu klassik ishlar hozirgi kungacha O‘zbekiston tuproqshunosligi va agrokimyosi ta'limotining nazariy asosi bo‘lib xizmat qilmoqda.

Zamonaviy adabiyotlarda tuproqning oziqa rejimi deganda, birinchi navbatda, gumus (organik modda), harakatchan fosfor, almashinuvchi kaliy va turli shakldagi azot birikmalarining tuproqdagi miqdori va o‘simliklar tomonidan o‘zlashtirilish darajasi tushuniladi. Bu ko‘rsatkichlarning har biri tuproq tipiga, uning mexanik tarkibiga, sug‘orish tartibiga hamda qo‘llaniladigan agrotexnik tadbirlarga qarab keskin farqlanishi ko‘plab tadqiqotlarda qayd etilgan.

“Tuproq tahlil markazi” davlat muassasasi tomonidan har bir tuman kesimida muntazam ravishda agrokimyoviy tekshiruvlar o‘tkazib boriladi. Ushbu tekshiruvlar yakunida sug‘oriladigan yerlarning oziqa moddalari bilan ta'minlanganlik darajasiga muvofiq mineral o‘g‘itlarga bo‘lgan ilmiy asoslangan ehtiyoj hisoblab chiqiladi va natijalar agrokimyoviy xaritanoma shaklida rasmiylashtiriladi. Xaritanomada har bir dala konturi tuproqning gumus, harakatchan fosfor va almashinuvchi kaliy bilan ta'minlanganligiga qarab turli ranglarda tasvirlanadi.

Umumiy qabul qilingan uslubiyotga ko‘ra (O‘zPITI tomonidan ishlab chiqilgan tavsiyalar asosida), tuproqlar harakatchan fosfor va almashinuvchi kaliy miqdoriga ko‘ra besh guruhga bo‘lib tahlil qilinadi: juda past, past, o‘rtacha, yuqori va juda yuqori ta'minlangan. Ushbu gradatsiya tizimi respublikaning barcha viloyat va tumanlarida bir xil metodika asosida qo‘llanilib, natijalarning qiyoslanishini ta'minlaydi.

So‘nggi yillarda respublikaning turli hududlarida olib borilgan tadqiqotlar sug‘oriladigan tuproqlarda organik modda va oziqa elementlari miqdorining umumiy pasayish tendentsiyasini ko‘rsatmoqda. Xususan, bir qator viloyatlar bo‘yicha o‘tkazilgan tekshiruvlarda sug‘oriladigan yerlarning katta qismida gumus miqdori kam va o‘rta darajada, azot, fosfor va kaliyning umumiy hamda harakatchan shakllari esa nisbatan past bo‘lganligi aniqlangan. Bunga sabab sifatida ko‘p yillik intensiv foydalanish, gumusni tiklovchi organik o‘g‘itlarning yetarli miqdorda qo‘llanilmasligi hamda shamol va suv eroziyasi jarayonlari ko‘rsatiladi.

Shu bilan birga, mavjud adabiyotlar tahlili shuni ko‘rsatadiki, Nurota tumani tuproqlari bo‘yicha olib borilgan tadqiqotlar asosan tuproqning genetik-morfologik tavsifi va gumus dinamikasiga qaratilgan bo‘lib, tumanning barcha sug‘oriladigan yer maydonlarini qamrab oluvchi, oziqa elementlari (harakatchan fosfor, almashinuvchi kaliy, azot shakllari) ning to‘liq va zamonaviy agrokimyoviy baholash tizimi asosidagi tadqiqotlar hali yetarli darajada olib borilmagan. Bu esa mazkur tadqiqot mavzusining dolzarbligini belgilaydi.

TADQIQOT OBYEKTI VA USLUBLARI

Tadqiqotlar Navoiy viloyati Nurota tumanidagi sug’oriladigan qishloq xo’jaligi yer maydonlarida olib borildi. Hudud geografik jihatdan shimolda viloyatining Tomdi tumani, garbda Konimex tumani va G’azg’on shahri, sharqda Jizzax viloyatining Forish tumani, janubda esa Xatirchi tumani bilan chegaradosh bo’lgan quruq iqlimli agroekotizim hisoblanadi.

Ozuqa elementlari bilan ta’minlanish darajasini baholash maqsadida dala kuzatuvlari asosida tuproq namunalari standart chuqurliklardan olinib, laboratoriya sharoitida tahlil qilindi. Tuproq mexanik tarkibi OZDST-81797, gumus-GOST-26213-91 davlat standarti asosida aniqlandi. Tuproq namunalari tarkibidagi harakatchan fosfor (P_2O_5) miqdori Machigin usulida (SINAO) modifikatsiyasi asosida va almashinuvchan kaliy (K_2O) miqdori alangali fotometr orqali aniqlanib, natijalar asosida tuproqlar ozuqa elementlari bilan ta’minlanish darajasi bo’yicha klassifikatsiya qilindi. Tahlillar “Tuproq tahlil markazi” davlat muassasasi sinov laboratoriyasida amalga oshirildi 4, 6.

TADQIQOT NATIJALARI VA ULARNING MUHOKAMASI

Tuman hududi ikkita bioiqlim ya’ni cho’l va yarim cho’l zonalarida joylashgan, murakkab geomorfologik tuzilishga ega bo’lib, konus yoyilmalari uchlamchi platolar va qoldiq ko’tarilmalar, turli yoshdagi qayir usti terassalariga tutashgan o’rta balandlikdagi va past tog’lar, past baland tog’ oldi hududlari hamda nishab qiyalik tog’ osti tekisliklaridan iborat bolib, Sug‘oriladigan dehqonchilikda och tusli bo’z tuproqlardan foydalaniladi 2.

O’tkazilgan tadqiqot natijalariga asosida tuproqning asosiy ozuqa elementlari bilan ta’minlanganlik darajasi hamda gumus, harakatchan fosfor (P_2O_5) va almashinuvchan kaliy (K_2O) miqdori ko’rsatkichlari ajratildi. Gumus miqdori ko’rsatkichlari umumiy 4190,40 gektar maydonning 46,53 % qismi o’rtacha darajada, 41,88 % qismi kam darajada hamda 9,58 %, 1,27% va 0,75 % qismi mos ravishda ko’proq, juda kam va ko’p darajada ta’minlangan (1-jadval, 1-rasm).

Hududda tadqiqot natijasi bo’yicha gumus miqdori yuqori darajada ta’minlangan yer maydonlari aniqlanmadi.

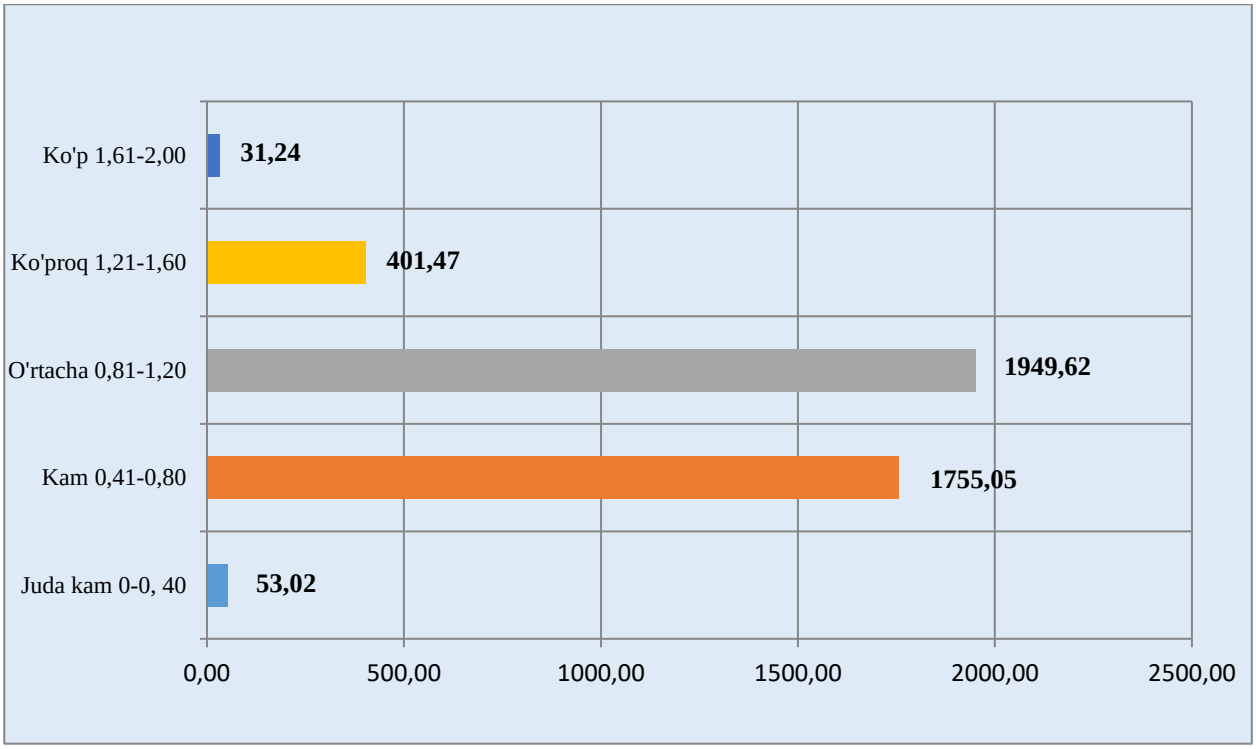
1-jadval

Nurota tumanidagi tadqiqot o'tkazilgan sug'oriladigan qishloq xo'jaligi yer maydonlarining gumus miqdori ko'rsatkichlari

T/r	Massivlar nomi	Tekshirilgan maydon, ga	Gumus miqdori % hisobida												Jami gumus, % hisobida
			Juda kam 0-0,40		Kam 0,41-0,80		O'rtacha 0,81-1,20		Ko'proq 1,21-1,60		Ko'p 1,61-2,00		Yuqori > 2,0		
			ga	%	ga	%	ga	%	ga	%	ga	%	ga	%	
1	Istiqlol	890,55	21,76	2,44	400,30	44,95	318,24	35,74	150,25	16,87					100,00
2	Nurota	156,11	20,00	12,81	136,11	87,19									100,00
3	A.Navoiy	1808,27	4,00	0,22	882,68	48,81	792,82	43,84	128,77	7,12					100,00
4	Mustaqillik	339,20	7,26	2,14	74,31	21,91	257,63	75,95							100,00
5	Sh.Rashidov	18,98			6,97	36,72	12,01	63,28							100,00
6	O'zbekiston	977,29			254,68	26,06	568,92	58,21	122,45	12,53	31,24	3,20			100,00
Jami:		4190,40	53,02	1,27	1755,05	41,88	1949,62	46,53	401,47	9,58	31,24	0,75			100,00

1-rasm

Tadqiqot o'tkazilgan sug'oriladigan qishloq xo'jaligi yer maydonlarining gumus bilan ta'minlanganlik darajasi, gektar hisobida



Harakatchan fosfor (P_2O_5) miqdori esa umumiy 4190,40 gektar maydonning 57,91 % qismi juda kam darajada, 40,64 % qismi kam darajada hamda 1,10 % va 0,35 % qismi mos ravishda o'rtacha va ko'proq darajada ta'minlangan. (2-jadval, 2-rasm). Hudud yer maydonlarida harakatchan fosfor (P_2O_5) bilan ko'p darajada ta'minlangan miqdori ko'rsatkichlari aniqlanmadi.

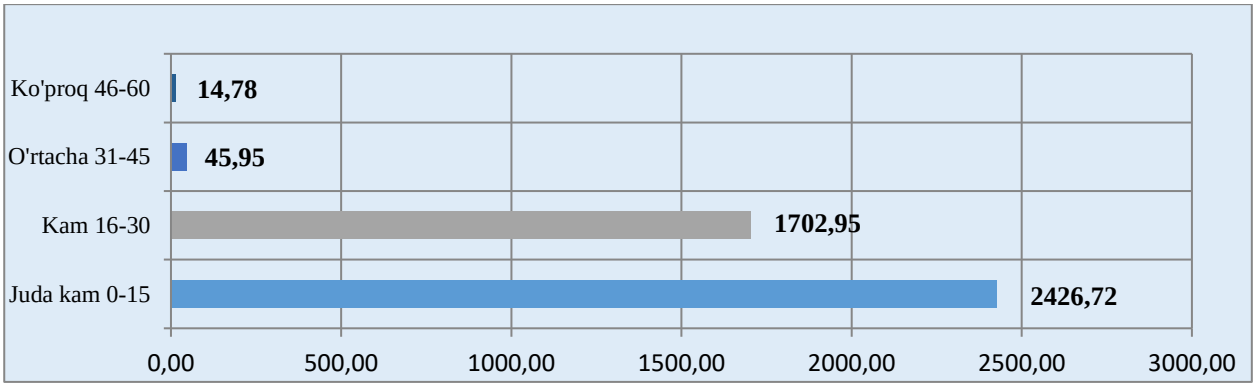
2-jadval

Nurota tumanidagi tadqiqot o'tkazilgan sug'oriladigan qishloq xo'jaligi yer maydonlarining harakatchan fosfor (P2O5) miqdori ko'rsatkichlari

T/r	Massivlar nomi	Tekshirilgan maydon, ga	Fosfor (P2O5) miqdori, mg/kg										Jami (P2O5), % hisobida
			Juda kam 0-15		Kam 16-30		O'rtacha 31-45		Ko'proq 46-60		Ko'p 60<		
			ga	%	ga	%	ga	%	ga	%	ga	%	
1	Istiqlol	890,55	195,24	21,92	678,39	76,18	16,92	1,90					100,00
2	Nurota	156,11	79,78	51,10	76,33	48,90							100,00
3	A.Navoiy	1808,27	1100,78	60,87	683,81	37,82	14,71	0,81	8,97	0,50			100,00
4	Mustaqillik	339,20	185,46	54,68	146,90	43,31	2,74	0,81	4,10	1,21			100,00
5	Sh.Rashidov	18,98			18,98	100,00							100,00
6	O'zbekiston	977,29	865,46	88,56	98,54	10,08	11,58	1,18	1,71	0,17			100,00
Jami:		4190,40	2426,72	57,91	1702,95	40,64	45,95	1,10	14,78	0,35			100,00

2-rasm

Tadqiqot o'tkazilgan sug'oriladigan qishloq xo'jaligi yer maydonlarining harakatchan fosfor (P_2O_5) bilan ta'minlanganlik darajasi, gektar hisobida



Shuningdek, almashinuchan kaliy (K_2O) miqdori ham umumiy 4190,40 gektar maydonning 36,67 % qismi, o'rtacha darajada, 24,89 % qismi kam darajada hamda 20,92 % va 17,51 % qismi mos ravishda ko'proq va ko'p darajada ta'minlangan (3-jadval, 3-rasm).

Tadqiqot natijasida hudud yer maydonlarining almashinuchan kaliy (K_2O) bilan juda kam darajada ta'minlangan miqdor ko'rsatkichlari aniqlanmadi.

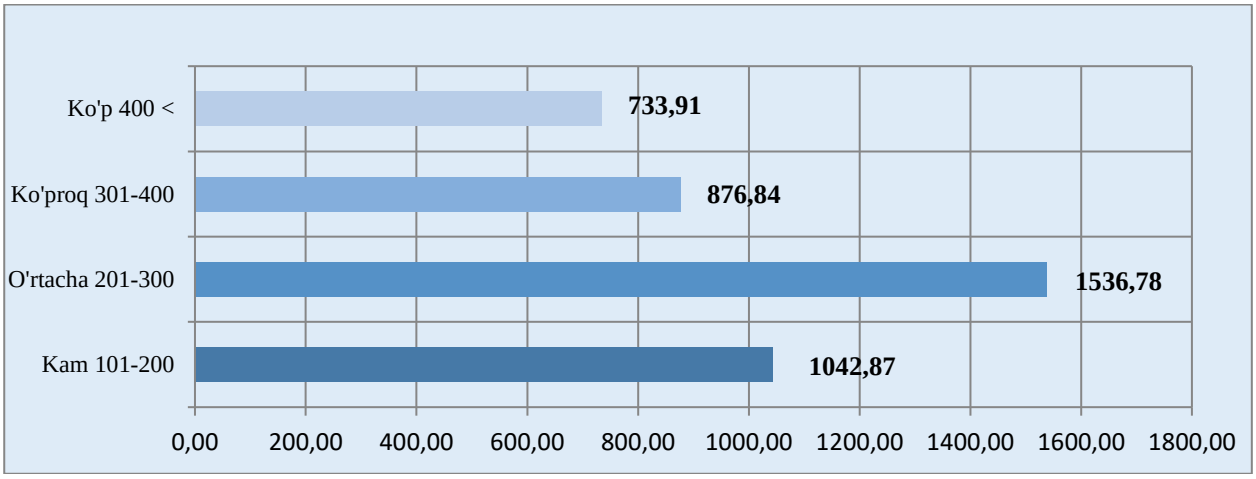
3-jadval

Nurota tumanidagi tadqiqot o'tkazilgan sug'oriladigan qishloq xo'jaligi yer maydonlarining almashinuvchan kaliy (K2O) miqdori ko'rsatkichlari

T/r	Massivlar nomi	Tekshirilgan maydon, ga	Kaliy (K2O) miqdori, mg/kg										Jami, (K2O) % hisobida
			Juda kam 0-100		Kam 101-200		O'rtacha 201-300		Ko'proq 301-400		Ko'p 400<		
			ga	%	ga	%	ga	%	ga	%	ga	%	
1	Istiqlol	890,55			160,70	18,05	251,31	28,22	288,13	32,35	190,41	21,38	100,00
2	Nurota	156,11					111,11	71,17	45,00	28,83			100,00
3	A.Navoiy	1808,27			342,01	18,91	772,30	42,71	358,03	19,80	335,93	18,58	100,00
4	Mustaqillik	339,20			203,05	59,86	84,37	24,87	43,28	12,76	8,50	2,51	100,00
5	Sh.Rashidov	18,98					18,98	100,00					100,00
6	O'zbekiston	977,29			337,11	34,49	298,71	30,57	142,40	14,57	199,07	20,37	100,00
Jami:		4190,40			1042,87	24,89	1536,78	36,67	876,84	20,92	733,91	17,51	100,00

3-rasm

Tadqiqot o'tkazilgan sug'oriladigan qishloq xo'jaligi yer maydonlarining almashinuvchan kaliy (K_2O) bilan taminlanganlik darajasi, gektar hisobida



Taxlillar hudud tuproqlarining gumus bilan ta'minlanganlik ko'rsatkichi o'rtacha-kam darajada, harakatchan fosfor (P_2O_5) miqdori ko'rsatkichlari esa kam-juda kam darajada, shuningdek, almashinuchan kaliy (K_2O) miqdori ko'rsatkichlari ham o'rtacha darajada ekanligini ko'rsatadi. Umuman olganda, hudud yer maydonlarining ozuqa elementlari bilan ta'minlanganlik darajasini yaxshilash uchun ilmiy asoslangan chora-tadbirlar muhim hisoblanadi. Mineral va organik o'g'itlar faqat o'simliklar uchun oziqa va tuproq unumdorligini oshiruvchi manba bo'lib qolmay, ular tuproq tarkibidagi oziqa elementlar zaxiralarini va qishloq xo'jalik ekinlari hosildorligini ham oshiruvchi omildir. Sifatli qishloq xo'jaligi maxsulotlarini yetishtirish uchun esa gumus miqdori, fosfor va kaliy ozuqa elementlari juda muhim ahamiyatga ega bo'lib, uning agrokimyoviy kartogrammalarini tuzish iqtisodiy samaradorlikni ham oshiradi.

XULOSA

Hudud tuproqlari unumdorligini muhofaza etish va qishloq xo'jaligi ekinlari hosildorligini oshirish maqsadida yer maydonlarida davriy tekislash ishlarini o'tkazish, bu sug'orish suvlaridan samarali foydalanish imkonini beradi. Tuproq unumdorligini oshirish maqsadida qishloq xo'jaligi ekinlarini almashlab ekishni joriy etish mihim hisoblanadi. Qishloq xo'jaligi ekinlarini to'g'ri almashlab ekish dehqonchilikni yuksak madaniyat bilan yuritishning asosiy shartlaridan biri bo'lib, uning eng asosiy vazifasi birinchi navbatda aholini oziq-ovqat mahsulotlariga bo'lgan ehtiyojlarini qondirish bo'lsa, ikkinchidan tuproq unumdorligini saqlash, begona o'tlar, qishloq xo'jaligi zararkunandalari va kasalliklariga qarshi samarali kurashish orqali ekinlar hosilini oshirishdan iborat.

O'g'itlar samaradorligini oshirish maqsadida organik va maxalliy (go'ng) o'g'itlarni mineral o'g'itlar bilan kompost holda tayyorlab, xo'jalik ekinlarini oziqlantirish uchun gektariga 30-35 tonnadan solish. Tuproqlarning unumdorligini oshirish uchun ularning xossa-xususiyatlarini, jumladan, gumus va ozuqa moddalar miqdorini oshirish, tuproqlarning ekologik holatini yaxshilash uchun alohida ahamiyatga ega. Qishloq xo'jaligi ekinlarini turiga, naviga, biologik xususiyatiga va tuproq iqlim sharoitlariga bog'liq holda o'simliklarni biologik talabidan kelib chiqib,

vegetatsiya davrida mineral o'g'itlarni tabaqalashtirilgan holda to'g'ri qo'llash tuproq unumdorligini tiklashda, mineral o'g'itlarning samaradorligini va qishloq xo'jaligi ekinlarining hosildorligini oshirishda, ayniqsa, mahsulot sifatini yaxshilashda ahamiyati beqiyosdir.

Organik o'g'itlardan foydalanish o'simliklarni makro va mikro elementlar bilan ta'minlaydi, tuproqdagi oziq moddalar balansini tartibga solib turadi, qiyin eruvchan fosfatlarni o'simliklar tomonidan yengil o'zlashtiriladigan holatga o'tkazish imkonini beradi. Mineral o'g'itlarning samaradorligini oshirishda mikroelementlarni qo'llash eng muhim omillardan biridir. O'simliklar mikroelementlarni juda oz miqdorda talab qilsada, fiziologik hayotiy jarayonlarida nihoyatda muhim o'rin tutadi. Mikroelementlar ta'sirida o'simlik barglarida xlorofill ortadi, fotosintez jarayoni yaxshilanadi, o'simlikning barcha qismlarida hayotiy faollik oshadi. Tuproqda mikroelementlar yetarli bo'lsa, o'simliklar fosfor, kaliy va boshqa elementlarni yaxshi o'zlashtiradi.

Fosforli o'g'itlarni o'zlashtirishni yaxshilash maqsadida go'ng-fosforli o'g'itlaridan foydalanish samarali hisoblanadi. Go'ng-fosforli va tut ipak qurti g'umbaklari hamda ularning eksperimentlaridan, parranda go'ngi, go'ng sharbati shuningdek, boshqa turdagi organik chiqindilardan ham keng foydalanish muhim. Xulosa o'rnida tuman hududidagi yer maydonlarining ozuqa moddalari bilan ta'minlanish darajasi o'rtacha-past darajada. Tuproq unumdorligini oshirish uchun ilmiy asoslangan o'g'itlash tizimini joriy etish, organik o'g'itlardan keng foydalanish, suv tejovchi sug'orish texnologiyalarini qo'llash hamda yer maydonlarining meliorativ holatni yaxshilash zarur.

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POLIETILEN PARCHALANISHINI TEZLASHTIRUVCHI BAKTERIAL SHTAMMLARNI (PSEUDOMONAS SPP., BACILLUS SPP.) MAHALLIY HUDUDLARDAN AJRATIB OLISH VA IDENTIFIKATSIYA QILISH

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Annotatsiya. *Maqolada polietilen (PE) chiqindilarini biologik parchalashda ishtirok etuvchi Pseudomonas spp. va Bacillus spp. avlodlariga mansub bakterial shtammlarni mahalliy ifloslangan hududlardan — chiqindi poligonlari, polimer korxonalari atrofidagi tuproqlar va oqova suvlardan — ajratib olish hamda identifikatsiya qilishning zamonaviy uslubiy yondashuvlari tahlil qilingan. Tahlil 2018–2025-yillarda nashr etilgan xalqaro tadqiqotlar hamda O‘zbekistonda o‘tkazilgan skrining natijalari asosida amalga oshirildi. Adabiyot ma’lumotlariga ko‘ra, mineral tuzli muhitda (MSM) polietilen yagona uglerod manbai sifatida qo‘llanilganda 30–112 kunlik inkubatsiya davomida shtammlar 1,14–52,0 % oralig‘ida vazn yo‘qotishni ta’minlagan. Eng yuqori ko‘rsatkichlar Bacillus siamensis (52,0 %; 60 kun), Bacillus cereus A5,a (35,72 %; 16 hafta) hamda UV nurlari bilan dastlabki ishlov berilgan polietilenda Pseudomonas balearica PDI-17 (19,90 %; 30 kun) shtammlarida qayd etilgan. UV bilan dastlabki ishlov berish parchalanish samaradorligini 4,2–9,3 barobarga oshirgan. Shtammlarni identifikatsiya qilishda Gram usulida bo‘yash va biokimyoviy testlar bilan bir qatorda MALDI-TOF MS, 16S rRNA geni ketma-ketligini aniqlash hamda alkB (alkan gidroksilaza) genini polimeraza zanjir reaksiyasi orqali aniqlash usullari yuqori samara berishi ko‘rsatilgan. Maqolada O‘zbekistonning quruq iqlimli va sho‘rlangan tuproqlari sharoiti uchun moslashtirilgan besh bosqichli uslubiy sxema taklif etilgan.*

Kalit so‘zlar: *polietilen, biodegradatsiya, Pseudomonas spp., Bacillus spp., mineral tuzli muhit, 16S rRNA, alkB geni, MALDI-TOF MS, bioremediatsiya, chiqindi poligoni.*

Аннотация. *В статье проанализированы современные методические подходы к выделению и идентификации бактериальных штаммов родов Pseudomonas spp. и Bacillus spp., участвующих в биологической деградации отходов полиэтилена (ПЭ), из местных загрязнённых территорий — свалок, почв вокруг полимерных предприятий и сточных вод. Анализ выполнен на основе международных исследований, опубликованных в 2018–2025 годах, а также*

результатов скрининга, проведённого в Узбекистане. Согласно литературным данным, при использовании полиэтилена в качестве единственного источника углерода в минеральной солевой среде (MSM) за 30–112 суток инкубации штаммы обеспечивали потерю массы в диапазоне 1,14–52,0 %. Наивысшие показатели зафиксированы у Bacillus siamensis (52,0 %; 60 суток), Bacillus cereus A5,a (35,72 %; 16 недель) и у Pseudomonas balearica PDI-17 (19,90 %; 30 суток) на полиэтилене, предварительно обработанном УФ-излучением. Предварительная УФ-обработка повышала эффективность деградации в 4,2–9,3 раза. Показано, что наряду с окраской по Граму и биохимическими тестами высокую результативность при идентификации штаммов обеспечивают MALDI-TOF MS, секвенирование гена 16S рРНК и выявление гена alkB (алкангидроксилазы) методом ПЦР. Предложена адаптированная пятиэтапная методическая схема для условий засушливых и засолённых почв Узбекистана.

Ключевые слова: *полиэтилен, биодеградация, Pseudomonas spp., Bacillus spp., минеральная солевая среда, 16S рРНК, ген alkB, MALDI-TOF MS, биоремедиация, свалка.*

Abstract. *The article analyses current methodological approaches to the isolation and identification of bacterial strains of the genera Pseudomonas spp. and Bacillus spp. involved in the biological degradation of polyethylene (PE) waste from locally contaminated sites — landfills, soils around polymer enterprises and wastewater. The analysis is based on international studies published between 2018 and 2025, together with screening results obtained in Uzbekistan. According to the literature, when polyethylene is supplied as the sole carbon source in mineral salt medium (MSM), strains achieved weight losses of 1.14–52.0 % over 30–112 days of incubation. The highest values were recorded for Bacillus siamensis (52.0 %; 60 days), Bacillus cereus A5,a (35.72 %; 16 weeks) and Pseudomonas balearica PDI-17 (19.90 %; 30 days) on UV-pretreated polyethylene. UV pretreatment increased degradation efficiency by a factor of 4.2–9.3. Alongside Gram staining and biochemical tests, MALDI-TOF MS, 16S rRNA gene sequencing and PCR detection of the alkB (alkane hydroxylase) gene were shown to be highly effective for strain identification. A five-stage methodological scheme adapted to the arid and saline soils of Uzbekistan is proposed.*

Keywords: *polyethylene, biodegradation, Pseudomonas spp., Bacillus spp., mineral salt medium, 16S rRNA, alkB gene, MALDI-TOF MS, bioremediation, landfill.*

KIRISH

Plastmassa jahon iqtisodiyotining ajralmas qismiga aylangan bo‘lib, 2024-yilda uning global ishlab chiqarish hajmi 430 million tonnaga yaqinlashdi va 2009-yildan buyon yiliga o‘rtacha 4,8 % ga o‘sib bormoqda [9]. Yevropada bu ko‘rsatkich 54,6 million tonnani tashkil etib, jahon ishlab chiqarishining 12 % iga to‘g‘ri keladi [10]. Ishlab chiqarilayotgan polimerlarning eng katta ulushi polietilenga (PE) — past zichlikdagi (LDPE) va yuqori zichlikdagi (HDPE) modifikatsiyalariga to‘g‘ri keladi. Polietilen yuqori molekulyar massaga, gidrofoblik xususiyatga va gidrolizga uchraydigan funksional guruhlarning yo‘qligiga ega bo‘lgan uglevodorod zanjiridan

tashkil topgani bois tabiiy sharoitda o‘n yillar davomida parchalanmasdan saqlanadi [1, 3].

O‘zbekiston Respublikasida yiliga taxminan 10,2 million tonna maishiy qattiq chiqindi hosil bo‘ladi va uning 10 % dan ortig‘i (taxminan 1,05 million tonna) plastik chiqindilar hissasiga to‘g‘ri keladi. Hozirda mamlakatda faoliyat yuritayotgan 116 ta qayta ishlash korxonasi yiliga atigi 130 ming tonnaga yaqin plastikni, ya’ni umumiy hajmning 6,6 % ini qayta ishlash quvvatiga ega [11]. Qolgan qism poligonlarga ko‘miladi yoki nazoratsiz to‘planadi. Bu holat tuproq unumdorligining pasayishi, mikroplastikning oziq-ovqat zanjiriga o‘tishi va yer osti suvlarining ifloslanishi kabi ekologik xavflarni keltirib chiqaradi.

Plastik chiqindilarni yo‘q qilishning an’anaviy usullari — yoqish va ko‘mish — mos ravishda atmosferaga zaharli gazlar chiqarilishi va uzoq muddatli ikkilamchi ifloslanish bilan bog‘liq [1]. Shu bois so‘nggi yillarda mikroorganizmlar yordamida polimerlarni biologik parchalash (biodegradatsiya) arzon, energiya talab qilmaydigan va ekologik xavfsiz muqobil sifatida keng o‘rganilmoqda [3, 4].

Polietilenning mikrobiologik parchalanishi ko‘p bosqichli jarayon hisoblanadi. Dastlab bakteriyalar polimer yuzasida bioplyonka hosil qiladi; abiotik omillar (UV nurlanish, yuqori harorat) ta’sirida polimer yuzasida karbonil, karboksil va gidroksil guruhlari shakllanib, gidrofoblik pasayadi va mikrobial hujum osonlashadi. Keyingi bosqichda alkan monooksigenaza (AlkB) fermenti uglevodorod zanjirining terminal metil guruhini gidroksillab, uni mos spirtga aylantiradi; hosil bo‘lgan spirt ketma-ket aldegid va yog‘ kislotasiga oksidlanib, hujayra ichidagi β-oksidlanish yo‘liga kiradi [8]. Bu jarayonda ishtirok etuvchi alkB1 va alkB2 genlari *Pseudomonas aeruginosa* genomida aniqlangan bo‘lib, ular polietilen parchalovchi shtammlarni tanlashda molekulyar marker sifatida qo‘llaniladi [1, 8]. Bundan tashqari, lakkaza, peroksidaza, proteaza va esteraza kabi hujayradan tashqari fermentlar ham polimer zanjirining uzilishida ishtirok etadi [1, 5].

Hozirgi kunga qadar polietilenni parchalash qobiliyatiga ega *Bacillus*, *Pseudomonas*, *Brevibacillus*, *Acinetobacter*, *Rhodococcus*, *Lysinibacillus* va *Enterobacter* avlodlariga mansub ko‘plab shtammlar tavsiflangan [1, 2, 6, 7]. Ular, asosan, uzoq vaqt davomida plastik chiqindilar to‘plangan tuproqlardan ajratib olinadi, chunki bunday hududlarda tabiiy tanlanish natijasida polimerdan uglerod manbai sifatida foydalana oladigan mikrobiotsenozlar shakllangan bo‘ladi [3, 4].

O‘zbekistonda ham bu yo‘nalishda dastlabki ishlar boshlangan: O‘zR FA Mikrobiologiya institutida *Pseudomonas putida*, *P. aeruginosa*, *Rahnella aquatilis*, *Enterobacter cloacae* va *E. ludwigii* shtammlarining LDPE, HDPE, PET va polivinilpirrolidonga nisbatan faolligi UB-spektrofotometrik usulda skrining qilingan; *E. cloacae* shtammi HDPE bilan inkubatsiyada nazoratga nisbatan 13,99 barobar ko‘p organik birikma hosil qilgani aniqlangan [6]. Shu bilan birga, mamlakatimizning quruq iqlimli, sho‘rlangan va yuqori haroratli tuproqlaridan aynan *Pseudomonas* va *Bacillus* avlodlariga mansub polietilen parchalovchi shtammlarni maqsadli ajratib olish va ularni molekulyar darajada identifikatsiya qilish bo‘yicha tizimli tadqiqotlar hali yetarli emas.

Mazkur maqolaning maqsadi — polietilen parchalanishini tezlashtiruvchi *Pseudomonas* spp. va *Bacillus* spp. shtammlarini mahalliy ifloslangan hududlardan ajratib olish, skrining qilish va identifikatsiya qilish bo‘yicha zamonaviy uslubiy yondashuvlarni tahlil qilish hamda O‘zbekiston sharoitida qo‘llash uchun asoslangan uslubiy sxemani ishlab chiqishdan iborat.

MATERIALLAR VA USLUBLAR.

Tadqiqot tahliliy-uslubiy xarakterga ega bo‘lib, unda 2018–2025-yillarda xalqaro retsenziyalanadigan jurnallarda chop etilgan oltita asosiy tajriba maqolasi hamda O‘zbekistonda o‘tkazilgan skrining natijalari birlamchi manba sifatida foydalanildi [1–7]. Manbalarni tanlashda quyidagi mezonlarga amal qilindi: (a) shtammlar tabiiy ifloslangan hududlardan (poligon, tuproq, oqova suv) ajratib olingan bo‘lishi; (b) polietilen (LDPE, HDPE yoki umumiy PE) parchalanishi miqdoriy usulda — gravimetrik tahlil yoki shaffof zona diametri orqali — baholangan bo‘lishi; (c) shtammlar kamida biokimyoviy yoki molekulyar usulda identifikatsiya qilingan bo‘lishi.

Solishtirma tahlil uchun har bir manbadan quyidagi ko‘rsatkichlar ajratib olindi: shtamm nomi, ajratib olingan hudud, o‘rganilgan polimer turi, inkubatsiya muddati va sharoiti, vazn yo‘qotish foizi hamda identifikatsiya usuli. Vazn yo‘qotish ko‘rsatkichi barcha manbalarda quyidagi umumiy formula asosida hisoblangan [1, 5]:

Vazn yo‘qotish (%) = [(Dastlabki vazn − Yakuniy vazn) / Dastlabki vazn] × 100

Ma’lumotlar solishtirilishi uchun turli polimer turlari (LDPE, HDPE, umumiy PE) va turli inkubatsiya muddatlari alohida belgilab ko‘rsatildi, chunki bu omillar natijaga sezilarli ta’sir qiladi va ularni e’tiborga olmasdan taqqoslash noto‘g‘ri xulosalarga olib kelishi mumkin. Grafik tahlil va diagrammalar Python 3.9 (Matplotlib 3.9) dasturiy muhitida tayyorlandi.

Shuningdek, tahlil qilingan manbalar asosida O‘zbekiston sharoiti uchun moslashtirilgan besh bosqichli uslubiy sxema — namuna olish va boyitish, shtammlarni ajratib olish, skrining, identifikatsiya hamda optimallashtirish bosqichlari — shakllantirildi va quyida bayon etildi.

NATIJALAR VA MUNOZARALAR.

1. Namuna olish hududlari va boyitish bosqichi.

Tahlil qilingan barcha manbalarda samarali shtammlar uzoq muddat plastik chiqindilar ta’sirida bo‘lgan hududlardan ajratib olingan: Adama (Efiopiya) chiqindi poligonidan [1], Owerri (Nigeriya) shahar poligonlaridan [2], Morogoro (Tanzaniya) qishloq xo‘jaligi tuproqlaridan [3], Lagos (Nigeriya) Alimosho tumani chiqindixonalaridan [4] va Dandora (Keniya) poligonidan [7]. Bu qonuniyat mahalliy sharoitda namuna olish nuqtalarini tanlashda muhim mezon bo‘lib xizmat qiladi: eng istiqbolli obyektlar sifatida polietilen chiqindilari ko‘milgan tuproq qatlamlari, chiqindi poligonlari, polimer qayta ishlash korxonalari atrofidagi tuproq hamda oqova suvlar tavsiya etiladi.

Boyitish (enrichment) bosqichida tuproq namunasi UV nurlari bilan dastlabki ishlov berilgan polietilen plyonka bo‘laklari bilan birga mineral tuzli muhitga (MSM) joylashtiriladi. Efiopiya tadqiqotida uglerodsiz bazal muhit tarkibi quyidagicha bo‘lgan (g/l): KH_2PO_4 — 0,7; K_2HPO_4 — 0,7; $MgSO_4 \cdot 7H_2O$ — 0,7; NH_4NO_3 — 1,0 va

mikroelementlar; namunalar 37 °C da 14 sutkadan ortiq inkubatsiya qilingan [1]. Bunday sharoitda polietilen yagona uglerod manbai bo‘lgani sababli faqat undan foydalanishga qodir mikroorganizmlargina ko‘payadi, ya’ni tanlanish jarayoni avtomatik ravishda amalga oshadi.

2. Shtammlarni ajratib olish va dastlabki skrining.

Boyitilgan muhitdan olingan namunalar ozuqaviy agarga (Nutrient Agar) yoki tanlab olinadigan muhitlarga ekiladi. *Pseudomonas* avlodini ajratib olishda King A va King B muhitlari, *Bacillus* avlodini ajratib olishda esa namunani 80 °C da 10 daqiqa termik ishlovdan o‘tkazish (vegetativ hujayralarni yo‘qotib, endosporalarni saqlab qolish) usuli samarali hisoblanadi. Turli morfologiyaga ega koloniyalar takroriy ekish orqali tozalanib, sof kulturalar olinadi [1, 4].

Dastlabki skrining ikki usulda amalga oshiriladi. Birinchisi — maydalangan polietilen qo‘shilgan mineral agarda koloniya atrofida shaffof zona (clear zone) hosil bo‘lishini kuzatish. Tanzaniya tadqiqotida bakterial izolyatlar 17 kunda 19,3–47,5 mm, aktinomitsetlar 25,9–32,2 mm, zamburug‘lar esa 13 kunda 30,0–66,3 mm diametrli zonalar hosil qilgan [3]. Ikkinchisi — suyuq muhitda optik zichlik (OD_{600}) o‘sishini kuzatish: Nigeriya tadqiqotida *B. siamensis* uchun OD_{600} 60 kun ichida 0,12 dan 0,84 gacha, *B. pumilus* uchun 0,11 dan 0,67 gacha ortgan, nazorat muhitida esa o‘zgarmagan (0,11) [2].

3. Polietilenni parchalash samaradorligi.

Tahlil qilingan manbalarda qayd etilgan asosiy natijalar 1-jadvalda umumlashtirilgan.

1-jadval

Mahalliy ifloslangan hududlardan ajratib olingan shtammlarning polietilenni parchalash ko‘rsatkichlari (adabiyot ma’lumotlari umumlashtirilgan)

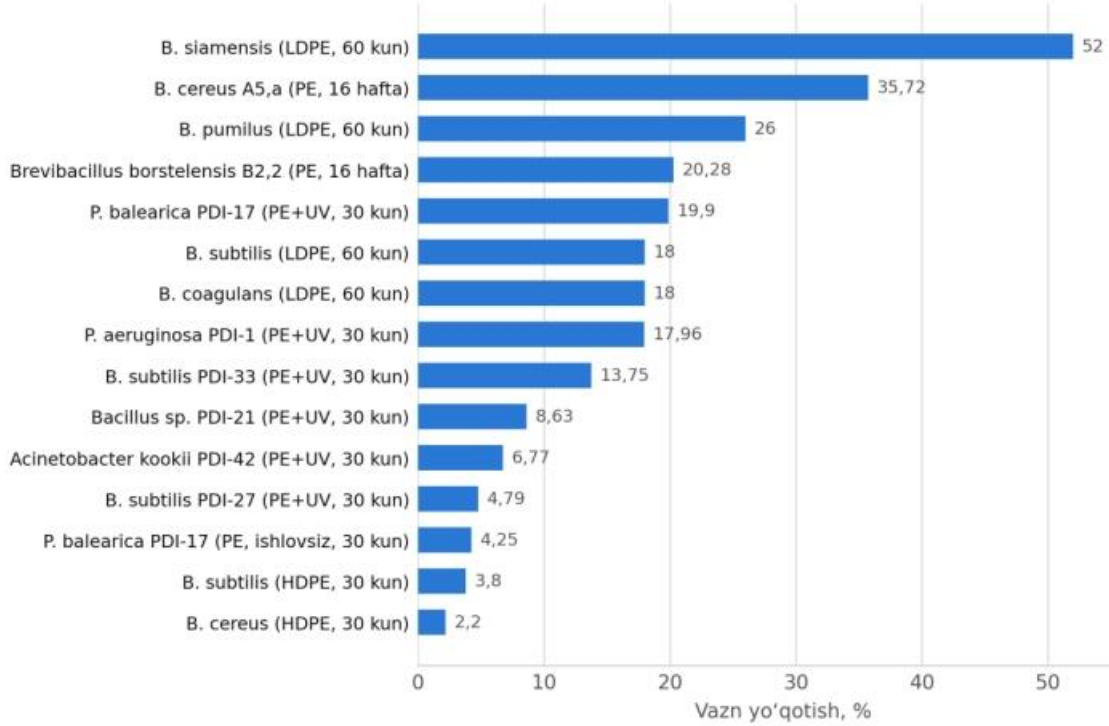
Shtamm	Ajratib olingan hudud	Polimer	Muddat	Vazn yo‘qotish, %	Identifikatsiya usuli	Manba
Bacillus siamensis	Owerri, Nigeriya	LDPE	60 kun	52,0	16S rDNK	[2]
Bacillus pumilus	Owerri, Nigeriya	LDPE	60 kun	26,0	16S rDNK	[2]
Bacillus coagulans	Owerri, Nigeriya	LDPE	60 kun	18,0	16S rDNK	[2]
Bacillus subtilis	Owerri, Nigeriya	LDPE	60 kun	18,0	16S rDNK	[2]
Bacillus cereus A5,a	Dandora, Keniya	PE	16 hafta	35,72 ± 4,01	16S rRNA	[7]
Brevibacillus borstelensis B2,2	Dandora, Keniya	PE	16 hafta	20,28 ± 2,30	16S rRNA	[7]
Pseudomonas balearica PDI-17	Adama, Efiopiya	PE + UV	30 kun	19,90	MALDI-TOF MS, 16S rRNA, alkB	[1]
Pseudomonas aeruginosa PDI-1	Adama, Efiopiya	PE + UV	30 kun	17,96	MALDI-TOF MS, 16S rRNA, alkB	[1]
Bacillus subtilis PDI-33	Adama, Efiopiya	PE + UV	30 kun	13,75	MALDI-TOF MS	[1]
Bacillus sp. PDI-21	Adama, Efiopiya	PE + UV	30 kun	8,63	16S rRNA	[1]

Shtamm	Ajratib olingan hudud	Polimer	Muddat	Vazn yo‘qotish, %	Identifikatsiya usuli	Manba
Acinetobacter kookii PDI-42	Adama, Efiopiya	PE + UV	30 kun	6,77	MALDI-TOF MS	[1]
Bacillus subtilis PDI-27	Adama, Efiopiya	PE + UV	30 kun	4,79	MALDI-TOF MS	[1]
Pseudomonas balearica PDI-17	Adama, Efiopiya	PE (ishlovsiz)	30 kun	4,25	MALDI-TOF MS, 16S rRNA	[1]
Bacillus subtilis	Kafrelsheikh, Misr	HDPE	30 kun	3,80	Biokimyoviy, SDS-PAGE	[5]
Bacillus cereus	Kafrelsheikh, Misr	HDPE	30 kun	2,20	Biokimyoviy, SDS-PAGE	[5]
Bacillus sp., Micrococcus sp.	Lagos, Nigeriya	PE / PS	6 hafta	25,0–31,2	Biokimyoviy testlar	[4]

Izoh: PE + UV — polietilenga tajribadan oldin ultrabinafsha nurlar bilan ishlov berilgan variant. PS — polistirol. Ko‘rsatkichlar tegishli manbalardagi gravimetrik tahlil natijalari asosida keltirilgan.

1-jadval ma’lumotlaridan ko‘rinib turibdiki, polietilenning bakterial parchalanish darajasi juda keng oralig‘da — 2,20 % dan 52,0 % gacha — o‘zgaradi. Bu farq uch asosiy omil bilan izohlanadi: polimer turi (LDPE HDPE ga qaraganda ancha oson parchalanadi, chunki uning kristalliligi past va tarmoqlanish darajasi yuqori), inkubatsiya muddati hamda polimerga dastlabki ishlov berilgan-berilmagani. Masalan, *B. subtilis* shtammi LDPE bilan 60 kun inkubatsiyada 18,0 % vazn yo‘qotishni ta’minlagan bo‘lsa [2], HDPE bilan 30 kunlik tajribada bu ko‘rsatkich atigi 3,80 % ni tashkil etgan [5].

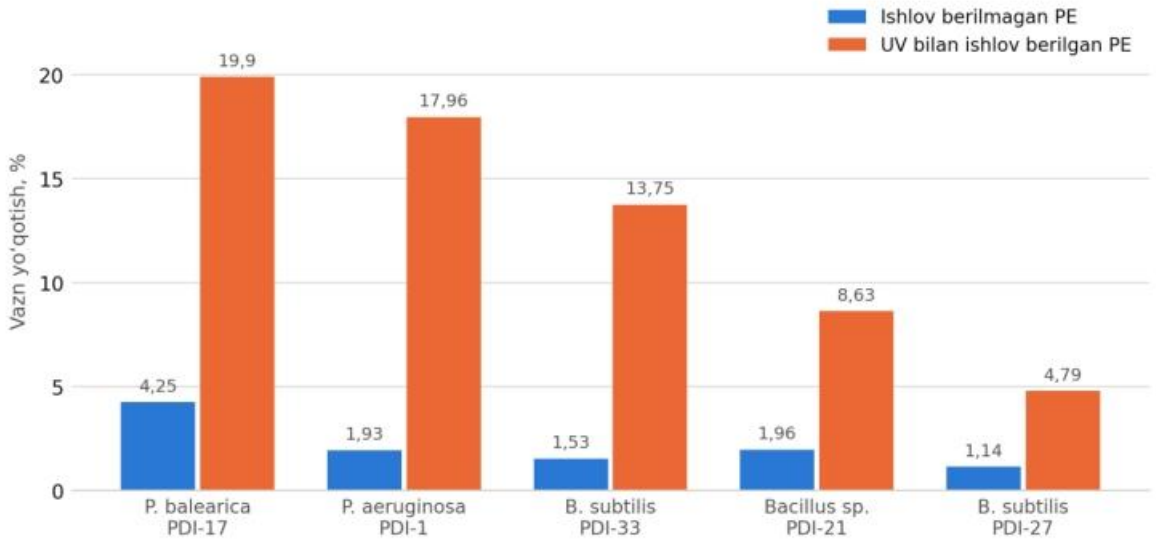
Umumiy natijalarning taqqoslama tahlili 1-rasmda keltirilgan.



1-rasm. Adabiyot manbalarida qayd etilgan Pseudomonas va Bacillus shtammlarining polietilenni parchalash samaradorligi (vazn yo‘qotish, %) [1, 2, 5, 7].

4. Dastlabki ishlov berishning parchalanish samaradorligiga ta’siri.

Polietilenning biologik parchalanishini cheklovchi asosiy omil — uning yuzasida fermentlar hujum qila oladigan qutbli guruhlarning yo‘qligidir. UV nurlari (365 nm) yoki termik ishlov (70 °C) ta’sirida polimer yuzasida karbonil guruhlari hosil bo‘lib, gidrofoblik pasayadi va mikrobial adgeziya kuchayadi [1]. Efiopiya tadqiqotida bu samaraning miqdoriy bahosi berilgan: bir oylik inkubatsiyada UV bilan ishlov berilmagan polietilenda vazn yo‘qotish 1,14–4,25 % ni tashkil etgan bo‘lsa, UV bilan ishlov berilganda bu ko‘rsatkich 4,79–19,90 % gacha ko‘tarilgan (2-rasm) [1].



2-rasm. Polietilenga UV nurlari bilan dastlabki ishlov berishning bakterial parchalanish samaradorligiga ta’siri (Adama, Efiopiya shtammlari misolida) [1].

Hisob-kitoblarga ko‘ra, UV bilan ishlov berish *P. aeruginosa* PDI-1 shtammida samaradorlikni 9,3 barobarga, *B. subtilis* PDI-33 shtammida 9,0 barobarga, *Bacillus* sp. PDI-21 shtammida 4,4 barobarga va *P. balearica* PDI-17 shtammida 4,7 barobarga oshirgan. Bu natija mahalliy sharoitda ishlab chiqiladigan bioremediatsiya texnologiyalarida polimerga fotooksidlovchi dastlabki ishlov berish bosqichini majburiy element sifatida kiritish zarurligini ko‘rsatadi. O‘zbekistonning quyoshli kunlar soni yuqori bo‘lgan iqlim sharoiti bu bosqichni tabiiy insolyatsiya hisobiga arzon amalga oshirish imkonini beradi.

5. Shtammlarni identifikatsiya qilish usullari.

Tahlil qilingan manbalarda identifikatsiya bosqichi ketma-ket uch darajada olib borilgan. Birinchi daraja — morfologik va biokimyoviy tavsiflash: Gram usulida bo‘yash, koloniya morfologiyasini o‘rganish, katalaza, oksidaza, indol, sitrat, urease testlari hamda uglevodlarni fermentlash xususiyatlari [1, 4]. Ikkinchi daraja — MALDI-TOF mass-spektrometriya: bunda hujayra oqsillarining mass-spektri ma’lumotlar bazasi bilan solishtiriladi; ≥ 2,0 ball tur darajasidagi ishonchli identifikatsiya sifatida qabul qilinadi [1]. Uchinchi daraja — molekulyar identifikatsiya: 16S rRNA genini universal praymerlar (8F — AGAGTTTGATCCTGGCTCAG va 1492R — TACGGTTACCTTGTTACGACTT) yordamida amplifikatsiya qilish, sekvenirlash va BLAST algoritmi orqali ma’lumotlar bazasidagi ketma-ketliklar bilan taqqoslash [1, 2, 7].

Alohida ahamiyatga ega bo‘lgan yondashuv — funksional genlarni aniqlash. Efiopiya tadqiqotida alkB (alkan gidroksilaza) geniga PZR o‘tkazilib, *P. aeruginosa* PDI-1, *P. aeruginosa* PDI-2, *P. balearica* PDI-17, PDI-11 va *P. balearica* PDI-39 shtammlari ushbu gen bo‘yicha musbat natija bergani aniqlangan; *B. cereus* PDI-8, *B. subtilis* PDI-27 va *Acinetobacter kookii* PDI-42 shtammlarida esa gen aniqlanmagan [1]. Muhim jihati shundaki, alkB geni bo‘yicha musbat bo‘lgan shtammlar aynan eng yuqori vazn yo‘qotish ko‘rsatkichlarini namoyon etgan. Bu holat alkB genini polietilen parchalovchi shtammlarni tez tanlab olish uchun ishonchli molekulyar marker sifatida qo‘llash mumkinligini ko‘rsatadi.

Amaliy ishda *Pseudomonas* va *Bacillus* avlodlarini dastlabki differensiatsiya qilish uchun 2-jadvalda keltirilgan test majmuasidan foydalanish tavsiya etiladi.

2-jadval

Pseudomonas spp. va Bacillus spp. avlodlarini differensiatsiya qilishning asosiy morfologik, biokimyoviy va molekulyar mezonlari

Mezon / test	*Pseudomonas spp.*	*Bacillus spp.*
Gram usulida bo‘yash	Manfiy (–), to‘g‘ri tayoqcha	Musbat (+), yirik tayoqcha
Endospora hosil qilish	Yo‘q	Bor (markaziy yoki terminal)
Katalaza	Musbat (+)	Musbat (+)
Oksidaza	Musbat (+), aksariyat turlarda	Odatda manfiy (–), o‘zgaruvchan
Harakatchanlik	Qutbiy xivchin(lar) hisobiga	Peritrix xivchinlar hisobiga
Pigment hosil qilish	Flüoressent pigmentlar (pioverdin, piotsianin)	Odatda pigmentsiz
Glyukozaga munosabat (OF test)	Oksidlovchi	Fermentlovchi yoki oksidlovchi
Tanlab olish usuli	King A va King B muhitlari	Namunani 80 °C da 10 daqiqa termik ishlash
Optimal o‘sish harorati	25–37 °C	30–45 °C (ayrim turlar termotolerant)
Optimal pH (PE muhitida)	7,2 (5,5–8,5 oralig‘ida o‘sadi)	7,2 (5,5–8,5 oralig‘ida o‘sadi)
Kalit molekulyar marker	alkB1, alkB2 genlari; 16S rRNA	16S rRNA; lakkaza va peroksidaza faolligi
Hujayradan tashqari fermentlar	Proteaza, lipaza	Proteaza, amilaza, esteraza

Izoh: jadval [1, 4] manbalaridagi tajriba ma’lumotlari va umumiy bakteriologiya uslubiyoti asosida tuzilgan.

6. Optimal sharoitlar va konsorsiumdan foydalanish.

Parchalanish samaradorligini oshirish uchun kultivatsiya sharoitlarini optimallashtirish talab etiladi. Efiopiya tadqiqotida uchta yetakchi shtamm uchun pH (5,5; 7,2; 8,5), harorat (25; 30; 37 °C) va polietilen konsentratsiyasi (0,05; 0,1; 0,5 % w/v) bo‘yicha optimallashtirish o‘tkazilgan. Eng yuqori hujayra quruq massasi va optik zichlik ko‘rsatkichlari pH 7,2 da qayd etilgan; *P. balearica* PDI-17 shtammi 0,5 % polietilen konsentratsiyasida eng yuqori OD_{600} (0,208) ni namoyon etgan [1]. Sho‘rlangan tuproqlardan ajratib olinadigan shtammlar uchun bu parametrlar qatoriga NaCl konsentratsiyasiga chidamlilik testini qo‘shish maqsadga muvofiq, chunki O‘zbekiston tuproqlarining sezilarli qismi turli darajada sho‘rlangan.

Yakka shtammlar o‘rniga konsorsiumdan foydalanish istiqbolli yo‘nalish hisoblanadi: turli fermentativ tizimga ega *Pseudomonas* va *Bacillus* shtammlarini birgalikda qo‘llash polimer zanjirining ketma-ket bosqichlarda parchalanishini ta’minlaydi. Zamburug‘larning ham yuqori faolligi qayd etilgan: Keniya tadqiqotida *Aspergillus oryzae* A5,1 shtammi 16 haftada 36,4 ± 5,53 % vazn yo‘qotishga erishgan va umuman zamburug‘lar bakteriyalarga nisbatan samaraliroq parchalovchi ekani ta’kidlangan [7]. Tanzaniya tadqiqotida esa *Phoma* sp. va *Aspergillus* sp. mos ravishda 66,3 mm va 61,1 mm shaffof zona hosil qilgan [3]. Shu bois kelgusi tadqiqotlarda bakterial-zamburug‘li aralash konsorsiumlarni sinash tavsiya etiladi.

7. O‘zbekiston sharoiti uchun taklif etilayotgan uslubiy sxema.

Tahlil natijalari asosida quyidagi besh bosqichli sxema taklif etiladi:

1-bosqich — namuna olish va boyitish. Toshkent, Samarqand, Buxoro va Farg‘ona vodiysidagi chiqindi poligonlari, polimer qayta ishlash korxonalari atrofidagi tuproqlar hamda oqova suvlardan 0–20 sm chuqurlikdan namunalar olinadi. Namunalar UV bilan ishlov berilgan polietilen plyonka bo‘laklari solingan MSM muhitiga joylashtirilib, 37 °C da 100–150 rpm tezlikda 30–60 kun inkubatsiya qilinadi.

2-bosqich — ajratib olish. Boyitilgan muhitdan Nutrient agar, King B (Pseudomonas uchun) muhitlariga ekiladi; Bacillus uchun namuna 80 °C da 10 daqiqa termik ishlovdan o‘tkaziladi. Koloniyalar takroriy ekish orqali tozalanib, sof kulturalar olinadi.

3-bosqich — skrining. Sof kulturalar maydalangan polietilen qo‘shilgan mineral agarda shaffof zona hosil qilishi hamda suyuq MSM muhitida OD600 o‘sishi bo‘yicha baholanadi. Eng faol 5–10 ta izolyat keyingi bosqichga tanlab olinadi.

4-bosqich — identifikatsiya. Morfologik va biokimyoviy tavsiflash (2-jadval), so‘ngra 16S rRNA genini sekvenirlash va BLAST tahlili; imkoniyat bo‘lsa MALDI-TOF MS. alkB geniga PZR o‘tkazish orqali funksional potensial tasdiqlanadi.

5-bosqich — samaradorlikni baholash va optimallashtirish. 30, 60 va 90 kunlik gravimetrik tahlil; FT-IR spektroskopiya orqali yangi funksional guruhlarni aniqlash; SEM orqali polimer yuzasidagi yoriq va g‘ovaklarni kuzatish. pH, harorat, polimer konsentratsiyasi va NaCl darajasi bo‘yicha optimallashtirish o‘tkaziladi.

Ushbu sxemaning ustunligi shundaki, u nisbatan arzon va standart mikrobiologik laboratoriya imkoniyatlari doirasida bajariladigan bosqichlardan (boyitish, skrining, gravimetriya) boshlanib, faqat eng istiqbolli izolyatlar uchun qimmat instrumental usullarga (MALDI-TOF MS, sekvenirlash, SEM, FT-IR) murojaat qilishni nazarda tutadi. Bu esa cheklangan resurslar sharoitida tadqiqot samaradorligini oshiradi.

XULOSA

1. Tahlil qilingan manbalar polietilenni parchalash qobiliyatiga ega shtammlar, asosan, uzoq muddat plastik chiqindilar ta’sirida bo‘lgan hududlardan — chiqindi poligonlari, polimer korxonalari atrofidagi tuproqlar va oqova suvlardan ajratib olinishini ko‘rsatadi. Mineral tuzli muhitda polietilenni yagona uglerod manbai sifatida qo‘llash tanlab olishning eng samarali usuli hisoblanadi.

2. Adabiyot ma’lumotlariga ko‘ra, Pseudomonas va Bacillus avlodlariga mansub shtammlar 30–112 kunlik inkubatsiyada 1,14–52,0 % oralig‘ida vazn yo‘qotishni ta’minlaydi. Eng yuqori ko‘rsatkichlar B. siamensis (52,0 %; LDPE, 60 kun), B. cereus

A5,a (35,72 %; PE, 16 hafta) va P. balearica PDI-17 (19,90 %; PE + UV, 30 kun) shtammlarida qayd etilgan.

3. Polietilenga UV nurlari bilan dastlabki ishlov berish parchalanish samaradorligini 4,2–9,3 barobarga oshiradi. Shu sababli bioremediatsiya texnologiyalarida fotooksidlovchi dastlabki ishlov berish bosqichi majburiy element sifatida qaralishi lozim.

4. Shtammlarni identifikatsiya qilishda uch bosqichli yondashuv — morfologik-biokimyoviy tavsiflash, MALDI-TOF MS va 16S rRNA genini sekvenirlash — eng ishonchli natija beradi. alkB (alkan gidroksilaza) genining mavjudligi shtammning yuqori parchalash faolligi bilan bog‘liq bo‘lib, uni tez skrining uchun molekulyar marker sifatida qo‘llash mumkin.

5. O‘zbekiston sharoitida yiliga 1 million tonnadan ortiq plastik chiqindi hosil bo‘lishi va qayta ishlash quvvatining atigi 6,6 % ni tashkil etishini hisobga olganda, mahalliy tuproqlardan sho‘rlanish va yuqori haroratga chidamli polietilen parchalovchi shtammlarni ajratib olish hamda ular asosida konsorsium yaratish dolzarb ilmiy-amaliy vazifa hisoblanadi. Taklif etilgan besh bosqichli uslubiy sxema bu ishlarni tizimli tashkil etish uchun asos bo‘lib xizmat qilishi mumkin.

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ISOLATION AND IDENTIFICATION OF BACTERIAL STRAINS (PSEUDOMONAS SPP., BACILLUS SPP.) ACCELERATING POLYETHYLENE DEGRADATION FROM LOCAL SITES

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Abstract. *The article analyses current methodological approaches to the isolation and identification of bacterial strains of the genera Pseudomonas spp. and Bacillus spp. involved in the biological degradation of polyethylene (PE) waste from locally contaminated sites — landfills, soils around polymer enterprises and wastewater. The analysis is based on international studies published between 2018 and 2025, together with screening results obtained in Uzbekistan. According to the literature, when polyethylene is supplied as the sole carbon source in mineral salt medium (MSM), strains achieved weight losses of 1.14–52.0 % over 30–112 days of incubation. The highest values were recorded for Bacillus siamensis (52.0 %; 60 days), Bacillus cereus A5,a (35.72 %; 16 weeks) and Pseudomonas balearica PDI-17 (19.90 %; 30 days) on UV-pretreated polyethylene. UV pretreatment increased degradation efficiency by a factor of 4.2–9.3. Alongside Gram staining and biochemical tests, MALDI-TOF MS, 16S rRNA gene sequencing and PCR detection of the alkB (alkane hydroxylase) gene were shown to be highly effective for strain identification. A five-stage methodological scheme adapted to the arid and saline soils of Uzbekistan is proposed.*

Keywords: *polyethylene, biodegradation, Pseudomonas spp., Bacillus spp., mineral salt medium, 16S rRNA, alkB gene, MALDI-TOF MS, bioremediation, landfill.*

Annotatsiya. *Maqolada mahalliy polietilen (PE) bilan ifloslangan hududlardan — chiqindi poligonlari, polimer korxonalari atrofidagi tuproqlar va oqova suvlardan — ajratib olingan hamda polietilen chiqindilarining biologik parchalanishida ishtirok etuvchi Pseudomonas spp. va Bacillus spp. avlodlariga mansub bakterial shtammlarni ajratish va identifikatsiya qilishning zamonaviy metodik yondashuvlari tahlil qilingan. Tahlil 2018–2025-yillarda e'lon qilingan xalqaro tadqiqotlar hamda O'zbekistonda olingan skrining natijalariga asoslangan. Adabiyotlar ma'lumotlariga ko'ra, polietilen mineral tuzlar muhitida (MSM) yagona uglerod manbai sifatida berilganda, bakterial shtammlar 30–112 kunlik inkubatsiya davomida uning massasini 1,14–52,0 % gacha kamaytirgan. Eng yuqori ko'rsatkichlar Bacillus siamensis shtammida 52,0 %*

(60 kun), Bacillus cereus A5,a shtammida 35,72 % (16 hafta) va ultrabinafsha (UV) nurlanish bilan oldindan ishlov berilgan polietilenda Pseudomonas balearica PDI-17 shtammida 19,90 % (30 kun) qayd etilgan. UV bilan oldindan ishlov berish biodegradatsiya samaradorligini 4,2–9,3 baravar oshirgan. Gram bo'yicha bo'yash va biokimyoviy testlar bilan bir qatorda, MALDI-TOF MS, 16S rRNK genini sekvenslash hamda alkB (alkan gidroksilaza) genini PCR yordamida aniqlash shtammlarni identifikatsiya qilishda yuqori samaradorlikka ega ekani ko'rsatilgan. O'zbekistonning qurg'oqchil va sho'rlangan tuproqlari sharoitiga moslashtirilgan besh bosqichli metodik sxema taklif etilgan.

Kalit so'zlar: *polietilen, biodegradatsiya, Pseudomonas spp., Bacillus spp., mineral tuzlar muhiti, 16S rRNK, alkB geni, MALDI-TOF MS, bioremediatsiya, chiqindi poligoni.*

Аннотация. *В статье проанализированы современные методические подходы к выделению и идентификации бактериальных штаммов родов Pseudomonas spp. и Bacillus spp., участвующих в биологической деструкции полиэтиленовых (ПЭ) отходов, из локально загрязнённых полиэтиленом участков — полигонов твёрдых бытовых отходов, почв вблизи предприятий полимерной промышленности и сточных вод. Анализ основан на международных исследованиях, опубликованных в период с 2018 по 2025 год, а также на результатах скрининга, проведённого в Узбекистане. Согласно литературным данным, при использовании полиэтилена в качестве единственного источника углерода в минеральной солевой среде (MSM) штаммы обеспечивали снижение его массы на 1,14–52,0 % в течение 30–112 суток инкубации. Наиболее высокие показатели были зарегистрированы для Bacillus siamensis — 52,0 % за 60 суток, Bacillus cereus A5,a — 35,72 % за 16 недель и Pseudomonas balearica PDI-17 — 19,90 % за 30 суток при использовании полиэтилена, предварительно обработанного ультрафиолетовым (УФ) излучением. Предварительная УФ-обработка повышала эффективность биодеструкции в 4,2–9,3 раза. Наряду с окрашиванием по Граму и биохимическими тестами, MALDI-TOF MS, секвенирование гена 16S рРНК и ПЦР-детекция гена alkB (алкангидроксилазы) продемонстрировали высокую эффективность для идентификации бактериальных штаммов. Предложена пятиэтапная методическая схема, адаптированная к условиям аридных и засолённых почв Узбекистана.*

Ключевые слова: *полиэтилен, биодеградация, Pseudomonas spp., Bacillus spp., минеральная солевая среда, 16S рРНК, ген alkB, MALDI-TOF MS, биоремедиация, полигон отходов.*

INTRODUCTION

Plastics have become an integral part of the global economy, with global production reaching nearly 430 million tons in 2024, growing at an average annual rate of 4.8% since 2009 [9]. In Europe, this figure stands at 54.6 million tons, accounting for 12% of global production [10]. The largest share of produced polymers belongs to polyethylene (PE), specifically its low-density (LDPE) and high-density (HDPE) modifications. Because polyethylene consists of a hydrocarbon chain with a high

molecular weight, hydrophobic properties, and a lack of hydrolyzable functional groups, it persists in natural conditions without degradation for decades [1, 3].

In the Republic of Uzbekistan, approximately 10.2 million tons of municipal solid waste are generated annually, with over 10% (about 1.05 million tons) consisting of plastic waste. Currently, the 116 processing enterprises operating in the country have the capacity to recycle only about 130,000 tons of plastic per year, which accounts for 6.6% of the total volume [11]. The remaining portion is land filled or accumulates uncontrolled. This situation causes environmental hazards such as a decrease in soil fertility and pollution of groundwater. Traditional methods of plastic waste disposal—incineration and landfilling—are associated with the emission of toxic gases into the air and long-term secondary pollution, respectively [1]. Therefore, in recent years, the biological degradation (biodegradation) of polymers using microorganisms has been widely studied as a low-cost, energy-efficient, and environmentally safe alternative [3, 4].

The microbiological degradation of polyethylene is a multi-stage process. Initially, bacteria form a biofilm on the polymer surface; under the influence of abiotic factors (UV radiation, high temperatures), carbonyl, carboxyl, and hydroxyl groups are formed on the polymer surface, reducing hydrophobicity and facilitating microbial attack. In the next stage, the alkane monooxygenase (AlkB) enzyme hydroxylates the terminal methyl group of the hydrocarbon chain, converting it into the corresponding alcohol; the resulting alcohol is sequentially oxidized to an aldehyde and a fatty acid, entering the intracellular beta-oxidation pathway [8]. The alkB1and alkB2 genes involved in this process have been identified in the genome of *Pseudomonas aeruginosa* and are used as molecular markers in selecting polyethylene-degrading strains [1, 8]. In addition, extracellular enzymes such as laccase, peroxidase, protease, and esterase also participate in the cleavage of the polymer chain [1, 5].

To date, numerous strains belonging to the genera *Bacillus spp., Pseudomonas spp., Brevibacillus, Acinetobacter, Rhodococcus, Lysinibacillus,* and *Enterobacter* with polyethylene-degrading properties have been described [1, 2, 6, 7]. They are mainly isolated from soils where plastic waste has accumulated for a long time, because in such areas, microbiocenoses capable of utilizing the polymer as a carbon source have formed as a result of natural selection [3, 4]. Initial work in this direction has also begun in Uzbekistan: at the Institute of Microbiology of the Academy of Sciences of the Republic of Uzbekistan, the activity of *Pseudomonas putida, P. aeruginosa, Rahnella aquatilis, Enterobacter cloacae,* and *E. ludwigii* strains against LDPE, HDPE, PET, and polyvinylpyrrolidone was screened using UV spectrophotometry; it was found that the E. cloacae strain produced 13.99 times more organic compounds upon incubation with HDPE compared to the control [6]. At the same time, systematic research on targeted isolation and molecular-level identification of polyethylene-degrading strains belonging specifically to the genera *Pseudomonas* and *Bacillus* from the dry, saline, and high-temperature soils of our country is still insufficient. "The purpose of this article is to isolate and identify strains of *Pseudomonas spp.* and *Bacillus spp.* that accelerate polyethylene degradation from locally polluted areas, and to develop a methodological scheme applicable under the conditions of Uzbekistan."

MATERIALS AND METHODS.

The study is of an analytical and methodological nature, utilizing as primary sources six key experimental articles published in international peer-reviewed journals between 2018 and 2025, alongside the results of screening conducted in Uzbekistan [1–7]. The selection of sources was guided by the following criteria: (a) strains must have been isolated from naturally polluted environments (landfills, soil, waste water); (b) the degradation of polyethylene (LDPE, HDPE, or general PE) must have been evaluated quantitatively—via gravimetric analysis or clear zone diameter; (c) strains must have been identified using at least biochemical or molecular methods. For comparative analysis, the following indicators were extracted from each source: strain name, isolation source, studied polymer type, incubation period and conditions, weight loss percentage, and identification method. The weight loss indicator was calculated across all sources based on the following general formula [1, 5]: Weight loss (%) = [(Initial weight − Final weight) / Initial weight] × 100 To ensure comparability, various polymer types (LDPE, HDPE, general PE) and differing incubation periods were designated separately, as these factors significantly influence the results and comparing them without consideration could lead to erroneous conclusions. Graphical analysis and diagrams were prepared in the Python 3.9 (Matplotlib 3.9) programming environment.

Additionally, based on the analyzed sources, a five-stage methodological scheme adapted for the conditions of Uzbekistan—comprising sampling and enrichment, strain isolation, screening, identification, and optimization stages—was formulated and described below.

RESULTS AND DISCUSSION.

1. Sampling sites and enrichment stage. In all analyzed sources, effective strains were isolated from areas subjected to long-term plastic waste exposure: from the Adama (Ethiopia) landfill [1], municipal landfills in Owerri (Nigeria) [2], agricultural soils in Morogoro (Tanzania) [3], dumpsites in Alimosho district, Lagos (Nigeria) [4], and the Dandora (Kenya) landfill [7]. This pattern serves as an important criterion in selecting sampling points under local conditions: soil layers buried with polyethylene waste, landfills, soil around polymer recycling enterprises, and wastewater are recommended as the most promising objects.

At the enrichment stage, the soil sample is placed in a mineral salt medium (MSM) along with pieces of polyethylene film pre-treated with UV rays. In the Ethiopian study, the composition of the carbon-free basal medium was as follows (g/l): KH_2PO_4 — 0.7; K_2HPO_4 — 0.7; $MgSO_4 \cdot 7H_2O$ — 0.7; NH_4NO_3 — 1.0, and trace elements; samples were incubated at 37 °C for over 14 days [1]. Under such conditions, since polyethylene is the sole carbon source, only microorganisms capable of utilizing it multiply, meaning the selection process occurs automatically.

2. Strain isolation and primary screening. Samples taken from the enriched medium are inoculated onto nutrient agar or selective media. For the isolation of the genus *Bacillus*, thermal treatment of the sample at 80 °C for 10 minutes (to eliminate vegetative cells while preserving endospores) is considered an effective method. Colonies with distinct morphologies are purified through repeated subculturing to

obtain pure cultures [1, 4]. Primary screening is carried out using two methods. The first is observing the formation of a clear zone around the colony on mineral agar supplemented with powdered polyethylene. In the Tanzanian study, bacterial isolates formed zones with diameters of 19.3–47.5 mm in 17 days, actinomycetes 25.9–32.2 mm, and fungi 30.0–66.3 mm in 13 days [3]. The second method is monitoring the increase in optical density (OD600) in a liquid medium: in the Nigerian study, OD600 increased from 0.12 to 0.84 for *B. siamensis* and from 0.11 to 0.67 for *B. pumilus* within 60 days, whereas it remained unchanged (0.11) in the control medium [2].

3. Polyethylene degradation efficiency. The main results reported in the analyzed sources are summarized in Table 1. Polyethylene degradation indicators of strains isolated from locally polluted areas (generalized literature data) **Strain Isolation site Polymer Period Weight loss, % Identification method Source**

STRAIN	ISOLATION SITE	POLYMER	PERIOD	WEIGHT LOSS, %	IDENTIFICATION METHOD	SOURCE
Bacillus siamensis	Owerri, Nigeria	LDPE	60 days	52,0	16S rDNK	[2]
Bacillus pumilus	Owerri, Nigeria	LDPE	60 days	26,0	16S rDNK	[2]
Bacillus coagulans	Owerri, Nigeria	LDPE	60 days	18,0	16S rDNK	[2]
Bacillus subtilis	Owerri, Nigeria	LDPE	60 days	18,0	16S rDNK	[2]
Bacillus cereus A5,a	Dandora, Kenia	PE	16 week	35,72 ± 4,01	16S rRNA	[7]
Brevibacillus borstelensis B2,2	Dandora, Kenia	PE	16 weeks	20,28 ± 2,30	16S rRNA	[7]
Pseudomonas balearica PDI-17	Adama, Efiopia	PE + UV	30 days	19,90	MALDI-TOF MS, 16S rRNA, alkB	[1]
Pseudomonas aeruginosa PDI-1	Adama, Efiopia	PE + UV	30 days	17,96	MALDI-TOF MS, 16S rRNA, alkB	[1]
Bacillus subtilis PDI-33	Adama, Efiopia	PE + UV	30 days	13,75	MALDI-TOF MS	[1]
Bacillus sp. PDI-21	Adama, Efiopia	PE + UV	30 days	8,63	16S rRNA	[1]
Acinetobacter kookii PDI-42	Adama, Efiopia	PE + UV	30 days	6,77	MALDI-TOF MS	[1]
Bacillus subtilis PDI-27	Adama, Efiopia	PE + UV	30 dayss	4,79	MALDI-TOF MS	[1]
Pseudomonas balearica PDI-17	Adama, Efiopia	PE (ishlovsiz)	30 days	4,25	MALDI-TOF MS, 16S rRNA	[1]
Bacillus subtilis	Kafrelsheikh,	HDPE	30 days	3,80	Biochemical, SDS-PAGE	[5]
Bacillus cereus	Kafrelsheikh,	HDPE	30 days	2,20	Biochemical, SDS-PAGE	[5]
Bacillus sp., Micrococcus sp.	Lagos, Nigeria	PE / PS	6 weeks	25,0–31,2	Biochemical tests	[4]

Note: PE + UV — variant where polyethylene was pre-treated with ultraviolet radiation prior to the experiment. PS — polystyrene. Indicators are presented based on gravimetric analysis results from respective sources. As can be seen from the data in Table 1, the bacterial degradation rate of polyethylene varies across a very wide range—from 2.20% to 52.0%. This difference is explained by three main factors: the type of polymer (LDPE degrades much easier than HDPE due to its lower crystallinity

and higher degree of branching), the incubation period, and whether the polymer was pre-treated or not. For instance, while the *B. subtilis* strain provided an 18.0% weight loss upon 60 days of incubation with LDPE [2], this figure was only 3.80% in a 30-day experiment with HDPE [5].

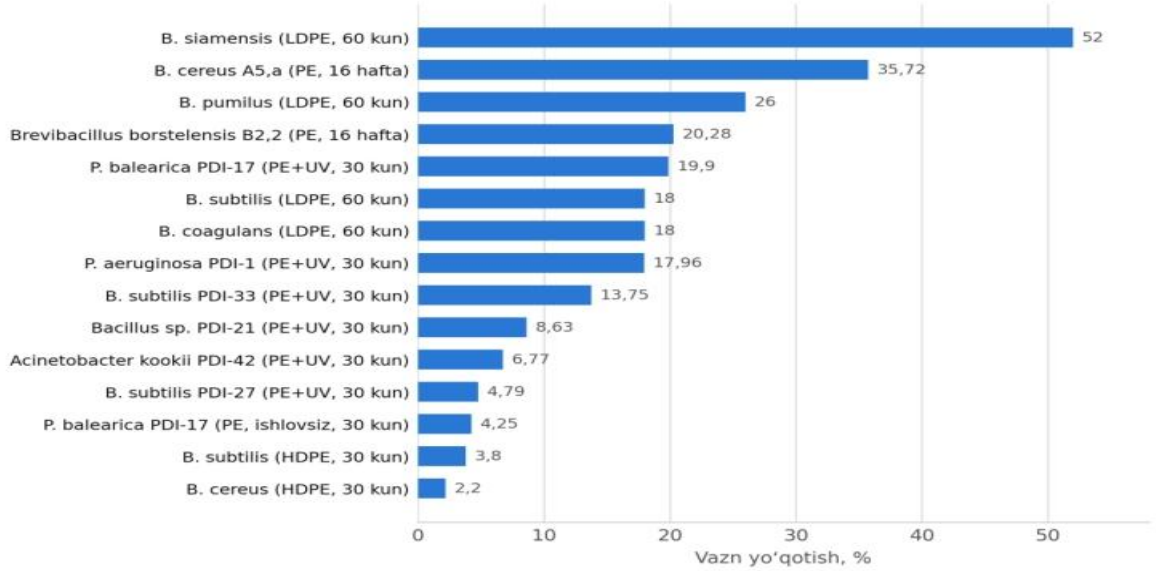

Figure 1. Degradation efficiency of polyethylene (weight loss, %) by Pseudomonas and Bacillus strains reported in literature sources [1, 2, 5, 7].

4. Effect of pre-treatment on degradation efficiency.

The main factor limiting the biodegradation of polyethylene is the absence of polar groups on its surface that enzymes can attack. Under the influence of UV rays (365 nm) or thermal treatment (70 °C), carbonyl groups form on the polymer surface, reducing hydrophobicity and enhancing microbial adhesion [1]. The Ethiopian study provided a quantitative evaluation of this effect: after one month of incubation, weight loss in non-UV-treated polyethylene was 1.14–4.25%, whereas with UV treatment, this figure increased to 4.79–19.90% (Figure 2) [1].

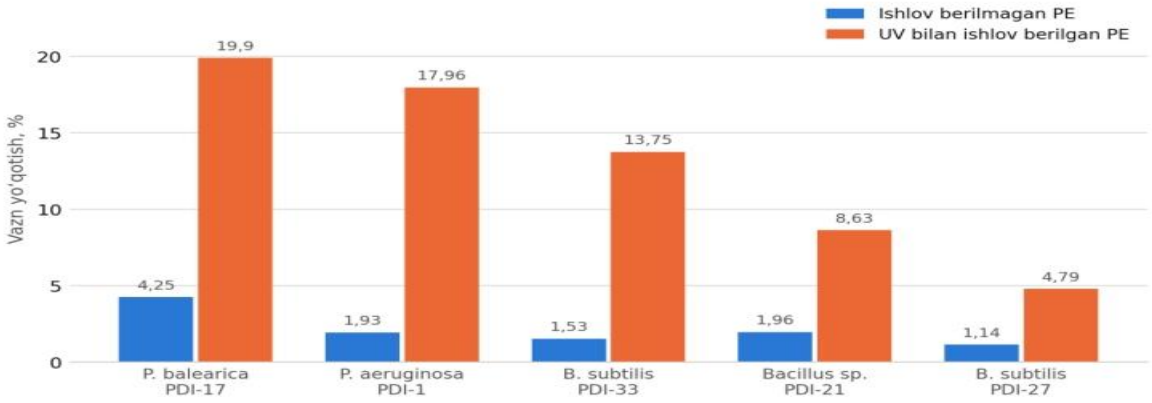

Figure 2. Effect of pre-treatment of polyethylene with UV radiation on bacterial degradation efficiency (using strains from Adama, Ethiopia as an example) [1].

According to calculations, UV pre-treatment increased the efficiency by 9.3-fold for the P. aeruginosa PDI-1 strain, 9.0-fold for the B. subtilis PDI-33 strain, 4.4-fold for the Bacillus sp. PDI-21 strain, and 4.7-fold for the P. balearica PDI-17 strain. This result demonstrates the necessity of incorporating the photo-oxidative pre-treatment

stage as a mandatory element in bioremediation technologies developed under local conditions. Uzbekistan's climatic conditions, characterized by a high number of sunny days, allow this stage to be implemented cost-effectively through natural insolation.

5. Strain identification methods. In the analyzed sources, the identification stage was carried out at three successive levels. The first level is morphological and biochemical characterization: Gram staining, studying colony morphology, catalase, oxidase, indole, citrate tests, and carbohydrate fermentation properties [1, 4]. The second level is MALDI-TOF mass spectrometry, where the mass spectrum of cellular proteins is compared with a database; a score of ≥ 2.0 is accepted as reliable identification at the species level [1]. The third level is molecular identification: amplification of the 16S rRNA gene using universal primers (8F — AGAGTTTGATCCTGGCTCAG and 1492R — TACGGTTACCTTGTTACGACTT), sequencing, and comparison with sequences in the database using the BLAST algorithm [1, 2, 7].

An approach of particular importance is the identification of functional genes. In the Ethiopian study, PCR was performed for the *alkB* (alkane hydroxylase) gene, and it was found that *Pseudomonas aeruginosa* PDI-1, *P. aeruginosa* PDI-2, *P. balearica* PDI-17, PDI-11, and *P. balearica* PDI-39 strains tested positive for this gene; whereas the gene was not detected in *Bacillus cereus* PDI-8, *B. subtilis* PDI-27, and *Acinetobacter kookii* PDI-42 strains [1]. Importantly, the strains that tested positive for the *alkB* gene exhibited the highest weight loss rates. This indicates that the *alkB* gene can be used as a reliable molecular marker for the rapid selection of polyethylene-degrading strains. In practical work, it is recommended to use the test set presented in Table 2 for the initial differentiation of the genera *Pseudomonas* and *Bacillus*.

Ctirerion / test	*Pseudomonas spp.*	*Bacillus spp.*
Gram straining	Negative (–), straight rod	Positive (+), large rod
Endospore formation	Absent	Present
Catalase	Positive (+)	Positive (+)
Oxidase	Positive (+)	Usually negative(-)
Motility	Via polar flagellum	Peritrix xivchinlar hisobiga
Pigment production	Fluorescent pigments (pyoverdine, pyocyanin)	Usually non-pigmented
Response to gluose (OF test)	Oxidative	Fermentative or oxidative
Selection method	King A va King B media	Thermal treatment of the sample 80 °C for 10 minutes
Optimal growth terperature	25–37 °C	30–45 °C
Optimal pH (PE medium)	7,2 (grows in the 5,5–8,5 range)	7,2 (grows in the 5,5–8,5 range)
Key molekular marker	alkB1, alkB2 genes ; 16S rRNA	16S rRNA;
Extracelluler enzymes	Protease , lipase	Protease , amylase, esterase

Note: The table is compiled based on experimental data from sources [1, 4] and general bacteriological methodology.

6. Optimal conditions and use of consortia. Optimizing cultivation conditions is required to increase degradation efficiency. In the Ethiopian study, optimization was carried out for three leading strains regarding pH (5.5; 7.2; 8.5), temperature (25; 30; 37 °C), and polyethylene concentration (0.05; 0.1; 0.5% w/v) [1]. The highest dry cell mass and optical density values were recorded at pH 7.2; the *P. balearica* PDI-17 strain showed the highest OD600 (0.208) at a 0.5% polyethylene concentration [1]. For strains isolated from saline soils, it is advisable to include a NaCl concentration resistance test among these parameters, as a significant portion of Uzbekistan's soils are saline to varying degrees.

Using a consortium instead of single strains is a promising approach: the combined application of *Pseudomonas* and *Bacillus* strains with different enzymatic systems ensures the sequential breakdown of the polymer chain. High activity of fungi has also been noted: in the Kenyan study, the *Aspergillus oryzae* A5.1 strain achieved a weight loss of 36.4 ± 5.53% in 16 weeks, and it was emphasized that fungi are generally more efficient degraders than bacteria [7]. In the Tanzanian study, *Phoma* sp. and *Aspergillus* sp. formed clear zones of 66.3 mm and 61.1 mm, respectively [3]. Therefore, testing mixed bacterial-fungal consortia in future research is recommended.

7. Proposed methodological scheme for the conditions of Uzbekistan. Based on the analysis results, the following five-stage scheme is proposed: Stage 1 — sampling and enrichment. Samples are collected from a depth of 0–20 cm from municipal solid waste landfills, soils around polymer processing enterprises, and wastewaters in Tashkent, Samarkand, Bukhara, and the Fergana Valley. Samples are placed in an MSM medium containing pieces of polyethylene film pre-treated with UV radiation, and incubated at 37 °C with shaking at 100–150 rpm for 30–60 days. Stage 2 — isolation. Inoculation from the enriched medium is carried out onto Nutrient Agar and King B media (for *Pseudomonas*); for *Bacillus*, the sample is subjected to thermal treatment at 80 °C for 10 minutes. Colonies are purified through repeated subculturing to obtain pure cultures.

Stage 3 — screening. Pure cultures are evaluated based on clear zone formation on mineral agar supplemented with powdered polyethylene and the increase in OD600 in liquid MSM medium. The 5–10 most active isolates are selected for the next stage. Stage 4 — identification. Morphological and biochemical characterization (Table 2), followed by 16S rRNA gene sequencing and BLAST analysis; MALDI-TOF MS when available. The functional potential is confirmed by PCR targeting the *alkB* gene. Stage 5 — efficiency evaluation and optimization. Gravimetric analysis at 30, 60, and 90 days; identification of new functional groups via FT-IR spectroscopy; observation of cracks and pores on the polymer surface using SEM. Optimization is carried out regarding pH, temperature, polymer concentration, and NaCl levels. The advantage of this scheme is that it begins with relatively inexpensive steps achievable within standard microbiological laboratory capabilities (enrichment, screening, gravimetry), while reserving expensive instrumental methods (MALDI-TOF MS, sequencing, SEM, FT-IR) exclusively for the most promising isolates. This increases research efficiency under conditions of limited resources.

CONCLUSION

1. The analyzed sources indicate that strains capable of degrading polyethylene are mainly isolated from areas subjected to long-term plastic waste exposure—landfills, soils around polymer enterprises, and wastewaters. Using polyethylene as the sole carbon source in a mineral salt medium is the most effective selection method.
2. According to literature data, strains belonging to the genera *Pseudomonas* and *Bacillus* provide a weight loss ranging from 1.14% to 52.0% during 30–112 days of incubation. The highest rates were recorded for *B. siamensis* (52.0%; LDPE, 60 days), *B. cereus* A5,a (35.72%; PE, 16 weeks), and *P. balearica* PDI-17 (19.90%; PE + UV, 30 days) strains.
3. Pre-treatment of polyethylene with UV radiation increases degradation efficiency by 4.2- to 9.3-fold. Therefore, the photo-oxidative pre-treatment stage should be considered a mandatory element in bioremediation technologies.
4. A three-tier approach in strain identification—morphological-biochemical characterization, MALDI-TOF MS, and 16S rRNA gene sequencing—yields the most reliable results. The presence of the *alkB* (alkane hydroxylase) gene is associated with high degradation activity of the strain, allowing it to be used as a molecular marker for rapid screening.
5. Considering that over 1 million tons of plastic waste are generated annually in Uzbekistan and the recycling capacity accounts for only 6.6%, isolating salt- and high-temperature-tolerant polyethylene-degrading strains from local soils and creating a consortium based on them is an urgent scientific and practical task. The proposed five-stage methodological scheme can serve as a basis for organizing these efforts systematically.

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SCIENTIFIC AND PRACTICAL ANALYSIS OF FACTORS INFLUENCING THE SELECTION OF GASKET MATERIALS

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Abstract. *This review article presents a comparative analysis of the engineering, materials science, and operational principles underlying gasket selection based on three scientific and technical sources. The study considers the specific operating conditions encountered in the industrial, municipal utility, water supply, district heating, and oil and gas infrastructure sectors of the Republic of Uzbekistan. Particular attention is paid to the effects of high summer temperatures, water mineralization and salt content, as well as the corrosion susceptibility of pipelines and flange materials on the service life and reliability of gaskets. The mechanical, thermal, and chemical properties of metallic, non-metallic, polymeric, and hybrid gasket materials are analyzed, and their performance in both low- and high-pressure systems is evaluated. Furthermore, corrosion mechanisms and geometric incompatibility resulting from improper gasket selection are discussed from a scientific perspective. Based on the findings, practical recommendations are proposed for gasket selection under the operating conditions of Uzbekistan, and optimal selection strategies are suggested for municipal and industrial facilities. This article provides methodological and practical value for engineering students, design engineers, and maintenance and operation specialists.*

Keywords: *gasket, flanged joints, sealing performance, material selection, corrosion, water supply systems, district heating networks, oil and gas infrastructure, low- and high-pressure systems, polymer and hybrid gaskets, operational reliability, Uzbekistan.*

Annotatsiya. *Ushbu sharh maqolada uchta ilmiy-texnik manba asosida zichlagich prokladkalarini tanlashning muhandislik, materialshunoslik va ekspluatatsion tamoyillari qiyosiy tahlil qilingan. Tadqiqotda O‘zbekiston Respublikasining sanoat, kommunal xo‘jalik, suv ta’minoti, issiqlik ta’minoti hamda neft-gaz infratuzilmasi sohalariga xos ekspluatatsiya sharoitlari ko‘rib chiqilgan. Ayniqsa, yozgi yuqori haroratlar, suvning minerallashuvi va tuz miqdori, shuningdek, quvurlar hamda flanets materiallarining korroziyaga moyilligi zichlagich prokladkalarining xizmat muddati va ishonchliligiga ta’siriga alohida e’tibor qaratilgan. Metall, nometall, polimer va gibrid zichlagich materiallarining mexanik, termik va kimyoviy xossalari tahlil qilinib, ularning past va yuqori bosimli tizimlardagi ekspluatatsion samaradorligi baholangan. Shuningdek, prokladkani noto‘g‘ri tanlash*

natijasida yuzaga keladigan korroziya mexanizmlari va geometrik mos kelmaslik muammolari ilmiy nuqtai nazardan yoritilgan. Olingan natijalar asosida O‘zbekiston ekspluatatsiya sharoitlari uchun zichlagich prokladkalarini tanlash bo‘yicha amaliy tavsiyalar ishlab chiqilgan hamda kommunal va sanoat obyektlari uchun optimal tanlash strategiyalari taklif etilgan. Maqola muhandislik yo‘nalishi talabalari, loyihalash muhandislari, shuningdek, muhandislik tizimlarini ekspluatatsiya qilish va texnik xizmat ko‘rsatish sohasi mutaxassislari uchun uslubiy va amaliy ahamiyatga ega.

Kalit so‘zlar: *zichlagich prokladka, flanetsli birikmalar, germetiklik, material tanlash, korroziya, suv ta’minoti tizimlari, issiqlik ta’minoti tarmoqlari, neft-gaz infratuzilmasi, past va yuqori bosimli tizimlar, polimer va gibrid prokladkalar, ekspluatatsion ishonchlilik, O‘zbekiston.*

Аннотация. *В данной обзорной статье представлен сравнительный анализ инженерных, материаловедческих и эксплуатационных принципов выбора уплотнительных прокладок на основе трех научно-технических источников. В исследовании рассмотрены особенности условий эксплуатации, характерные для промышленного сектора, коммунального хозяйства, систем водоснабжения, теплоснабжения, а также нефтегазовой инфраструктуры Республики Узбекистан. Особое внимание уделено влиянию высоких летних температур, минерализации и солесодержания воды, а также коррозионной активности трубопроводов и материалов фланцев на срок службы и надежность уплотнительных прокладок. Проанализированы механические, термические и химические свойства металлических, неметаллических, полимерных и гибридных уплотнительных материалов, а также дана оценка их эксплуатационной эффективности в системах низкого и высокого давления. Кроме того, с научной точки зрения рассмотрены механизмы коррозии и проблемы геометрической несовместимости, возникающие вследствие неправильного выбора прокладок. На основе полученных результатов предложены практические рекомендации по выбору уплотнительных прокладок для условий эксплуатации Республики Узбекистан, а также определены оптимальные стратегии их применения на объектах коммунального и промышленного назначения. Статья представляет методическую и практическую ценность для студентов инженерных специальностей, инженеров-проектировщиков, а также специалистов по эксплуатации и техническому обслуживанию инженерных систем.*

Ключевые слова: *уплотнительная прокладка, фланцевые соединения, герметичность, выбор материала, коррозия, системы водоснабжения, сети теплоснабжения, нефтегазовая инфраструктура, системы низкого и высокого давления, полимерные и гибридные прокладки, эксплуатационная надежность, Узбекистан.*

INTRODUCTION

The reliable and uninterrupted operation of pipelines, heat exchangers, pumping stations, and various technological equipment used in industrial and municipal utility systems primarily depends on the integrity of their sealing performance. Ensuring leak-

tightness is largely determined by the quality of flange connections and the proper selection of gaskets installed between the mating surfaces. Gaskets compensate for microscopic surface irregularities and roughness between two rigid flanges, thereby preventing the leakage of working media such as water, steam, gas, petroleum products, or chemical solutions while ensuring the safe operation of engineering systems. In modern engineering practice, gasket selection is not merely a routine technical task but a complex multidisciplinary process involving materials science, mechanics, thermodynamics, and corrosion engineering. An improperly selected gasket may lead not only to fluid leakage and energy losses but also to accelerated corrosion of flange surfaces, equipment failure, emergency shutdowns, and increased environmental risks. Therefore, scientifically justified and standards-based gasket selection has become an essential requirement for industrial enterprises and municipal utility systems.

The issue of gasket selection is particularly important under the conditions of the Republic of Uzbekistan. The country's continental climate, characterized by high summer temperatures, the elevated mineralization and salt content of water resources in certain regions, and the widespread presence of oil and gas as well as chemical processing industries impose more stringent requirements on gasket materials. For example, elevated operating temperatures may accelerate thermal degradation and creep-relaxation phenomena in rubber- and polymer-based gaskets, while mineralized water containing chloride ions can increase the risk of corrosion when in contact with metallic flange materials. In recent years, considerable international research has focused on evaluating the chemical stability, mechanical performance, and operational reliability of gasket materials. These studies have investigated the behavior of metallic, non-metallic, polymeric, and hybrid gasket materials under various pressure-temperature conditions and working environments, as well as their interactions with flange materials.

The objective of this analytical paper is to systematically examine the theoretical and practical aspects of gasket selection based on the comparative analysis of three scientific and technical sources and to adapt the obtained findings to the operational conditions of industrial and municipal utility systems in Uzbekistan. The paper discusses the classification of gasket materials, their mechanical, thermal, and chemical characteristics, the potential problems arising from improper gasket selection, and practical recommendations for preventing sealing failures and improving operational reliability.

PROBLEM STATEMENT

With the rapid development of industrial and municipal infrastructure, ensuring the reliable and uninterrupted operation of pipeline systems, district heating networks, oil and gas facilities, and water supply installations has become a strategic priority. The leak-tight performance of these systems largely depends on the proper selection of flange connections and the gaskets installed between mating surfaces. Practical experience demonstrates that inappropriate gasket selection frequently results in fluid leakage, energy losses, equipment failure, accelerated corrosion, and, ultimately, operational accidents. This issue is particularly significant under the environmental and

operating conditions of the Republic of Uzbekistan. The country's sharply continental climate, characterized by high summer temperatures, together with the elevated mineralization and salt concentration of water resources in certain regions, imposes additional aggressive effects on both metallic flanges and gasket materials. Under such conditions, improperly selected gaskets may experience accelerated degradation, leading to premature sealing failure and increased corrosion of flange assemblies. Furthermore, the growing national policy of import substitution and the expanded use of locally available engineering materials have highlighted the importance of evaluating the technical and chemical properties of gasket materials, their compliance with international standards, and their suitability for local operating environments. Although the use of inexpensive or readily available materials may reduce initial costs, it often results in higher maintenance expenses, reduced service life, and lower overall system reliability over the long term.

In addition, increasingly stringent environmental protection requirements and occupational health and safety regulations have transformed gasket selection into not only a technical challenge but also an important socio-economic and environmental issue. Leakage of hazardous or valuable process media may cause environmental contamination, pose risks to public health, and increase the economic liabilities of industrial enterprises. Consequently, the optimization of gasket selection has become an essential component of sustainable industrial operation and infrastructure management.

Considering these factors, the development of a scientifically justified, standardized, and locally adapted methodology for gasket selection represents an important scientific and practical challenge. This paper analyzes the engineering, materials science, and operational aspects of gasket selection and proposes practical recommendations specifically adapted to the environmental and industrial conditions of Uzbekistan.

LITERATURE REVIEW

Extensive research has been conducted on gasket materials and their operational performance. Numerous studies have focused on the classification of gasket materials, as well as their mechanical strength, thermal stability, and chemical resistance. The advantages and limitations of metallic, non-metallic, polymeric, and composite gasket materials have been comparatively evaluated from the perspective of materials science. These investigations demonstrate that gasket selection should be based not only on pressure and temperature conditions but also on the chemical characteristics of the working medium and the compatibility of the gasket with the flange material. Engineering studies have primarily concentrated on the sealing mechanism of flanged joints. It has been established that leak-tightness is governed by the equilibrium among bolt preload, gasket deformation, and internal operating pressure. According to the literature, adequate contact pressure must be maintained throughout service life to prevent leakage through microscopic surface imperfections. Insufficient gasket compression or loss of preload caused by relaxation may significantly reduce sealing performance, particularly under cyclic thermal and mechanical loading. Research on corrosion has demonstrated that gasket materials may either accelerate or mitigate crevice corrosion occurring at the flange interface. In particular, studies have reported

that stainless steel flanges used with graphite- and PTFE-filled gaskets may exhibit increased electrochemical activity in chloride-containing environments, thereby promoting localized corrosion. Furthermore, investigations of spiral-wound metallic gaskets employed in high-pressure systems have emphasized the importance of galvanic compatibility between gasket components and flange materials. Electrochemical coupling between dissimilar metals may accelerate corrosion of the less noble material, reducing the service life of the sealing assembly.

A number of internationally recognized standards are widely applied in gasket selection and flange joint design. The most significant standards include:

- **ASME B16.5** – specifies the dimensions, pressure classes, and design requirements for pipe flanges and flanged fittings.
- **ASTM A182** – defines the material requirements for forged alloy steel and stainless steel flanges, fittings, valves, and related components intended for high-temperature applications.
- **ISO 7005** – establishes international requirements for flange dimensions, geometric parameters, and compatibility.
- **NORSOK M-001** – provides recommendations for the selection of corrosion-resistant materials, particularly for aggressive industrial environments.

These standards provide the theoretical and engineering basis for gasket selection by defining acceptable limits for flange geometry, bolt loading, mechanical properties, and material compatibility. In Uzbekistan, many construction and industrial regulations have been harmonized with these international standards, and their requirements are increasingly incorporated into engineering design and industrial practice.

Based on the available literature, several fundamental concepts have been established for understanding gasket selection:

- **Leak-tightness** – the capability of a gasket–flange interface to prevent leakage of the process medium by maintaining sufficient contact pressure.
- **Contact pressure** – the compressive stress generated on the gasket surface by bolt preload, which represents the primary factor governing sealing performance.
- **Creep relaxation** – the gradual deformation of a gasket material under sustained compressive loading, resulting in a reduction of contact pressure over time.
- **Thermal degradation** – the deterioration of the mechanical and chemical properties of gasket materials caused by prolonged exposure to elevated temperatures.
- **Galvanic compatibility** – the electrochemical compatibility between gasket components and flange materials, influencing the likelihood of galvanic corrosion.

From a theoretical perspective, gasket selection is generally regarded as a multidisciplinary problem involving three closely interconnected scientific fields: **solid mechanics**, which addresses deformation behavior and contact pressure distribution; **materials science**, which evaluates the mechanical, thermal, and chemical properties

of gasket materials; and **corrosion engineering**, which investigates electrochemical interactions and long-term durability under aggressive service conditions.

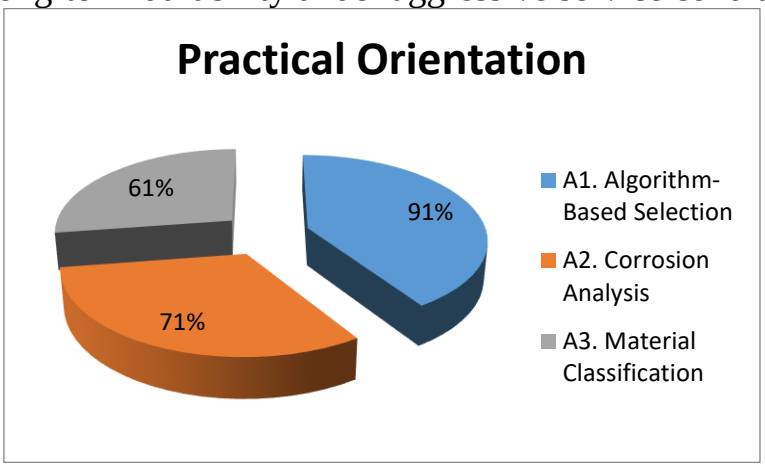

Figure 1. Practical Applicability

According to this analysis, the most effective approach to gasket material selection is the algorithm-based method. Based on the STAMPS methodology, it enables the systematic and accurate selection of materials for district heating systems, water supply networks, and industrial pipelines, while reducing installation errors and preventing leakage. At the same time, corrosion analysis is important for assessing the risks at the flange–gasket interface in highly mineralized water and aggressive environments and is mainly applied under specialized operating conditions. The classification of gasket materials provides a theoretical basis based on their physicochemical properties and serves as a primary supporting reference because it offers limited direct practical guidance.

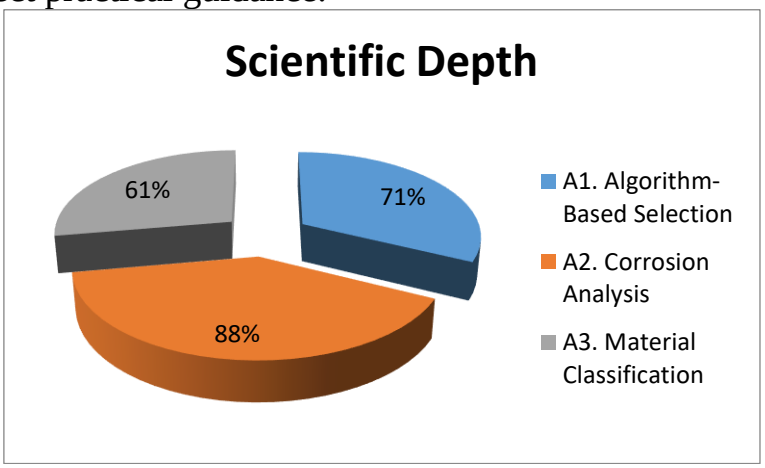

Figure 2. Scientific Depth

According to this analysis, **corrosion analysis** demonstrates the highest level of scientific depth by providing a comprehensive explanation of chloride ion effects and galvanic corrosion mechanisms. The **algorithm-based selection approach**, through the STAMPS methodology, systematizes the relationships among operating parameters and represents an intermediate level of scientific depth by integrating both theoretical and practical approaches. The **classification of gasket materials** serves as the fundamental theoretical basis by describing their general physicochemical properties; however, its scientific depth is relatively limited due to the lack of extensive experimental investigations.

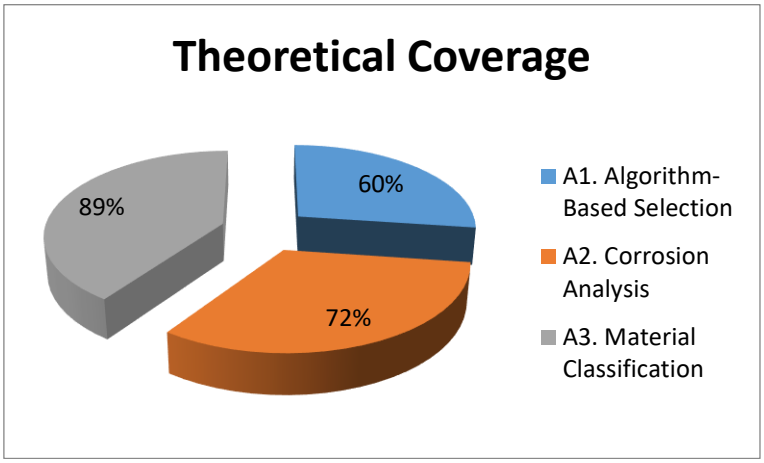

Figure 3. Theoretical Coverage

From the perspective of theoretical coverage, the **classification of gasket materials** provides the most comprehensive theoretical basis by extensively describing their mechanical, thermal, and chemical properties, making it particularly relevant to the operating conditions of Uzbekistan. **Corrosion analysis** offers a moderate level of theoretical depth by explaining the galvanic and electrochemical processes occurring at the flange–gasket interface. In contrast, the **algorithm-based selection approach** is primarily oriented toward practical decision-making, and therefore its theoretical coverage is relatively limited.

PRACTICAL CASE ANALYSIS

Under the operating conditions of Uzbekistan, the proper selection of gasket materials for flanged joints in district heating systems, water supply networks, and industrial pipelines plays a decisive role in ensuring system reliability and long-term service performance. This practical analysis was conducted using a **DN100–PN16** flanged joint as a case study, where the working medium was mineralized water at a temperature of **110–130°C** and a pressure of **1.0–1.2 MPa**. Based on the **STAMPS methodology** presented in *Guidelines on Gasket Selection, Selection Troubles, and Countermeasures*, gasket selection was systematically evaluated by considering size, operating temperature, application, medium composition, pressure, and flow velocity. As a result, an **aramid fiber composite gasket** was identified as the most suitable solution, eliminating leakage after installation while maintaining stable bolt preload.

Based on *Factors Affecting Gasket Selection for Stainless Steels in Seawater*, the possibility of galvanic and electrochemical corrosion at the flange–gasket interface caused by dissolved salts in the working medium was taken into consideration. Therefore, a **low-electrical-conductivity composite gasket** together with a **PTFE-coated flange surface** was adopted, significantly reducing corrosion processes.

According to *Review on Various Gaskets Based on the Materials, their Characteristics and Applications*, rubber, PTFE, graphite, and composite gaskets were comparatively evaluated in terms of temperature resistance, mechanical stability, and chemical compatibility. The analysis indicated that **rubber gaskets** undergo rapid aging at elevated temperatures, **PTFE gaskets** are susceptible to deformation under high pressure, and **graphite gaskets** may increase the risk of corrosion. In contrast, **composite gaskets** demonstrated the best overall performance with respect to stability and corrosion protection. Overall, the combined application of the algorithm-based

selection approach, corrosion analysis, and material classification successfully eliminated fluid leakage, reduced flange surface deterioration, decreased maintenance frequency, and extended the operational service life of the system. These findings demonstrate that the integrated application of these approaches is essential for ensuring the safe and efficient operation of municipal and industrial systems in Uzbekistan. The operating conditions of industrial and municipal infrastructure in the Republic of Uzbekistan are determined by a combination of climatic, hydrochemical, and technological factors. These factors directly influence the service life, reliability, and sealing performance of gasket materials. Consequently, gasket selection under local conditions should consider not only general international recommendations but also the specific environmental and operational characteristics of the country.

Uzbekistan has a sharply continental climate, with summer temperatures frequently exceeding **+40°C** in many regions, while winter temperatures may decrease considerably in certain areas. Such large temperature fluctuations impose stringent requirements on the thermal resistance of gasket materials. In practice, rubber- and polymer-based gaskets may soften or become excessively rigid under elevated temperatures, resulting in reduced bolt preload, accelerated creep relaxation, and loss of sealing performance. Therefore, the use of **metallic** or **glass-filled PTFE gaskets** is considered more appropriate for district heating networks, steam pipelines, and other high-temperature process equipment. The chemical composition of water resources varies significantly throughout Uzbekistan, and in some regions the concentration of dissolved minerals and chloride ions is relatively high. These conditions promote corrosion at the interface between metallic flanges and gasket materials. In practice, **graphite-filled gaskets** and **galvanically incompatible spiral-wound metallic gaskets** may promote crevice corrosion in such environments. Consequently**, synthetic fiber, EPDM, or non-asbestos gaskets** are recommended for water supply and wastewater systems, while metallic flange surfaces should be protected using suitable anti-corrosion coatings or compounds. Municipal district heating systems generally operate with low- or medium-pressure steam and hot water in pipelines, pumping stations, and heat exchangers. Under these conditions, long service life and economic efficiency are the primary selection criteria. Practical experience indicates that **EPDM** and **non-asbestos sheet gaskets** provide satisfactory sealing performance. However, **spiral-wound metallic gaskets** are recommended for high-temperature locations such as boiler outlets and steam headers.

Oil and gas production, refining, and chemical processing facilities operate under aggressive environments involving high pressure and elevated temperatures. In these industries, gasket selection is of strategic importance for operational safety. **Metal–graphite** and **glass-filled PTFE spiral-wound gaskets** are widely used in practice. Nevertheless, to minimize galvanic corrosion, the electrochemical compatibility between gasket and flange materials should be carefully evaluated before installation.

Water supply systems generally operate under relatively low pressures, where economic efficiency and sanitary requirements are the primary considerations. Wastewater systems, however, may contain contaminants and chemically aggressive

components. Practical experience has shown that **synthetic fiber** and **rubber–aramid gaskets** provide satisfactory performance in such applications, whereas metallic gaskets are mainly reserved for high-pressure pumping units and transmission pipelines. A significant proportion of gasket materials used in Uzbekistan is imported, increasing the cost of high-quality metallic and hybrid gasket products. Consequently, **rubber, EPDM,** and **non-asbestos gaskets**, which are more readily available and less expensive in the domestic market, are frequently used. However, from a long-term operational perspective, inappropriate use of low-cost materials may increase maintenance expenses and reduce system reliability. Therefore, economic evaluation should consider not only the initial purchase cost but also the **life-cycle cost** of the gasket throughout its service life. Practical observations have shown that rubber gaskets used in municipal district heating systems tend to harden under prolonged exposure to elevated temperatures, leading to leakage after several operating seasons. Replacing these gaskets with **spiral-wound metallic gaskets** significantly improved sealing performance and service life. Similarly, in the oil and gas industry, the use of galvanically incompatible metallic gaskets resulted in flange corrosion and deformation. Subsequent replacement with gaskets manufactured from electrochemically compatible alloys substantially reduced the risk of corrosion.

MAIN ANALYSIS

This paper presents a comprehensive analysis of **gasket selection and application** from engineering, materials science, and operational perspectives. The primary objective of the analysis is to establish the relationship between theoretical approaches, findings reported in the scientific literature, and practical experience under the operating conditions of Uzbekistan, thereby developing a scientific and practical framework for gasket selection.

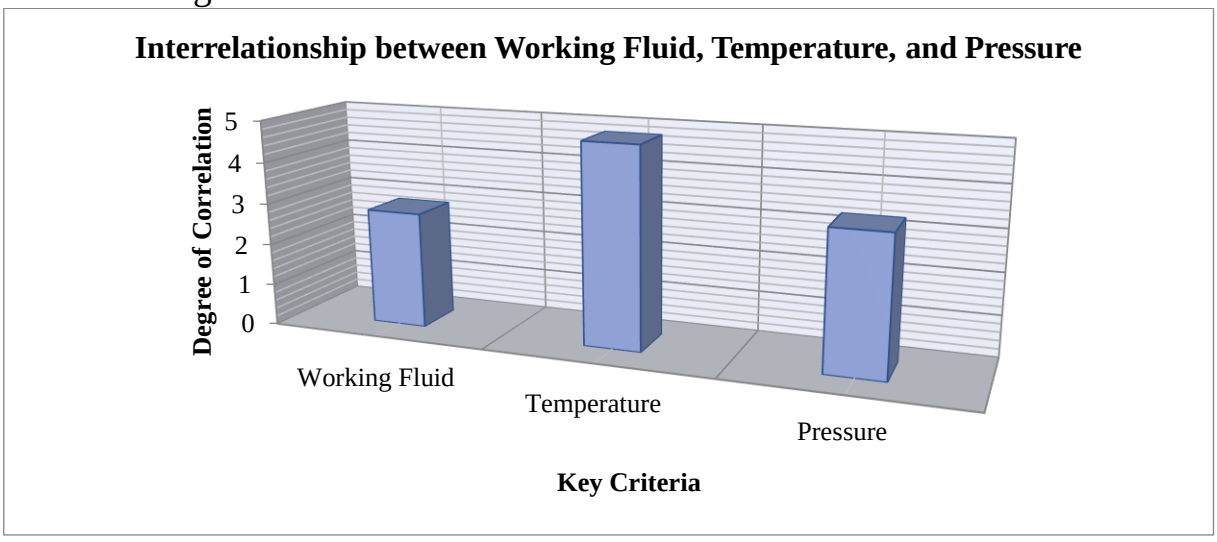

Figure 4. Interrelationship between Working Fluid, Temperature, and Pressure

According to the scientific literature, the three primary criteria for gasket selection are the **working fluid, operating temperature**, and **pressure**. These parameters are closely interrelated, and each has a direct influence on the mechanical behavior and sealing performance of the gasket material. Under elevated temperatures, molecular bonds in rubber and certain polymeric materials gradually weaken, leading to **thermal degradation.** This process is manifested by either hardening or excessive

softening of the gasket material, resulting in a reduction of contact pressure and sealing efficiency. Under high-pressure conditions, however, **metallic** and **composite gaskets** are capable of maintaining sealing performance through controlled plastic deformation. In Uzbekistan, district heating systems, steam pipelines, and oil and gas facilities frequently operate under simultaneous high-temperature and high-pressure conditions. Therefore, the **thermal resistance** and **mechanical strength** of gasket materials should be considered the primary selection criteria for these applications.

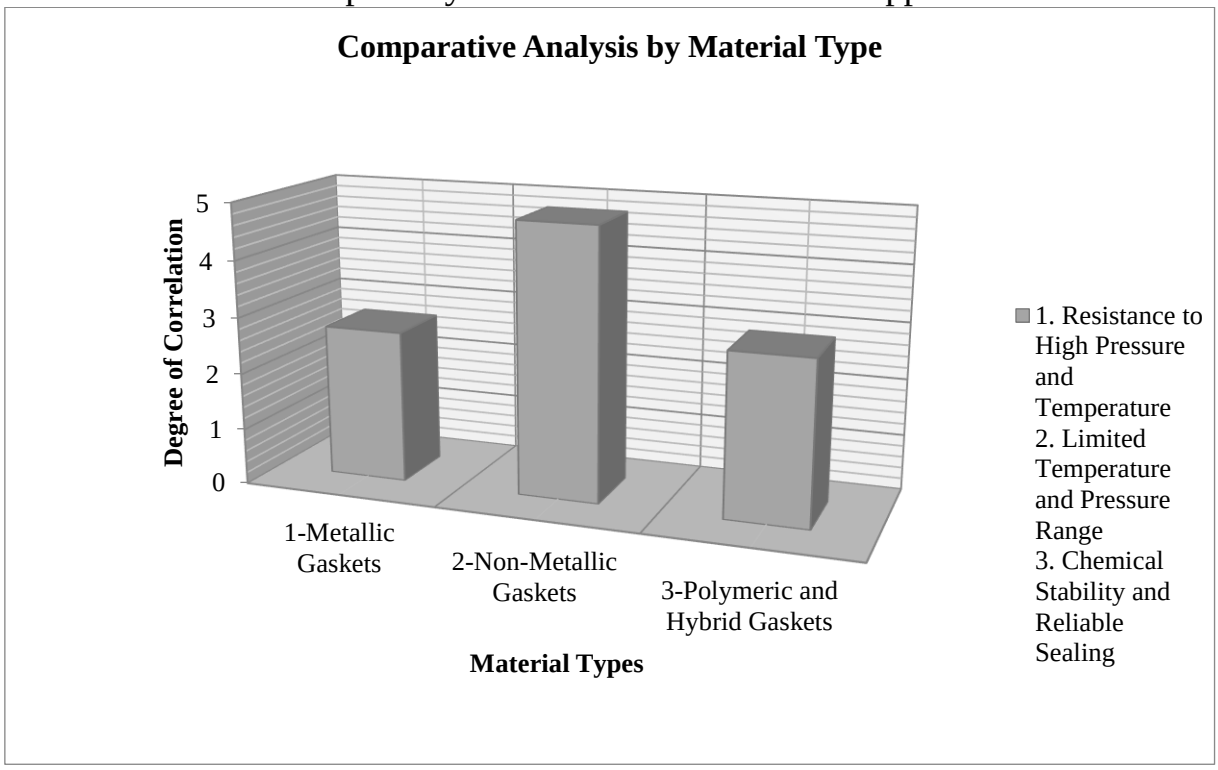

Figure 5. Comparative Analysis by Material Type

Metallic gaskets – Metallic gaskets are distinguished by their excellent resistance to high pressure and elevated temperatures. Their principal advantages include low susceptibility to **creep relaxation** and excellent long-term mechanical stability. **Spiral-wound metallic gaskets** provide high contact pressure at the flange interface, ensuring reliable sealing performance under high-pressure operating conditions. However, practical experience has shown that galvanically incompatible metallic gaskets may form electrochemical couples with flange materials, thereby accelerating corrosion processes. Therefore, the electrochemical compatibility of the flange alloy should be carefully considered when selecting metallic gaskets.

Non-metallic gaskets – Non-metallic gaskets, including **rubber, synthetic fiber**, and **non-asbestos** materials, possess high deformability, allowing them to effectively compensate for surface irregularities in low- and medium-pressure flange joints. They are economically attractive and relatively easy to install. However, under elevated temperatures, these materials are more susceptible to **thermal degradation** and **creep relaxation**, which limits their application in high-temperature and high-pressure service conditions.

Polymeric and hybrid gaskets – Polymeric gaskets, particularly those based on **PTFE,** are distinguished by their excellent chemical resistance and are well suited for aggressive service environments. However, as reported in the scientific literature,

PTFE materials are susceptible to **creep relaxation** under elevated temperatures and sustained compressive loading. **Hybrid gaskets** combine the mechanical strength of metallic components with the sealing performance of non-metallic materials, enabling reliable operation over a wide range of temperatures and pressures. Under the operating conditions of Uzbekistan, these types of gaskets are considered the preferred choice for applications in the oil and gas as well as the chemical processing industries.

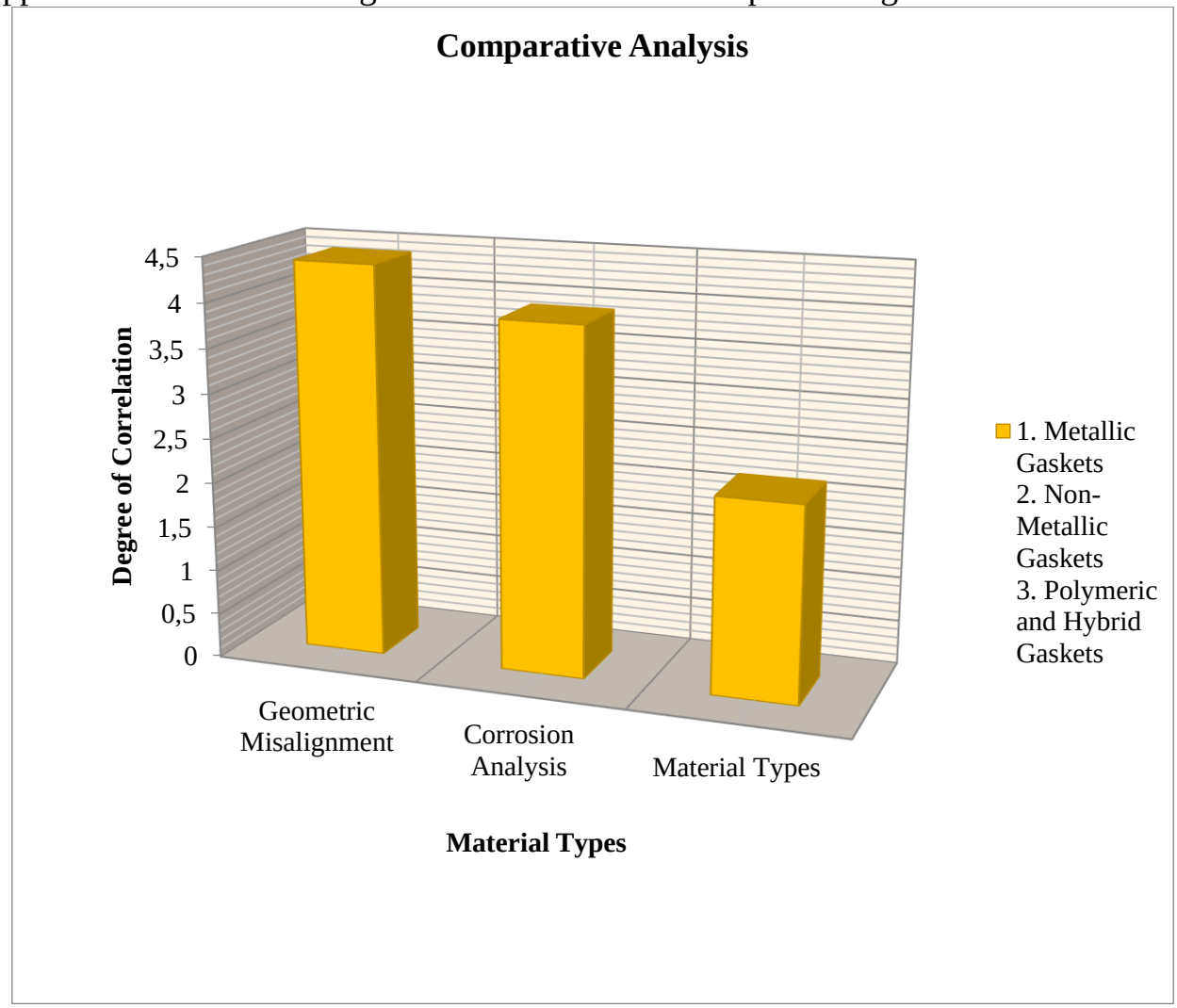

Figure 6. Geometric Compatibility and Installation Factors

The scientific literature emphasizes that incompatibility between **gasket dimensions** and **flange geometry** has a detrimental effect on sealing performance. In practice, if the gasket diameter does not properly match the flange dimensions, the effective contact area is reduced, resulting in increased localized contact pressure that may cause material deformation or cracking. In addition, non-uniform bolt tightening during installation leads to an uneven distribution of gasket loading. This condition may result in leakage and a reduction in service life. From this perspective, proper installation practices and bolt-tightening procedures constitute an essential factor in achieving reliable gasket performance.

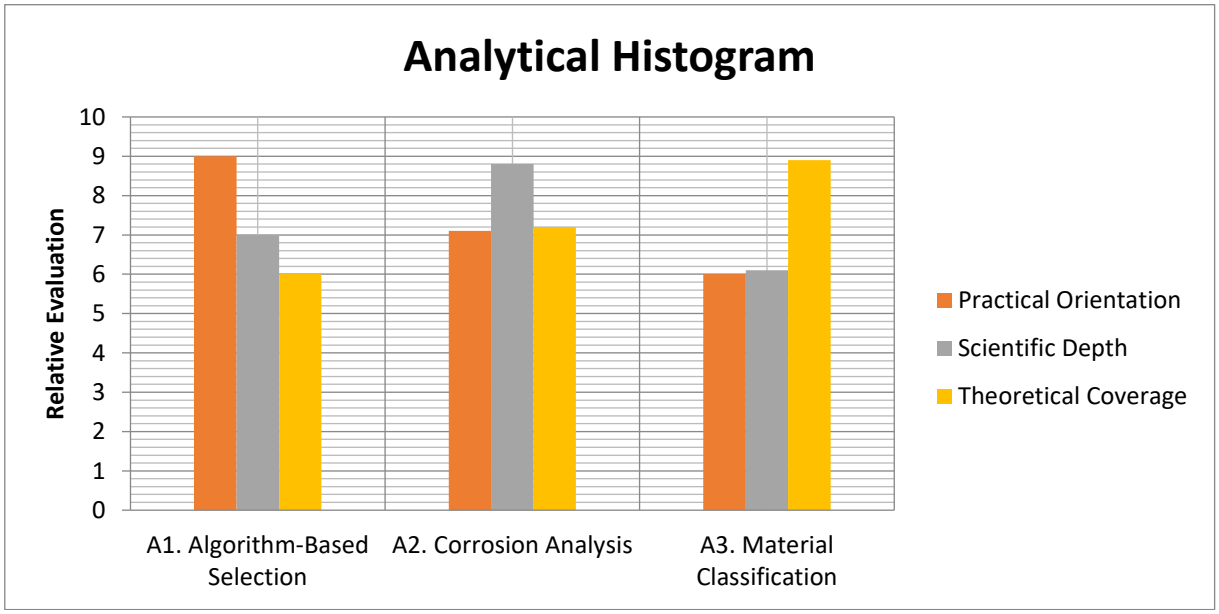

Figure 7. Comparative Analysis of Three Articles

The comparison shows that the **first article** is distinguished by its practice-oriented algorithm-based approach. The **second article** demonstrates greater scientific and experimental depth by providing a comprehensive analysis of corrosion phenomena and galvanic compatibility. The **third article** excels in terms of theoretical coverage and the classification of gasket materials, making it particularly valuable as an educational and reference resource.

CONCLUSION

Based on the results of the analysis and the evaluation of practical case studies, the implementation of an **algorithm-based approach** is essential for improving the effectiveness of gasket material selection and application under the operating conditions of Uzbekistan. In particular, the **STAMPS methodology** enables a comprehensive assessment of the working medium, operating temperature, pressure, application requirements, and geometric compatibility, thereby reducing installation errors and minimizing the risk of leakage. At the same time, in highly mineralized water and chemically aggressive environments, the potential for galvanic and electrochemical corrosion at the flange–gasket interface should be considered during the design stage. Under such conditions, the use of **low-electrical-conductivity composite gaskets** or **PTFE-coated gaskets** is recommended. Material selection should always be based on the intended service conditions: **metallic** or **metal–hybrid gaskets** are most suitable for high-temperature and high-pressure systems, **PTFE** or **composite materials** are preferred for chemically aggressive environments, whereas **non-metallic gaskets** provide effective performance in low- and medium-pressure engineering systems. Furthermore, proper installation practices—including uniform diagonal bolt tightening, careful cleaning of flange surfaces, and verification of gasket dimensional compatibility—significantly extend gasket service life and improve sealing reliability. In conclusion, the combined application of **algorithm-based gasket selection**, **corrosion analysis,** and **material classification** provides an effective strategy for enhancing the safety, reliability, and economic efficiency of industrial and municipal systems in Uzbekistan. This integrated approach ensures the long-term

performance of flanged joints, reduces maintenance costs, and improves the overall operational efficiency of engineering systems.

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ASSESSMENT AND ANALYSIS OF RELIABILITY INDICATORS IN POWER SUPPLY SYSTEMS WITH INTEGRATED DISTRIBUTED GENERATION SOURCES

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Abstract. *This paper presents an assessment and analysis of the reliability indicators of power supply systems integrated with distributed generation (DG) sources. The increasing penetration of distributed generation, particularly renewable energy sources, has significantly changed the operating conditions of modern distribution networks and created new challenges for reliability evaluation. In this study, the reliability performance of the power supply system was analyzed using the Monte Carlo simulation method. The main reliability indices, including SAIDI (System Average Interruption Duration Index), SAIFI (System Average Interruption Frequency Index), CAIDI (Customer Average Interruption Duration Index), and ENS (Energy Not Supplied), were evaluated for systems with and without distributed generation. The simulation results demonstrate that the integration of distributed generation reduces the frequency and duration of power interruptions, decreases the amount of unsupplied energy, and improves the continuity of electricity supply to consumers. The study confirms that the proper integration of distributed generation sources enhances the operational efficiency and reliability of power supply systems. The obtained results can be used to improve the planning, operation, and reliability assessment of modern electrical distribution networks.*

Keywords. *Distributed generation, power supply system, reliability assessment, Monte Carlo simulation, SAIDI, SAIFI, CAIDI, Energy Not Supplied (ENS).*

Annotatsiya. *Ushbu maqolada taqsimlangan generatsiya (DG) manbalari integratsiyalashgan elektr ta'minoti tizimlarining ishonchlilik ko'rsatkichlarini baholash va tahlil qilish masalalari ko'rib chiqilgan. Taqsimlangan generatsiya, ayniqsa qayta tiklanuvchi energiya manbalarining keng joriy etilishi zamonaviy taqsimlash tarmoqlarining ishlash sharoitlarini sezilarli darajada o'zgartirib, ishonchlilikni baholashda yangi muammolarni yuzaga keltirmoqda. Tadqiqotda elektr ta'minoti tizimining ishonchliligi Monte-Karlo modellashtirish usuli yordamida tahlil qilindi. SAIDI (uzilishlarning o'rtacha davomiyligi indeksi), SAIFI (uzilishlarning o'rtacha chastotasi indeksi), CAIDI (uzilishlarning o'rtacha davomiyligi indeksi) hamda ENS (iste'molchiga yetkazib berilmagan energiya) ko'rsatkichlari taqsimlangan generatsiya mavjud va mavjud bo'lmagan holatlar uchun baholandi. Natijalar taqsimlangan generatsiyaning uzilishlar soni va davomiyligini kamaytirishi, yetkazib berilmagan energiya miqdorini qisqartirishi hamda iste'molchilarga elektr energiyasini uzluksiz yetkazib berish ishonchliligini oshirishini ko'rsatdi. Tadqiqot natijalari zamonaviy taqsimlash tarmoqlarini rejalashtirish, ekspluatatsiya qilish va ishonchliligini baholashni takomillashtirishda qo'llanilishi mumkin.*

Kalit so'zlar: *taqsimlangan generatsiya, elektr ta'minoti tizimi, ishonchlilikni baholash, Monte-Karlo modellashtirish usuli, SAIDI, SAIFI, CAIDI, iste'molchiga yetkazib berilmagan energiya (ENS).*

Аннотация. *В данной статье рассматриваются вопросы оценки и анализа показателей надежности систем электроснабжения с интегрированными источниками распределенной генерации (DG). Широкое внедрение распределенной генерации, особенно возобновляемых источников энергии, существенно изменило условия функционирования современных распределительных электрических сетей и поставило новые задачи в области оценки надежности. В работе надежность системы электроснабжения исследована с использованием метода моделирования Монте-Карло. Для систем с распределенной генерацией и без нее были определены основные показатели надежности: SAIDI (средняя продолжительность отключений), SAIFI (средняя частота отключений), CAIDI (средняя продолжительность одного отключения) и ENS (недоотпуск электрической энергии). Результаты моделирования показали, что интеграция распределенной генерации способствует снижению частоты и продолжительности отключений, уменьшению объема недоотпущенной электроэнергии и повышению надежности электроснабжения потребителей. Полученные результаты могут быть использованы при планировании, эксплуатации и оценке надежности современных распределительных электрических сетей.*

Ключевые слова: *распределенная генерация, система электроснабжения, оценка надежности, метод моделирования Монте-Карло, SAIDI, SAIFI, CAIDI, недоотпуск электрической энергии (ENS).*

INTRODUCTION

In modern electric power systems, reliability is considered one of the most important technical and economic indicators determining the efficiency and stability of power system operation [1–4]. The reliability of a power supply system reflects its ability to continuously provide consumers with electrical energy of the required quantity and quality under both normal and emergency operating conditions [1–3]. Ensuring uninterrupted power supply is particularly important for industrial enterprises, critical infrastructure facilities, and residential consumers, since power interruptions may lead to significant economic losses, technological failures, and reductions in production efficiency. The continuous growth in electricity demand, rapid industrialization, urbanization, and the increasing complexity of modern energy systems further enhance the importance of reliability assessment and improvement.

In recent years, distributed generation (DG) sources, especially renewable energy systems such as solar photovoltaic and wind power plants, have been widely integrated into electric power networks. The large-scale penetration of distributed generation fundamentally changes the structure and operating principles of traditional centralized power supply systems and requires the development of new approaches for system management, planning, and reliability evaluation [8–10]. Unlike conventional centralized generation, distributed generation units are located close to consumers, thereby reducing transmission and distribution losses, improving voltage regulation, increasing system flexibility, and enhancing the overall resilience of the power network under fault conditions. Furthermore, DG systems can serve as backup power sources during fault conditions and contribute to the continuity of electricity supply for critical loads.

At the same time, the integration of distributed generation introduces a number of technical and operational challenges. The intermittent and stochastic nature of renewable energy sources, bidirectional power flows, changes in fault current levels, and the complexity of coordination between protection and automation devices complicate the operation and control of modern power systems [5,6]. Therefore, comprehensive reliability assessment methods based on probabilistic and statistical approaches become increasingly important for analyzing the impact of distributed generation on power supply systems.

The reliability of electric power systems is directly related to system stability, operational safety, and economic efficiency. In reliability theory, the ability of a system to maintain acceptable operating conditions over a specified period of time is generally evaluated using probabilistic models, mathematical statistics, and reliability indices. Such approaches allow researchers and engineers to analyze the behavior of power system components under different operating scenarios, estimate interruption frequencies and durations, and determine the effectiveness of distributed generation integration in improving overall system performance.

METHODS

Reliability Indicators and Assessment Methods of Power Supply Systems. In international practice, the reliability of power supply systems is evaluated based on the IEEE 1366 standard [3]. This standard defines the main indicators for assessing the

frequency and duration of interruptions in electric distribution networks. The most widely used indices are SAIDI, SAIFI, and CAIDI [4]. SAIDI (System Average Interruption Duration Index) represents the average time during which consumers remain without electrical power and is determined as follows:

$$SAIDI = \frac{\sum U_i N_i}{N_{total}} \quad (1)$$

Here, U_i — denotes the interruption duration, N_i— represents the number of affected consumers, and, N_{total}— is the total number of consumers.

SAIFI (System Average Interruption Frequency Index) represents the frequency of interruptions and is expressed as follows:

$$SAIFI = \frac{\sum N_i}{N_{total}} \quad (2)$$

This indicator reflects the average number of interruptions experienced by consumers in the system [4,7]. CAIDI (Customer Average Interruption Duration Index) characterizes the average duration of a single interruption and is determined as follows:

$$CAIDI = \frac{SAIDI}{SAIFI} \quad (3)$$

In addition, additional indicators such as ENS (Energy Not Supplied) and ASAI (Average Service Availability Index) are also used for a more comprehensive assessment of system reliability. The ENS indicator determines the amount of energy not supplied to consumers and is of significant importance in evaluating economic losses.

$$ENS = \sum_{i=1}^{n} P_i \cdot P_{avg} \cdot t_i \quad (4)$$

Here, P_i- the average load during the interruption (kW or MW), t_i- is the interruption duration (hours), and P_{avg}- is the average load of a single consumer.

The structural configuration of power supply systems also has a significant impact on system reliability [6–11]. In series systems, the failure of a single element causes the entire system to stop operating, and the overall reliability is determined as follows:

$$R = \Pi R_i \quad (5)$$

In parallel systems, reserve elements are available, resulting in higher system reliability:

$$R = 1 - \Pi(1 - R_i) \quad (6)$$

Practical electrical networks usually consist of mixed (combined) structures.

In evaluating the reliability of power supply systems, the main focus is placed on the failure probability and restoration characteristics of system components [2–11]. This process is described through the following main parameters: failure rate (λ), restoration rate (μ), mean time between failures (MTBF), and mean time to repair (MTTR). Based on these parameters, the probability of system operation is determined using the following exponential law:

$$R(t) = e^{-\lambda t} \quad (7)$$

The availability factor represents the probability of the system being in an operating condition and is determined as follows:

$$A = \frac{MTBF}{MTBF + MTTR} \quad (8)$$

Distributed generation significantly affects the reliability of power supply system when integrated into the electrical network. This impact is twofold: when properly organized, distributed generation improves system reliability, while improper management may lead to various operational problems [9–10].

From a positive perspective, distributed generation sources produce electrical energy close to consumers, which reduces transmission line losses and decreases the impact of faults occurring over long distances. In addition, since distributed generation systems are capable of operating in autonomous (islanding) mode, critical consumers can continue receiving electricity even when interruptions occur in the main grid [9]. Distributed generation sources also serve as additional backup power supplies, especially during peak load periods, thereby supporting system operation. Furthermore, they increase system flexibility and enable voltage and reactive power control through the use of modern inverter technologies.

On the other hand, the presence of distributed generation sources complicates the operation and control of electrical networks. Since traditional relay protection systems are designed for unidirectional current flow, the integration of distributed generation sources may cause their improper operation. Moreover, because renewable energy sources such as solar and wind power are intermittent in nature, there is a possibility of voltage and frequency instability. Distributed generation sources also affect short-circuit currents, making equipment selection more difficult. In addition, inverter-based systems may deteriorate power quality and lead to harmonic distortions. In general, if distributed generation is properly designed and implemented together with modern control systems, it can significantly improve the reliability of power supply systems. Otherwise, it may negatively affect overall system stability.

Reliability Assessment Methods

Various methods are used to evaluate the reliability of power supply systems. These methods are selected depending on system complexity, available data, and research objectives. The main methods include deterministic, probabilistic-statistical, Monte Carlo, and Markov models.

The deterministic method is one of the simplest and most classical approaches used in the reliability assessment of power supply systems and is based on the "N-1" criterion. According to this criterion, the system must continue supplying consumers with electrical energy even if any single component of the system (transformer, transmission line, or generator) fails.

According to this approach, each component is considered important, and its failure significantly affects system operation. Therefore, the system must contain reserve paths or alternative power transmission capabilities. In emergency situations, the load is redistributed through other system components [2-5].

This criterion is mathematically expressed through the power balance equation:

$$\sum P_{gen} - P_{loss} \geq P_{load} \qquad (8)$$

The main advantage of the deterministic method lies in its simplicity and fast calculation capability. Therefore, it is considered convenient for preliminary assessment during the design stage.

However, this method does not take into account the probabilistic nature of failures and does not reflect random processes occurring under real operating conditions. For this reason, in complex systems it is recommended to use it together with probabilistic and simulation methods.

The probabilistic-statistical method is a modern approach used in evaluating the reliability of power supply systems, which considers the failure probability and time-dependent operating characteristics of system components. Unlike the deterministic method, this approach takes into account random processes occurring during real operation and provides a more accurate assessment of system conditions.

The main parameter is the failure rate λ\lambdaλ, which is determined as the ratio of the number of failures to time. The probability of system operation is evaluated based on the exponential law.

Since this method is based on real statistical data, it is considered practically effective. However, it requires a large amount of reliable statistical information; otherwise, the accuracy of the results may decrease.

Markov models are mathematical approaches used in the reliability assessment of power supply systems and are based on system states and transition probabilities between these states.

In this model, the system consists of several states (operational, failed, and restoration), and transitions between them are represented through certain probabilities or intensities. Using this approach, the time-dependent condition and reliability level of the system can be determined.

Markov models are especially effective in considering restoration processes. However, as the system becomes more complex, the number of states increases, making the calculation process more difficult. Therefore, this method is often applied to simplified systems.

The Monte Carlo method is one of the most advanced and highly accurate simulation techniques used for evaluating the reliability of power supply systems. This

method is based on probability theory and assesses system operation through repeated random simulations.

The essence of the Monte Carlo method is that failures and restoration processes of system components are generated using random numbers. During each simulation process, the state of the system is determined, and this process is repeated thousands or even millions of times. As a result, the obtained data are statistically processed to determine the overall reliability indicators of the system [6–7].

The main advantage of this method is its ability to accurately model complex and large-scale electrical systems. In particular, the Monte Carlo method is highly effective for systems integrated with distributed generation sources (solar and wind energy), since it also takes into account the variability of power generation.

In this study, the Monte Carlo simulation method based on a probabilistic-statistical approach was applied to evaluate the reliability of power supply systems integrated with distributed generation sources. The main reason for selecting this method is related to the random nature of failures and restoration processes of electrical system components, as well as the necessity of considering the variable generation characteristics of distributed generation sources.

Within the framework of the research, a distribution network with a voltage level of 6–10 kV was considered as the model system. In addition to transmission lines, transformers, and consumers, the network also included a distributed generation source represented by a solar photovoltaic power plant. The system was analyzed under the following two conditions:

1. Without distributed generation (traditional system)
2. With integrated distributed generation sources

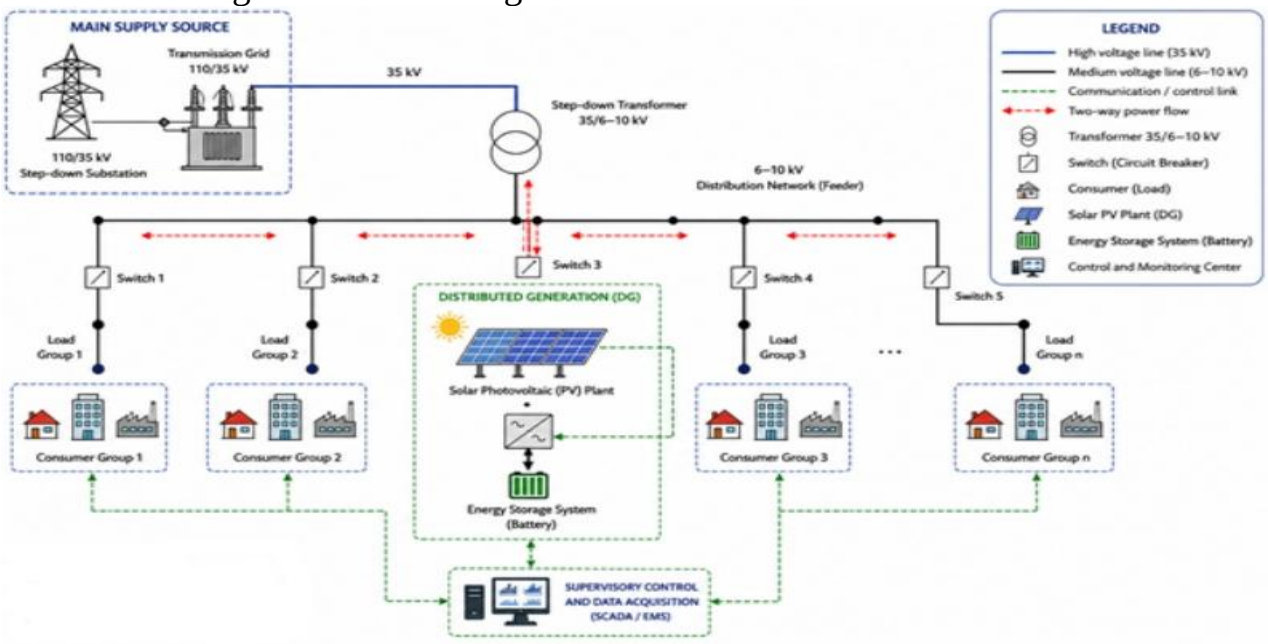

Figure 1. Structural diagram of a power supply system integrated with distributed generation sources

During the simulation process, the operating condition of system components was modeled based on the following main parameters: failure rate (λ) – the probability

of component failure (1/year), restoration rate (μ) – the speed of component restoration (1/hour), mean time to repair (MTTR), load level (P_{load}), and distributed generation output power (P_{DG}).

During the Monte Carlo simulation, the failure and restoration states of each component were determined using a random number generator, and the overall operating condition of the system was evaluated. The calculation process was carried out based on 1000 iterations, which made it possible to obtain statistically reliable results.

In each iteration, the number of interruptions occurring in the system, interruption duration, and the number of affected consumers were determined. Finally, the following reliability indicators were calculated: SAIDI, SAIFI, and ENS (Energy Not Supplied).

RESULTS

Within the framework of the study, the reliability indicators of the power supply system were evaluated for cases with and without distributed generation based on Monte Carlo simulation. The simulation results demonstrated that distributed generation sources have a significant positive impact on system reliability.

According to the obtained results, the system without distributed generation exhibited higher interruption frequency and duration, while the amount of unsupplied energy to consumers was also relatively large. In the case where distributed generation sources were integrated into the system, the load was partially supplied by local generation, thereby reducing the impact of interruptions on consumers [1-3].

In particular, in the system with distributed generation: the interruption duration decreased, the interruption frequency was reduced, and the amount of unsupplied energy significantly declined.

These results can be explained by the proximity of distributed generation sources to consumers and their capability to operate autonomously. Especially in radial distribution networks, distributed generation sources were found to be effective tools for protecting critical loads from interruptions. At the same time, the simulation results also showed that voltage stability and control issues are of great importance in systems integrated with distributed generation. If distributed generation is improperly controlled or if system protection devices are not properly coordinated, the reliability indicators may not improve to the expected level [6-7].

In general, the obtained results confirm that distributed generation is an effective solution for improving reliability in power supply systems; however, its effectiveness depends on proper integration and the application of modern control systems.

A distribution network consisting of 1000 consumers was considered as the study system. As a result of the simulation, the following interruptions were recorded:

Interruption 1: lasted 2 hours and affected 300 consumers.

Interruption 2: lasted 1 hour and affected 200 consumers.

1. SAIDI calculation:

$$SAIDI = \frac{\sum U_i N_i}{N_{total}} = \frac{(2 \cdot 300) + (1 \cdot 200)}{1000} = 0.8 hour$$

2. SAIFI calculation:

$$SAIFI = \frac{\sum N_i}{N_{total}} = \frac{300 + 200}{1000} = 0.5$$

3. CAIDI calculation: $CAIDI = \frac{SAIDI}{SAIFI} = \frac{0.8}{0.5} = 1.6hour$

4. ENS calculation: Average load of 1 kW per consumer.

$$ENS = \sum P_i \cdot t_i = (300 \cdot 1 \cdot 2) + (200 \cdot 1 \cdot 1) = 800kWh$$

In the presence of distributed generation sources, the results were as follows:
Interruption 1: reduced from 2 hours to 1.2 hours, affecting 200 consumers.
Interruption 2: reduced from 1 hour to 0.5 hours, affecting 150 consumers.

1. SAIDI calculation: $SAIDI = \frac{\sum U_i N_i}{N_{total}} = \frac{(1.2 \cdot 200) + (0.5 \cdot 150)}{1000} = 0.315hour$

2. SAIFI calculation: $SAIFI = \frac{\sum N_i}{N_{total}} = \frac{200+150}{1000} = 0.35$

3. CAIDI calculation: $CAIDI = \frac{SAIDI}{SAIFI} = \frac{0.315}{0.35} = 0.9hour$

4. ENS calculation:

$$ENS = \sum P_i \cdot t_i = (200 \cdot 1 \cdot 1.2) + (150 \cdot 1 \cdot 0.5) = 315kWh$$

Table 1. Comparison Table of Results

Indicator	Without DG	With DG	Change
SAIDI	0.8 hour	0.315 hour	↓ 60%
SAIFI	0.5	0.35	↓ 30%
CAIDI	1.6 hour	0.9 hour	↓ 44%
ENS	800 kWh	315 kWh	↓ 60%

Figure 2 compares the main reliability indicators of the power supply system — SAIDI, SAIFI, and CAIDI — for cases with and without distributed generation. As can be seen from the graph, all indicators significantly decreased after the integration of distributed generation. In particular, the reduction in SAIDI and CAIDI values indicates a decrease in interruption duration, while the reduction in SAIFI demonstrates a decrease in interruption frequency. These results confirm the positive impact of distributed generation on improving the reliability of power supply systems [3].

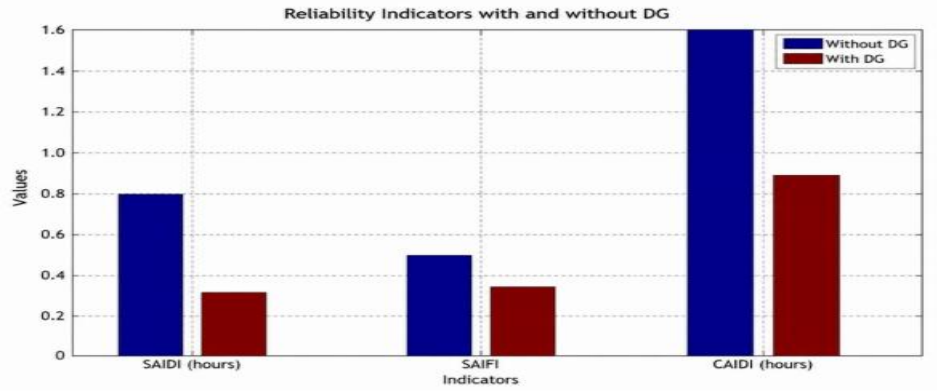

Figure 2. Comparison of reliability indicators in cases with and without distributed generation.

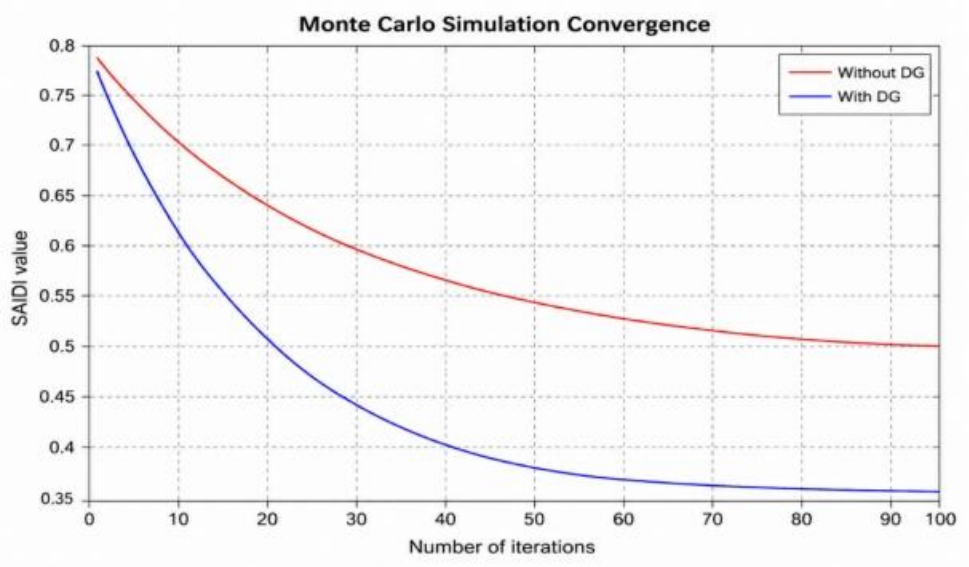

Figure 3. Convergence of the SAIDI indicator based on Monte Carlo simulation.

Figure 3 illustrates the variation of the SAIDI indicator over simulation iterations obtained through the Monte Carlo method. As can be observed from the graph, the results become more stable and converge as the number of iterations increases. In the case with distributed generation, the SAIDI value is formed at a significantly lower level compared to the system without distributed generation, which indicates that distributed generation reduces interruption duration. Furthermore, the faster stabilization of the results confirms the reliability of the model and the accuracy of the simulation.

The calculation results show that distributed generation has a significant positive impact on the operational efficiency and reliability of the power supply system. In particular, in the presence of distributed generation, the impact of interruptions on consumers decreases, while both the duration and coverage of interruptions are reduced, leading to lower SAIDI and CAIDI values.

In addition, the presence of local energy sources improves the quality of electricity supply, meaning that voltage levels become more stable and the system operates more flexibly under varying load conditions. As a result, the continuity of electricity supply to consumers is improved.

In general, distributed generation increases the overall reliability level of the system, reduces the number and duration of interruptions, and ensures the stable operation of the power supply system.

CONCLUSION

In this study, the reliability indicators of power supply systems integrated with distributed generation sources were evaluated using the Monte Carlo simulation method. The obtained results confirmed that distributed generation has a significant positive impact on system reliability.

The calculation results showed that, in the presence of distributed generation, the SAIDI indicator decreased from 0.8 hours to 0.315 hours (approximately 60%), SAIFI decreased from 0.5 to 0.35 (30%), and CAIDI decreased from 1.6 hours to 0.9 hours

(44%). In addition, the amount of energy not supplied (ENS) decreased from 800 kWh to 315 kWh, indicating an improvement in the economic efficiency of the system.

The analysis demonstrated that distributed generation reduces the impact of interruptions due to its proximity to consumers, supports local loads, and increases system flexibility. In particular, in radial distribution networks, distributed generation sources proved to be effective tools for protecting critical loads against interruptions.

At the same time, the research results showed that the effectiveness of distributed generation depends on its proper integration, modern control systems, and coordinated relay protection devices. In cases of improper control, system stability may decrease. For future research, it is recommended to expand the study by including energy storage systems, improving the model based on real operational data, and further investigating system reliability through the implementation of Smart Grid technologies.

The proposed methodology provides a practical framework for improving the reliability of modern power supply systems and can support decision-making in the planning, operation, and optimization of future Smart Grid distribution networks with integrated distributed generation sources.

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PARABOLASIMON AG‘DARGICH YUZALI QALAMCHA EKISH QURILMASINING ISHLASH JARAYONINI TADQIQ ETISH

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Annotatsiya. *Ushbu maqolada qalamchalarni mexanizatsiyalashgan usulda ekish jarayonini takomillashtirishga qaratilgan yangi konstruktiv va nazariy yechim ishlab chiqilgan. Taklif etilgan qurilma parabolasimon otval va avtomatik qalamcha bergich mexanizmi bilan jihozlangan bo‘lib, tuproqning tabiiy qayta tushishi effektidan foydalanish orqali qalamchaning vertikal holatda barqaror joylashishini ta’minlaydi. Tadqiqot doirasida kanal geometriyasi parabolik qonun asosida tavsiflanib, tuproq zarrachalarining harakati va qayta joylashishi geometrik hamda dinamik yondashuvlar asosida tahlil qilindi. Qalamchaning og‘ish jarayoni aylanma dinamika tenglamasi orqali modellashtirilib, uning barqaror holatga kelishi tuproqning so‘nish xususiyatlari bilan bog‘liqligi aniqlandi. Qalamchalarni avtomatik ravishda birma-bir uzatishni ta’minlash maqsadida zanjirli skrebokli mexanizm va tishli ajratgich qurilmasi ishlab chiqildi. Olingan natijalar taklif etilgan yechim qalamchalarni aniq joylashtirish, energiya sarfini kamaytirish va qurilmaning ishonchliligini oshirish imkonini berishini ko‘rsatdi.*

Kalit so‘zlar. *qalamcha ekish, parabolik otval, tuproq mexanikasi, avtomatik bergich, kurakli mexanizm, tishli ajratgich, tuproqning tabiiy qayta tushishi, mexanizatsiya.*

Аннотация*. В данной статье разработано новое конструктивно-теоретическое решение, направленное на совершенствование процесса механизированной посадки черенков. Предложенное устройство оснащено параболическим отвалом и механизмом автоматической подачи черенков, которое обеспечивает устойчивое вертикальное положение черенка за счет использования эффекта естественного осыпания почвы. В рамках исследования геометрия борозды была описана на основе параболического закона, а движение и перераспределение частиц почвы были проанализированы на основе геометрического и динамического подходов. Процесс отклонения черенка был смоделирован с помощью уравнения вращательной динамики, и было установлено, что его переход в устойчивое состояние связан с демпфирующими свойствами почвы. В целях обеспечения автоматической поштучной подачи черенков разработан цепной скребковый механизм и зубчатое разделяющее устройство. Полученные результаты показали, что предложенное решение*

позволяет обеспечить точное позиционирование черенков, снизить энергопотребление и повысить надежность устройства.

***Ключевые** слова: посадка черенков, параболический отвал, механика грунтов, автоматический податчик, скребковый механизм, зубчатый разделитель, естественное осыпание грунта, механизация.*

***Abstract**. This article develops a new constructive-theoretical solution aimed at improving the process of mechanized planting of cuttings. The proposed device is equipped with a parabolic backfill and an automatic cuttings feed mechanism, which ensures a stable vertical position for the cuttings by utilizing the effect of natural soil scattering. Within the framework of the study, the geometry of the furrow was described based on the parabolic law, and the movement and redistribution of soil particles were analyzed based on geometric and dynamic approaches. The process of cuttings deviation was modeled using the equation of rotational dynamics, and it was established that their transition to a stable state is related to the damping properties of the soil. To ensure the automatic individual feed of cuttings, a chain scraper mechanism and a toothed separating device have been developed. The results obtained showed that the proposed solution allows for the precise positioning of cuttings, reduces energy consumption, and increases the reliability of the device.*

***Keywords**: planting cuttings, parabolic embankment, soil mechanics, automatic feeder, scraper mechanism, toothed separator, natural soil shedding, mechanization.*

KIRISH

Qishloq xo‘jaligida o‘simliklarni vegetativ usulda ko‘paytirish, jumladan, qalamcha ekish texnologiyasi yuqori hosildorlik va nav xususiyatlarini saqlab qolish nuqtai nazaridan muhim ahamiyatga ega. So‘nggi yillarda ekish jarayonlarini mexanizatsiyalashtirishga bo‘lgan ehtiyoj ortib bormoqda, bu esa mehnat sarfini kamaytirish va ish samaradorligini oshirishga xizmat qiladi.

Mavjud tadqiqotlarda ekish mashinalari ishchi organlarining geometrik shakli tuproqning harakat xarakteriga sezilarli ta’sir ko‘rsatishi aniqlangan. Xususan, tuproqni ag‘darish va qayta joylashish jarayonlari ishchi organ yuzasining shakliga bog‘liq holda o‘zgaradi [1–3]. Bir qator ishlarda tuproq–ishchi organ o‘zaro ta’siri, tuproq zarrachalarining siljishi va ishqalanish jarayonlari nazariy va eksperimental jihatdan o‘rganilgan [4–19].

Shu bilan birga, ekish jarayonida qalamchalarni vertikal holatda joylashtirish va ularni tuproq bilan samarali qoplash muammosi to‘liq hal etilmagan. Amalda qo‘llanilayotgan qurilmalarda, odatda, tuproqni yopish uchun qo‘shimcha zichlash yoki yopish mexanizmlari talab etiladi, bu esa konstruksiyani murakkablashtiradi va energiya sarfini oshiradi [7,8].

Qalamchalarni avtomatik ravishda birma-bir uzatish masalasi ham alohida ahamiyatga ega. Mavjud mexanizmlarda qalamchalarning bir-biriga ilinib qolishi, ustma-ust joylashishi va noto‘g‘ri orientatsiyalanishi kuzatiladi, bu esa ekish sifatiga salbiy ta’sir ko‘rsatadi [9,10].

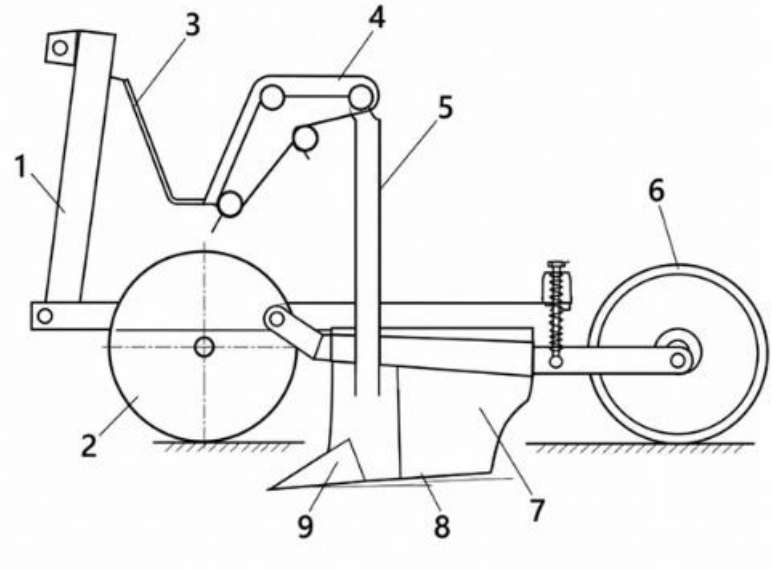
Yuqorida keltirilgan muammolarni hal qilish maqsadida ushbu ishda parabolasimon ag‘dargich yuzaga ega ishchi organ qo‘llanilib, tuproqning tabiiy qayta tushishi effektidan foydalanish orqali qalamchalarni vertikal holatda barqarorlashtirish

taklif etilgan. Shu bilan birga, zanjirli skrebokli va tishli ajratgich mexanizmga asoslangan avtomatik qalamcha bergich ishlab chiqildi.

Tadqiqotning asosiy maqsadi - parabolasimon ag‘dargich yuzali qalamcha ekish qurilmasining ishlash jarayonini nazariy jihatdan asos

METODLAR

Qalamcha ekish qurilmasi uchun takomillashtirilgan parabolasimon ag‘dargich yuzali ekish ishchi organi va qalamchalarni me’yorlab ekishishchi organiga yetkazib beruvchi me’yorlash mexanizmining konstruksiyasi ishlab chiqildi (1-rasm). Qurilma harakatlanganda parabolasimon otval tuproqni ko‘taradi va kanal hosil qiladi. Qalamcha avtomatik bergich orqali trubaga tushiriladi va kanal markaziga joylashtiriladi. Kanal devorining burchagi katta bo‘lgani sababli tuproq qayta tushib, qalamchani ikki tomondan qoplaydi va uni vertikal holatda mustahkamlaydi.



1-rasm. Kombinatsiyalangan qalamcha ekish apparatining umumiy sxemasi: 1 – rama; 2 – ekish chuqurligini boshqaruvchi g‘ildirak; 3 – qalamcha uchun bunker (quti); 4 – qalamcha ekish me’yorlagichi; 5 – qalamchani tushirish quvuri (yo‘naltiruvchi kanal);; 6 – zichlash g‘ildiragi; 7 – zichlash g‘ildiragini sozlash mexanizmi; 8 – parabolasimon juyak ochgich; 9 – ekish ishchi organi pichog‘i.

Qalamchalarni avtomatik uzatish uchun zanjirli skrebokli mexanizm va qiya tekislik qo‘llanildi. Qiya tekislikda qalamchalar ustma-ust joylashishi mumkinligi sababli, ularni bir qatlamli holatga keltirish uchun aylanuvchi tishli ajratgich mexanizm bilan jihozlangan.

Taklif etilgan qurilma qalamchalarni vertikal holatda barqaror joylashtirishni ta’minlaydi, shu bilan birga tuproqni qo‘shimcha mexanizmlarsiz tabiiy ravishda yopish imkonini beradi. Qalamchalar avtomatik ravishda birma-bir uzatilishi konstruksiyaning ishonchliligini oshiradi va uni soddalashtiradi. Natijada qurilmaning umumiy energiya sarfi kamayadi hamda uning ekspluatatsion samaradorligi yuqori darajada ta’minlanadi.

Qurilmaning ishlash jarayonini tahlil qilishda geometrik, kinematik va dinamik yondashuvlardan foydalanildi. Ishchi organning ko‘ndalang kesimi parabolik funksiya orqali tavsiflandi:

$$Z = aX^2, \quad (1)$$

bu yerda ***a*** - ag‘dargich yuzaning egrilik koeffitsienti, **X** - kanal o‘qidan gorizontal masofa.

Kanal devorining mahalliy og‘ish burchagi parabolaning hosilasi orqali aniqlandi:

$$tan\,\alpha = \frac{dZ}{dX} = 2aX. \quad (2)$$

Tuproq zarrachalarining kanalga qayta tushish sharti quyidagi tengsizlik orqali baholandi:

$$2aX_{max} > tan\,\varphi, \quad (3)$$

bu yerda **φ** - tuproqning ichki ishqalanish burchagi.

Qalamchaning kanalga tushgandan keyingi harakati aylanma dinamika tenglamasi asosida modellashtirildi:

$$\frac{ml^2}{3}\ddot{\theta} + c\dot{\theta} - mg\frac{l}{2}sin\,\theta = 0, \quad (4)$$

bu yerda **θ** - og‘ish burchagi, **c** -so‘nish (dempfirlash) koeffitsienti.

Qalamchaning vertikal barqarorlik sharti vaqtlar nisbati orqali baholandi:

$$t_{fall} < t_{tilt}, \quad (5)$$

bu yerda t_{fall} - tuproq qayta tushish vaqti, s; t_{tilt} - qalamchaning og‘ish vaqti, s.
Qalamchalarni avtomatik uzatish jarayonini ta’minlash uchun zanjirli skrebokli mexanizm va qiya tekislikda joylashgan aylanuvchi tishli ajratgich qo‘llanildi. Qatlam qalinligi quyidagi shart orqali cheklandi:

$$h \leq d, \quad (6)$$

bu yerda h - qalamchalar qatlami qalinligi, mm; d - qalamcha diametri, mm.

NATIJALAR

O‘tkazilgan nazariy tahlillar va konstruktiv yechimlarni baholash natijalari parabolasimon ag‘dargich yuza qo‘llanilishi tuproq harakatini samarali boshqarish imkonini berishini ko‘rsatdi. Kanal devorining og‘ish burchagi tuproqning ichki ishqalanish burchagidan katta bo‘lgan holatda tuproq zarrachalarining tabiiy ravishda kanalga qayta tushishi ta’minlandi. Bu esa qalamchaning qo‘shimcha mexanik ta’sirlarsiz vertikal holatda barqarorlashuviga olib keldi.

Dinamik modellashtirish natijalari qalamchaning og‘ish jarayoni tuproqning qayta tushish tezligiga bevosita bog‘liq ekanligini ko‘rsatdi. Hisoblashlar shuni ko‘rsatdiki, tuproq qayta tushish vaqti qalamchaning og‘ish vaqtidan kichik bo‘lgan holatda qalamcha vertikal holatda saqlanib qoladi. Parabolik parametrlarni optimal tanlash orqali ushbu shartning bajarilishi ta’minlandi.

Qalamcha bergich mexanizmining tahlili natijasida zanjirli skrebok va tishli ajratgich mexanizmning birgalikda ishlashi qalamchalarni bir qatlamli holatga keltirish va ularni birma-bir uzatishni ta’minlashi aniqlandi. Qiya tekislikda tishli mexanizm orqali yuqori qatlamdagi qalamchalar ajratib tashlanishi natijasida skrebokga faqat bitta qalamchaning uzatilishi ta’minlandi.

Taklif etilgan konstruksiyada tuproqni qo‘shimcha yopish mexanizmlarisiz tabiiy qayta tushishi hisobiga energiya sarfi kamayishi aniqlandi. Shu bilan birga, qurilmaning sodda konstruksiyasi uning ishonchliligini oshirishga xizmat qildi.

Olingan natijalar taklif etilgan parabolasimon ag‘dargich yuza va avtomatik qalamcha bergich mexanizmi asosidagi qurilmaning yuqori samaradorlikka ega ekanligini ko‘rsatdi.

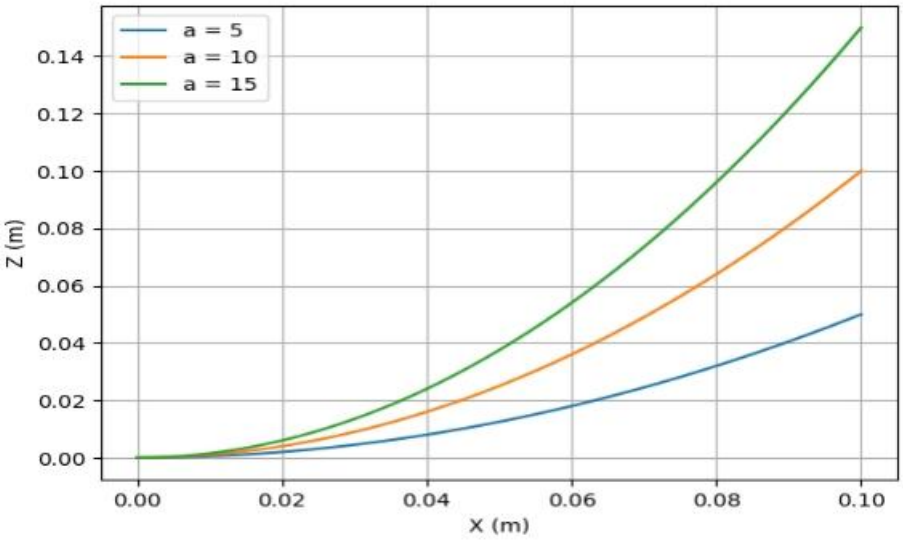
Qalamchaning dinamik harakatini modellashtirishda uning fizik-mexanik parametrlari muhim ahamiyatga ega. 1-jadvalda hisoblashlarda foydalanilgan asosiy parametrlar keltirilgan.

1-jadval

Qalamchalarning fizik-mexanik xususiyatlari

№	Ko‘rsatkich nomi	Belgi-lanishi	Birligi	Qiymat (tipik)	Izoh
1	Qalamcha uzunligi	l	m	0.15 – 0.25	Ekish materialining geometrik parametri
2	Qalamcha diametri	d	m	0.008 – 0.015	Bittalash va mexanizm o‘lchamlariga ta’sir qiladi
3	Qalamcha massasi	m	kg	0.01 – 0.05	Dinamikaga ta’sir qiladi
4	Zichlik	ρ	kg/m³	600 – 900	Namlikka bog‘liq
5	Og‘irlik markazi	l/2	m	0.075 – 0.125	Barqarorlik hisobida muhim
6	Inersiya momenti	$I = m\frac{l^2}{3}$	kg·m²	10^{-4}–10^{-3}	Og‘ish dinamikasi uchun
7	Ishqalanish koeffitsienti (qalamcha–tuproq)	μ	–	0.3 – 0.6	Tuproq holatiga bog‘liq
8	So‘nish koeffitsienti	c	N·m·s	0.001 – 0.01	Tuproq ta’siri
9	Elastiklik moduli	E	MPa	500 – 1500	Qalamcha mustahkamligi
10	Ichki namlik	W	%	40 – 70	Ishqalanish va massaga ta’sir qiladi

Ishchi organning geometrik shakli tuproq harakati va uning qayta joylashish jarayoniga sezilarli ta’sir ko‘rsatadi. Ushbu ta’sirni baholash maqsadida parabola parametri a ning kanal geometriyasiga bog‘liqligi grafik ko‘rinishda keltirilgan (2-rasm).



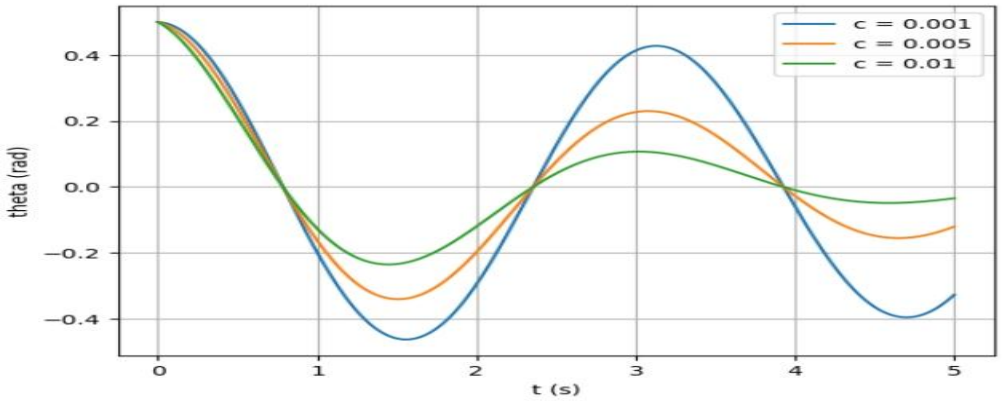
2-rasm. Parabola parametri *a* ning kanal geometriyasiga ta’siri

2-rasmda parabola parametri *a* ning kanal geometriyasiga ta’siri ko‘rsatilgan. Grafikdan ko‘rinib turibdiki, *a* parametrining ortishi bilan kanal chuqurligi va devorining tikligi sezilarli darajada oshadi. Bu bog‘lanish parabola tenglamasi $Z = aX^2$ orqali ifodalanadi.

a ning kichik qiymatlarida kanal nisbatan yotiq bo‘lib, tuproq zarrachalarining qayta tushishi sekin kechadi. *a* ortishi bilan kanal devori tiklashadi va tuproqning kanalga qayta tushish tezligi ortadi. Natijada qalamchaning tuproq bilan qoplanish jarayoni tezlashadi va uning vertikal holatda barqarorlashishi yaxshilanadi.

Shu bilan birga, *a* parametrining haddan tashqari katta qiymatlari kanal geometriyasining keskin tiklashishiga olib kelishi mumkin, bu esa amaliy jihatdan noqulayliklar keltirib chiqarishi ehtimoli mavjud. Shuning uchun *a* parametrining optimal qiymatini tanlash muhim ahamiyatga ega.

Qalamchaning kanalga tushgandan keyingi harakati dinamik jarayon sifatida qaraladi. Ushbu jarayonni baholash maqsadida qalamchaning og‘ish burchagi θ ning vaqt bo‘yicha o‘zgarishi grafik ko‘rinishda keltirilgan (3-rasm).



3-rasm. Qalamchaning og‘ish burchagi θ ning vaqt bo‘yicha o‘zgarishi (turli dempferlash koeffitsientlari uchun)

Grafikdan ko‘rinadiki, vaqt o‘tishi bilan og‘ish burchagi kamayib boradi, bu esa tizimda so‘nish jarayoni mavjudligini ko‘rsatadi.

So‘nish koeffitsienti kichik bo‘lgan holatda qalamcha uzoq vaqt davomida tebranadi va uning barqarorlashuvi sekin kechadi. So‘nish koeffitsienti ortishi bilan tebranish amplitudasi tezroq kamayadi va qalamcha qisqa vaqt ichida vertikal holatga keladi.

Natijalar shuni ko‘rsatadiki, tuproqning qarshilik kuchlari va ishqalanish ta’siri qalamchaning og‘ishini cheklaydi hamda uning barqaror joylashuvini ta’minlaydi. Ayniqsa, so‘nish koeffitsientining optimal qiymatlarida qalamcha deyarli tebranmasdan vertikal holatga o‘tadi.

Bu holat $t_{fall} < t_{tilt}$ sharti bajarilishini ta’minlaydi va qalamchaning tuproqda ishonchli hamda barqaror joylashishiga olib keladi.

MUHOKAMA

Olingan nazariy natijalar ko‘rsatadiki, parabolasimon ag‘dargich yuza tuproq harakatini boshqarishda muhim rol o‘ynaydi. Kanal devorining og‘ish burchagi tuproqning ichki ishqalanish burchagidan katta bo‘lgan holatda tuproq zarrachalari o‘z-o‘zidan kanalga qayta tushadi. Bu esa qo‘shimcha yopish mexanizmlarini talab etmasdan, qalamchani tabiiy ravishda qoplash imkonini beradi.

Dinamik tahlil natijalariga ko‘ra, qalamchaning barqaror holatda saqlanishi tuproqning qayta tushish tezligi bilan bog‘liq. Agar tuproq qayta tushish vaqti qalamchaning og‘ish vaqtidan kichik bo‘lsa, qalamcha vertikal holatda saqlanadi. Bu holat parabolik geometriyaning to‘g‘ri tanlanishi bilan ta’minlanadi.

Avtomatik bergich mexanizmining tahlili shuni ko‘rsatdiki, qiya tekislikda qo‘llanilgan tishli ajratgich mexanizm qalamchalarni bir qatlamli holatga keltirishda yuqori samaradorlikka ega. Bu esa kurakcha orqali qalamchalarni birma-bir uzatishni ta’minlaydi va umumiy ishonchlilikni oshiradi.

Amaliy jihatdan bu shuni anglatadiki, qurilma qo‘shimcha bosuvchi yoki yopuvchi mexanizmlarsiz ham samarali ishlay oladi. Taklif etilgan konstruksiyada geometrik, mexanik va dinamik omillarning o‘zaro uyg‘unligi ta’minlangan bo‘lib, bu qurilmaning samarali ishlashini asoslab beradi.

Shunday qilib, parabola shaklidagi ishchi organ tuproq oqimini boshqarish imkonini beradi, tizimdagi so‘nish effektlari esa qalamchaning barqaror joylashuvida hal qiluvchi rol o‘ynaydi.

XULOSA

Parabolasimon otval va avtomatik qalamcha bergich mexanizmiga asoslangan taklif etilgan qurilma qalamchalarni mexanizatsiyalashgan usulda ekish jarayonining samaradorligini sezilarli darajada oshiradi. O‘tkazilgan nazariy va dinamik tahlillar natijasida parabola shaklidagi ishchi organ tuproqning tabiiy qayta tushish jarayonini boshqarishi va shu orqali qalamchaning vertikal holatda barqaror joylashishini ta’minlashi asoslab berildi.

Tadqiqot natijalari shuni ko‘rsatdiki, kanal geometriyasining to‘g‘ri tanlanishi tuproq zarrachalarining qayta joylashish tezligiga bevosita ta’sir ko‘rsatadi, bu esa qalamchaning tez va ishonchli qoplanishiga olib keladi. Dinamik model asosida aniqlanishicha, tizimda mavjud so‘nish effektlari qalamchaning og‘ish jarayonini cheklab, uning qisqa vaqt ichida barqaror holatga kelishini ta’minlaydi. Bu esa $t_{fall} < t_{tilt}$ sharti bajarilishi orqali nazariy jihatdan isbotlandi.

Taklif etilgan konstruktiv yechim qo‘shimcha bosuvchi yoki yopuvchi mexanizmlarsiz ishlash imkonini berib, qurilmaning konstruktiv soddaligini saqlagan holda uning ishonchliligini oshiradi hamda energiya sarfini kamaytiradi. Shu bilan birga, avtomatik qalamcha uzatish mexanizmi ekish jarayonining uzluksizligi va aniqligini ta’minlaydi.

Umuman olganda, taklif etilgan texnologik yondashuv tuproq mexanikasidan samarali foydalanishga asoslangan bo‘lib, qishloq xo‘jaligida resurs tejovchi, energiya samarador va yuqori unumli texnologiyalarni joriy etish uchun ilmiy-amaliy asos yaratadi.

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MICROSTRUCTURAL ANALYSIS OF HIGH-STRENGTH CAST IRON

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Abstract: *This paper analyzes the microstructural characteristics of high-strength spheroidal graphite cast irons, including the morphology of graphite nodules, the phase composition of the metallic matrix, and their influence on mechanical properties. The scientific and methodological aspects of using metallographic analysis, optical microscopy, and digital image processing techniques for microstructural characterization are considered. It is shown that the strength of spheroidal graphite cast iron largely depends on the spherical shape of graphite, the degree of nodularity, the size and distribution of graphite nodules, and the ferrite-to-pearlite ratio. The results indicate that a high degree of graphite spheroidization reduces stress concentration in the metallic matrix and consequently improves the strength and ductility of the material. An increase in the pearlite fraction enhances hardness and tensile strength, whereas an increase in the ferrite fraction improves ductility and impact toughness. In addition, irregular, vermicular, or otherwise degenerated graphite morphologies can adversely affect the mechanical properties of the material.*

Keywords: *High-strength cast iron, spheroidal graphite cast iron, microstructure, graphite nodules, nodularity, ferrite, pearlite, metallography, mechanical properties, GGG-45, EN-GJS-450-10.*

Annotatsiya: *Ushbu maqolada mustahkamligi yuqori sferografitli cho‘yanlarning mikrostrukturaviy xususiyatlari, grafit zarrachalarining morfologiyasi, metall matritsaning fazaviy tarkibi hamda ularning mexanik xossalarga ta’siri tahlil qilingan. Tadqiqotda metallografik tahlil, optik mikroskopiya va tasvirlarni raqamli qayta ishlash usullaridan foydalanishning ilmiy-metodik jihatlari ko‘rib chiqildi. Sferografitli cho‘yanning mustahkamligi asosan grafitning sferik shakli, nodulyarlik darajasi, grafit zarrachalarining o‘lchami va taqsimlanishi hamda ferrit-perlit nisbatiga bog‘liqligi ko‘rsatildi. Tadqiqot natijalari shuni ko‘rsatadiki, grafitning yuqori darajadagi sferikligi matritsada kuchlanish konsentratsiyasini kamaytirib, materialning mustahkamligi va plastiklik xususiyatlarini yaxshilaydi. Perlit miqdorining ortishi qattiqlik va mustahkamlikni oshirsa, ferrit miqdorining ko‘payishi plastiklik va zarbiy qovushqoqlikni yaxshilaydi. Shuningdek, grafit zarrachalarining notekis, vermikulyar yoki boshqa degeneratsiyalangan shakllari materialning mexanik xususiyatlarini pasaytirishi mumkinligi aniqlangan.*

Kalit so‘zlar: *Yuqori mustahkam cho‘yan, sferografitli cho‘yan, mikrostruktura, grafit nodullari, nodulyarlik, ferrit, perlit, metallografiya, mexanik xossa, GGG-45, EN-GJS-450-10.*

Аннотация: *В статье проведён анализ микроструктурных характеристик высокопрочных чугунов с шаровидным графитом, включая морфологию графитовых включений, фазовый состав металлической матрицы и их влияние на механические свойства. Рассмотрены научно-методические аспекты применения металлографического анализа, оптической микроскопии и методов цифровой обработки изображений для исследования микроструктуры. Показано, что прочность чугуна с шаровидным графитом в значительной степени зависит от сферической формы графита, степени его сфероидизации, размера и распределения графитовых включений, а также соотношения феррита и перлита. Результаты показывают, что высокая степень сфероидизации графита снижает концентрацию напряжений в металлической матрице и, как следствие, способствует повышению прочности и пластичности материала. Увеличение доли перлита повышает твёрдость и прочность, тогда как увеличение содержания феррита способствует повышению пластичности и ударной вязкости. Кроме того, наличие неравномерных, вермикулярных и других вырожденных форм графита может отрицательно влиять на механические свойства материала.*

Ключевые слова: *Высокопрочный чугун, чугун с шаровидным графитом, микроструктура, графитовые включения, степень сфероидизации, феррит, перлит, металлография, механические свойства, GGG-45, EN-GJS-450-10.*

INTRODUCTION

The increasing requirements for structural materials in modern mechanical engineering have created a growing demand for materials capable of simultaneously providing high strength, wear resistance, impact toughness, and sufficient ductility. Among such materials, spheroidal graphite cast irons occupy an important position. Unlike conventional gray cast iron, spheroidal graphite cast iron is characterized by carbon being present predominantly in the form of spherical graphite nodules rather than flake graphite. The spherical morphology of graphite reduces stress concentration within the metallic matrix and, as a result, significantly improves the mechanical properties of cast iron [1]. The microstructure of spheroidal graphite cast iron generally consists of graphite nodules distributed within a metallic matrix. The matrix may be ferritic, pearlitic, or ferritic-pearlitic. Therefore, cast irons with the same chemical composition may exhibit significantly different mechanical properties depending on their microstructure and solidification conditions. Previous studies have demonstrated that the ferrite-to-pearlite ratio in the metallic matrix, as well as the number, size, and distribution of graphite nodules and the degree of nodularity, have a considerable influence on mechanical properties [1,2]. During the production of spheroidal graphite cast iron, magnesium, rare-earth metals, calcium, and other modifying elements are commonly used to promote the formation of spherical graphite. Melt treatment and inoculation processes affect the number of graphite nucleation sites and consequently influence the size and distribution of graphite nodules. The cooling rate also has a

significant effect on the resulting microstructure. In general, a higher cooling rate promotes the formation of finer graphite nodules and a more homogeneous microstructure [3]. Microstructural analysis is particularly important for evaluating the quality of high-strength cast iron because it provides a physical explanation for mechanical properties such as tensile strength, hardness, and elongation. For example, highly spheroidized graphite reduces stress concentration, while an increased pearlite fraction generally improves strength and hardness. In contrast, vermicular or irregular graphite morphologies may provide favorable sites for crack initiation and propagation [3,4].The objective of this study is to analyze the microstructure of high-strength spheroidal graphite cast iron using metallographic methods, to evaluate the morphology and distribution of graphite nodules, and to determine the influence of microstructural parameters on the mechanical properties of the material.

MATERIALS AND METHODS

The research object was high-strength spheroidal graphite cast iron, particularly a cast iron of the GGG-45/EN-GJS-450-10 type. Such cast irons can be used in mechanical engineering, automotive applications, and components subjected to various mechanical loads. For metallographic examination, specimens were cut from different regions of the cast material. During sampling, the central region, areas close to the surface, and transition zones were considered separately. This approach is important because differences in cooling conditions can result in variations in the size, morphology, and distribution of graphite nodules within different regions of the same casting. The surfaces of the specimens were initially leveled by mechanical machining. The samples were subsequently ground using abrasive papers with progressively finer grades. Final polishing was performed to obtain a sufficiently smooth surface suitable for microscopic examination. The prepared specimens were then etched using appropriate metallographic reagents. Optical metallography was used to investigate the microstructure. Microscopic observations were performed at low and medium magnifications. First, the overall distribution of graphite nodules was examined. Subsequently, their morphology, size, and spatial relationship with the metallic matrix were evaluated. The degree of graphite nodularity is one of the important parameters used to characterize spheroidal graphite cast iron. According to ISO 945-4, graphite morphology can be classified into different categories ranging from highly spheroidal graphite to vermicular and flake graphite. Highly spheroidal graphite is desirable in high-quality ductile iron because it minimizes stress concentration in the metallic matrix **[5,6]**.

The following principal microstructural parameters were evaluated:

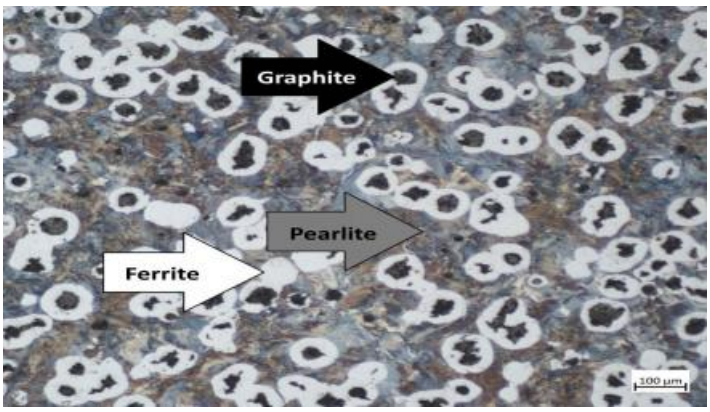
- morphology of graphite nodules;
- degree of graphite nodularity;
- average diameter of graphite nodules;
- number of graphite nodules per unit area;
- uniformity of graphite distribution;
- ferrite fraction;
- pearlite fraction;

- presence of carbides and other undesirable phases.

The number of graphite nodules can be determined by counting the particles within a defined microscopic field and expressing the result per unit area. Modern metallographic analysis also allows digital image processing to be used for quantitative characterization of graphite particles, including their area, perimeter, equivalent diameter, and shape factors. The metallic matrix was evaluated according to the relative fractions of ferrite and pearlite. Ferrite generally appears as relatively bright regions, while pearlite appears darker after etching and exhibits a lamellar structure. The formation of a ferritic halo around graphite nodules may occur in spheroidal graphite cast irons and is associated with the characteristic so-called “bull's-eye” microstructure **[**7]**.**

RESULTS:

Metallographic analysis showed that the microstructure of high-strength spheroidal graphite cast iron predominantly consists of spherical graphite nodules embedded in a ferritic-pearlitic metallic matrix. Relatively uniform distribution of graphite particles was identified as an important positive microstructural characteristic. The spherical morphology of graphite has a direct influence on the mechanical properties of cast iron. Compared with flake or sharp-edged graphite morphologies, spherical graphite particles produce lower local stress concentrations. Therefore, increasing the degree of graphite spheroidization can improve the strength and ductility of the material **[7,8]** .Previous studies have demonstrated that high nodularity values are generally associated with high-quality spheroidal graphite cast iron. In some studies, nodularity values above approximately 80% have been considered favorable for achieving good mechanical performance **[9]**. The presence of ferrite and pearlite in the microstructure also has a significant effect on material properties. Ferrite is a relatively soft and ductile phase that contributes to increased elongation and toughness. Pearlite, in comparison with ferrite, possesses higher hardness and strength. Therefore, increasing the pearlite fraction generally increases the tensile strength and hardness of the cast iron, although it may reduce its ductility. The optimum microstructure of high-strength cast iron cannot be determined solely by increasing the pearlite fraction. The number and size of graphite nodules are also important. Studies have shown that increasing the number of graphite nodules can improve structural homogeneity and, under certain conditions, reduce the probability of carbide formation . The cooling rate also has a considerable influence on the resulting microstructure. Under faster cooling conditions, graphite nodules generally become finer and their number increases, while the metallic matrix may also become finer. In contrast, slower cooling can lead to coarser graphite particles and, under certain conditions, the formation of degenerated graphite morphologies. High-silicon spheroidal graphite cast irons also demonstrate the importance of controlling graphite morphology. Although silicon can contribute to strengthening of ferrite, excessive silicon content under certain processing conditions may promote graphite degeneration, including the formation of chunky graphite **[9,10]**.



1-Pic: **Microstructure of High-Strength Cast Iron**

DISCUSSION

The obtained results demonstrate that the mechanical properties of high-strength cast iron are closely related not only to its chemical composition but also to its microstructural condition. Spheroidal graphite cast iron can be considered a natural composite material in which graphite nodules act as a dispersed phase embedded in a continuous ferritic-pearlitic metallic matrix **[5]**. The morphology of graphite is one of the primary factors determining the behavior of this composite material under mechanical loading. An ideal spherical graphite nodule produces a relatively uniform distribution of stresses. However, when graphite particles have elongated, irregular, or sharp-edged morphologies, stress concentration occurs at their edges and tips. These regions may subsequently become sites for the initiation of microcracks. Consequently, controlling graphite morphology is one of the most important technological objectives in the production of high-strength cast iron . In addition to nodularity, the size of graphite nodules is also important. Very large graphite nodules may increase local stress concentrations. Fine and uniformly distributed graphite nodules, on the other hand, contribute to a more homogeneous microstructure. Therefore, under optimized processing conditions, it is desirable to achieve a high nodule count combined with a sufficiently high degree of spheroidization. From the perspective of the metallic matrix, controlling the ferrite-to-pearlite ratio is another important factor. If high ductility and impact toughness are required, increasing the ferrite fraction is generally beneficial. If a component is subjected to high static loads or severe wear conditions, increasing the pearlite fraction can improve strength and hardness. Heat treatment can also be used to modify the initial ferritic-pearlitic microstructure. In particular, austempering can produce an ausferritic structure capable of combining high strength with relatively high ductility. In ADI-type ductile irons, spherical graphite nodules are embedded in an ausferritic matrix, and this microstructure provides high mechanical performance. Therefore, the microstructure of high-strength cast iron can be characterized by three principal groups of parameters: graphite morphology, graphite distribution, and phase composition of the metallic matrix. The interaction and balance among these three factors determine the final mechanical and service properties of the material.

CONCLUSION

Based on the conducted analysis, it was established that the mechanical properties of high-strength spheroidal graphite cast iron are directly associated with its microstructural characteristics.

- The most important microstructural parameters determining the strength of spheroidal graphite cast iron are the morphology of graphite nodules, degree of nodularity, nodule size and distribution, and the ferrite-to-pearlite ratio.
- The spherical morphology of graphite reduces stress concentration and improves the mechanical properties of cast iron. Irregular, vermicular, and other degenerated graphite morphologies facilitate microcrack initiation and may consequently reduce mechanical performance.
- Ferrite contributes primarily to ductility and toughness, whereas pearlite increases strength and hardness. Therefore, the ferrite-to-pearlite ratio should be controlled according to the specific service requirements of the component.
- Inoculation, modification, cooling rate, and heat treatment are among the main technological factors that can be used to control the microstructure of high-strength cast iron.
- Metallographic analysis is an effective method for evaluating the quality of high-strength cast iron. Optical microscopy combined with digital image processing makes it possible to quantitatively evaluate graphite morphology, nodularity, graphite distribution, and the phase composition of the metallic matrix.

In general, obtaining high-strength cast iron requires more than simply optimizing its chemical composition. High graphite nodularity, uniform graphite distribution, and an optimized ferritic-pearlitic matrix are key conditions for achieving high strength and satisfactory service performance.

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POLIETILEN QOPLAMAGA MUQOBIL SIFATIDA BIODEGRADATSIYALANADIGAN QOG‘OZ QOPLAMA MATERIALINI QO‘LLASH TEXNOLOGIYASINI ASOSLASH

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Annotatsiya. *Maqolada paxta ekishda qo‘llaniladigan polietilen qoplama materiallarining ekologik va ekspluatatsion muammolari tahlil qilingan. Polietilen chiqindilari tufayli tuproqning degradatsiyaga uchrashini kamaytirish maqsadida sellyuloza asosidagi biodegradatsiyalanadigan qog‘oz qoplama materialidan foydalanish imkoniyatlari asoslangan. Qog‘oz materialni kraxmal, glitserin va polivinil spirt (PVA) asosida modifikatsiya qilish hamda uning yuqori yuzasini gidrofob qatlam bilan qoplash orqali asimmetrik struktura hosil qilish texnologiyasi taklif etilgan. Shuningdek, materialni ekish agregatiga uzatish uchun sinxron rezina valikli mexanizm va urug‘ joylashgan nuqtalarda lokal teshishni ta’minlovchi silindrsimon baraban konstruksiyasi ishlab chiqilgan. Taklif etilayotgan texnologiya tuproq namligini saqlash, begona o‘tlar rivojlanishini cheklash, mehnat sarfini kamaytirish va ekologik xavfsizlikni ta’minlash imkonini beradi.*

Kalit so‘zlar: *biodegradatsiyalanadigan qog‘oz, paxta ekish, qoplama material, polietilen plyonka, sellyuloza, kraxmal, lokal teshish, ekish agregati, gidrofob qatlam.*

Аннотация. *В статье проанализированы экологические и эксплуатационные проблемы применения полиэтиленовых мульчирующих материалов при посеве хлопчатника. С целью снижения загрязнения почвы полиэтиленовыми отходами обоснована возможность использования биоразлагаемого бумажного материала на основе целлюлозы. Предложена технология модификации бумаги составом из крахмала, глицерина и поливинилового спирта (PVA) с последующим нанесением гидрофобного слоя на верхнюю поверхность для формирования асимметричной структуры. Разработаны синхронный резиновый валиковый механизм подачи материала и цилиндрический барабан для локального перфорирования в точках высева семян. Предлагаемая технология позволяет сохранять почвенную влагу, подавлять сорняки и улучшать экологическое состояние почвы.*

Ключевые слова: *биоразлагаемая бумага, посев хлопчатника, мульчирующий материал, полиэтиленовая пленка, целлюлоза, крахмал, локальная перфорация, посевной агрегат.*

Abstract. *The article analyzes the environmental and operational issues associated with the use of polyethylene mulching materials in cotton cultivation. To reduce polyethylene waste, the potential of using cellulose-based biodegradable paper mulch was investigated. A technology is proposed for modifying the paper material*

using starch, glycerol, and polyvinyl alcohol (PVA), followed by coating its upper surface with a hydrophobic layer to create an asymmetric structure. Additionally, a synchronous rubber roller feeding mechanism and a cylindrical perforating drum designed for localized puncturing at seed placement points were developed for integration with the seeding machine. The proposed technology allows for preserving soil moisture, suppressing weed growth, reducing labor costs, and eliminating plastic pollution.

Keywords: *biodegradable paper, cotton planting, mulching material, polyethylene film, cellulose, starch, local perforation, seeding unit.*

KIRISH

Qishloq xo‘jaligida, xususan paxtachilikda tuproqni mulchalash texnologiyasi tuproq namligini saqlash, mikroklimatni yaxshilash va begona o‘tlar o‘sishini cheklash orqali hosildorlikni oshirishning eng samarali usullaridan biri hisoblanadi. Paxta yetishtirishda sintetik polietilen (PE) plyonkalardan foydalanish erta va bir tekis nihol olishni ta’minlaydi.

Biroq, an’anaviy polietilen qoplamalar qator jiddiy ekologik va agrotexnik muammolarni keltirib chiqarmoqda. PE plyonkalar tuproqda yuzlab yillar davomida parchalanmaydi, ularni mavsum oxirida daladan yig‘ib olish qo‘shimcha ishchi kuchi va texnika xarajatlarini talab etadi. Dalada qolib ketgan plyonka qoldiqlari tuproqning aeratsiya va suv o‘tkazuvchanlik xususiyatlarini yomonlashtiradi, natijada tuproq degradatsiyaga uchraydi.

Ushbu muammoni hal etishning eng istiqbolli yo‘li — tabiiy komponentlar asosidagi biodegradatsiyalanadigan qoplama materiallariga o‘tishdir. Bunday materiallar ma’lum vegetatsiya davrida (20–30 kun) o‘z fizo-mexanik vazifasini bajarib, keyinchalik tuproq mikroorganizmlari va namlik ta’sirida zararsiz birikmalarga parchalanib ketishi lozim.

Tadqiqotning maqsadi: Paxta ekishda polietilen qoplamaga muqobil sifatida sellyuloza asosli biodegradatsiyalanadigan modifikatsiyalangan qog‘oz qoplama materialini qo‘llash texnologiyasini hamda uni ekish agregatlari bilan moslashtiruvchi ishchi organlarning kinematik va texnologik parametrlarini matematik asoslashdan iborat.

MATERIALLAR VA TADQIQOT USULLARI

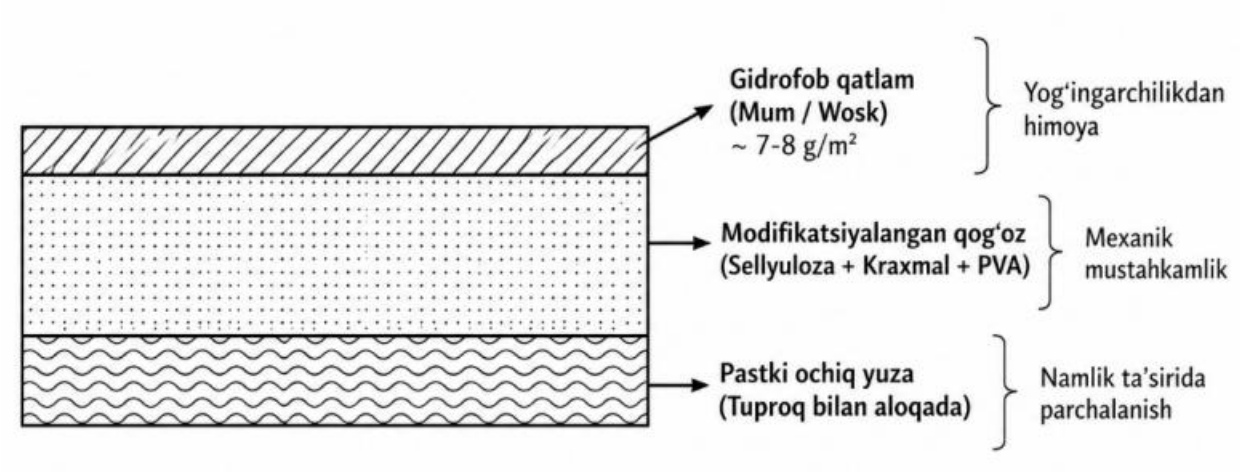
Tadqiqot ob’ekti sifatida organik asosli sellyulozadan tayyorlangan yupqa rulonli qog‘oz xom ashyosi tanlab olindi. Standart qog‘oz suv va fizik ta’sirlarga chidamsiz bo‘lganligi sababli, uning mexanik mustahkamligini oshirish va degradatsiya muddatini boshqarish uchun maxsus kompozitsiya yordamida impregnatsiya qilish usuli qo‘llanildi.

Modifikatsiyalovchi eritmaning umumiy massasi M_{um} quyidagi komponentlar nisbati asosida aniqlanadi:

$$M_{um} = M_{sell} + M_{kr} + M_{glis} + M_{PVA}, \quad (1)$$

bu yerda M_{sell} — boshlang‘ich sellyuloza qog‘ozining massasi, g/m²; M_{kr} — kraxmal massasi (umumiy massaga nisbatan 9–10%); M_{glis} — glitserin massasi (2,5–3%); M_{PVA} — polivinil spirt massasi (1–1,5%).

Qog‘ozning gidrofobligini ta’minlash uchun uning yuqori yuzasiga surtiladigan mum miqdori (m_{gidr}) yuza birligiga nisbatan me’yorlanadi (1-rasm).



1-rasm. Paxta ekishda qo‘llash uchun taklif etilgan biodegradatsiyalanadigan qog‘oz qoplama materialining qatlamli tuzilishi.

Tadqiqotda asimmetrik strukturali material hosil qilish usuli qo‘llanildi. Qog‘ozning pastki (tuproqqa tegib turadigan) qismi tuproq namligini so‘rib olish va biodegradatsiya jarayonini boshlash uchun ochiq qoldiriladi.

NATIJALAR VA MUHOKAMA

Ekish agregatiga qog‘oz uzatish mexanizmining kinematik hisobi

Qog‘oz materiali plyonkaga nisbatan cho‘zilishga kamroq chidamli $[\sigma_{cho'z}]$ (uzilish kuchi cheklangan) bo‘lganligi sababli, uzatish valiklarining chiziqli tezligi v_{val} ekish agregatining harakat tezligiga v_{agr} teng yoki juda yaqin bo‘lishi shart.

Uzatish mexanizmining kinematik koeffitsienti K_k quyidagicha ifodalanadi:

$$K_k = \frac{v_{val}}{v_{agr}} = \frac{\pi \cdot D_{val} \cdot n_{val}}{v_{agr}}, \quad (2)$$

bu yerda D_{val} — rezina uzatish valiklarining diametri, m; n_{val} — valiklarning aylanish chastotasi, ayl/sek.

Qog‘ozning yirtilishi yoki bo‘shashib qolishining oldini olish uchun quyidagi shart bajarilishi lozim:

$$0{,}98 < K_k < 1{,}02. \quad (3)$$

Agar $K_k > 1{,}02$ bo‘lsa, qog‘oz haddan tashqari tortilib uziladi; agar $K_k < 0{,}98$ bo‘lsa, qog‘oz tuproq yuzasida buklanib, to‘planib qoladi.

Modifikatsiyalangan qog‘ozning uzilish mustahkamligi σ vaqt bo‘yicha o‘zgarishi

Materialning mustahkamligi σ vaqt o‘tishi bilan namlikning so‘rilishi, gidrofob qatlamning yemirilishi va sellyuloza tolalarining gidrolizi sababli kamayadi.

Qog‘ozning mustahkamlik kamayish tezligi qoldiq mustahkamlikka proporsional bo‘lgan differensial tenglama bilan ifodalanadi :

$$\frac{d\sigma(t)}{dt} = -k_m \cdot (\sigma(t) - \sigma_\infty) \cdot S_h(t), \quad (4)$$

bu yerda $\sigma(t)$ — t vaqtdagi uzilish mustahkamligi, MPa; σ_∞ — material to‘liq namlangandagi chegaraviy (qoldiq) mustahkamlik, MPa; k_m — materialning destruksiyalanish tezligi koeffitsienti, kun^{-1}; $S_h(t)$ — gidrofob (mum) qatlamning himoya funksiyasi.

Gidrofob qatlamning vaqt bo‘yicha himoya funksiyasi:

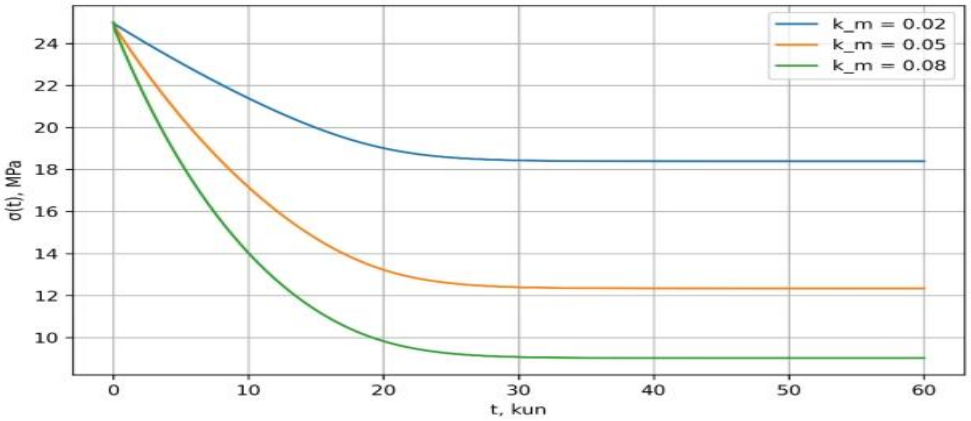
Mum qatlami (7 .... 8 g/m^2) dastlabki t_0 davrda (20–25 kun) suv o‘tkazuvchanlikni cheklaydi. Buni Sigmoidal (Logistik) funksiya orqali ifodalaymiz:

$$S_h(t) = \frac{1}{1 + e^{\alpha \cdot (t - t_0)}}, \quad (5)$$

bu yerda t_0— gidrofob qatlamning kritik yemirilish vaqti ($t_0 \approx$25 kun); α — gidrofob qatlamning parchalanish sur’ati koeffitsienti.

Differensial tenglamani boshlang‘ich shartlar $(\sigma(0) = \sigma_0 \approx 18$ MPa) bo‘yicha integrallash orqali 1-grafikning nazariy matematik modeli olinadi:

$$\sigma(t) = \sigma_\infty + (\sigma_0 - \sigma_\infty) \cdot exp\left(-k_m \int_0^t \frac{d\tau}{1 + e^{\alpha(\tau - t_0)}}\right). \quad (6)$$



2-rasm. Turli namlik sharoitlarida biodegradatsiyalanadigan qog‘oz qoplama materialining mustahkamligi σ(t) ning vaqt bo‘yicha o‘zgarishi

Modelning matematik tahlili:

- $t \leq 20$ kun bo‘lganda: $S_h(t) \approx$0 bo‘lib, $\sigma(t) \approx \sigma_0 = 15 \ldots$. 18 Mpa (barqaror mustahkamlik davri).

- t > 25 kun bo‘lganda: : S_h(t) $\rightarrow$1 bo‘lib, mustahkamlik eksponensial ravishda $\sigma_\infty \approx$ 2... 3 MPa gacha kamayadi (parchalanish davri).

Biodegradatsiyalanish darajasi (D_{bio}) va tuproq namligi (W) dinamikasi

Ushbu model ikkita bir-biriga bog‘liq differensial tenglamalar tizimidan iborat: birinchisi — tuproq namligining bug‘lanishi (kinetikasi), ikkinchisi — tuproq mikroorganizmlari ta’sirida qog‘ozning biodegradatsiyasi.

Biodegradatsiyalanish kinetikasi tenglamasi (Avrami-Yerofeev modeli):

Biodegradatsiya jarayoni mikroorganizmlar koloniyasining ko‘payishi va sellyulozani parchalashi bilan bog‘liq bo‘lib, Avrami tenglamasi asosida modellashtiriladi:

$$D_{bio}(t) = 100 \cdot (1 - \exp(-(k_b \cdot t)^n)), \quad (7)$$

bu yerda $D_{bio}(t)$ — vaqt o‘tishi bilan biodegradatsiyalanish darajasi, %; k_b — biodegradatsiyalanishning solishtirma konstantasi (tuproq harorati va namligiga

bog‘liq), kun^{-1}; n — reaksiyaning aviratsion (avaran) ko‘rsatkichi (n > 1 bo‘lganda jarayon lag-fazadan so‘ng jadallashadi, odatda n ≈ 2.5..... 3.0).

Tuproq namligining (W(t)) kamayishi qoplama materialining butunligiga (1 - $\frac{D_{bio}(t)}{100}$) bevosita bog‘liq:

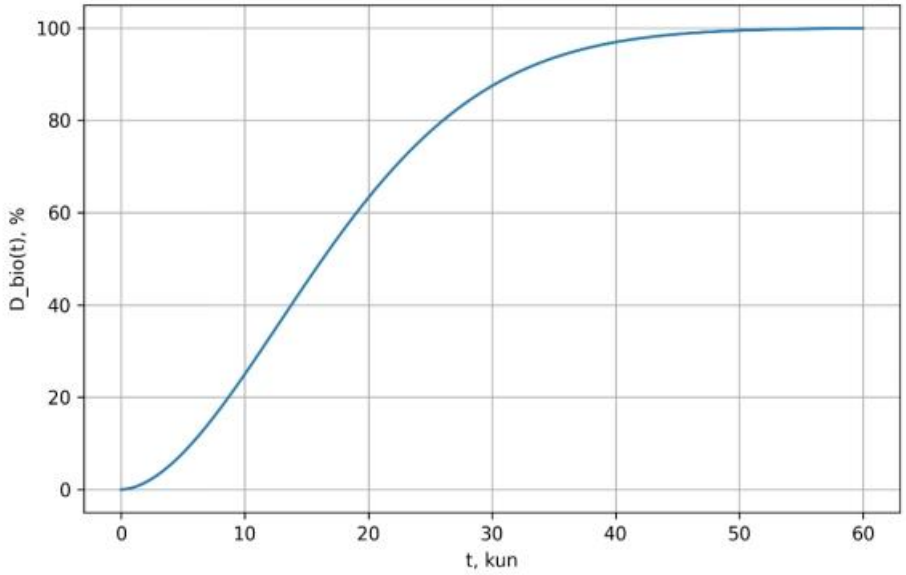
$$\frac{dW(t)}{dt} = -K_{evap} \cdot \left(1 + \gamma \cdot \frac{D_{bio}(t)}{100}\right) \cdot (W(t) - W_{xavo}, \quad (8)$$

bu yerda K_{evap} — qoplamali tuproqdan suvning bazis bug‘lanish koeffitsienti; γ — qog‘oz parchalanganidan so‘ng bug‘lanishning ortishini ifodalovchi koeffitsient; W_{xavo} — tuproqning havo-quruq holatdagi muvozanatli namligi, %.

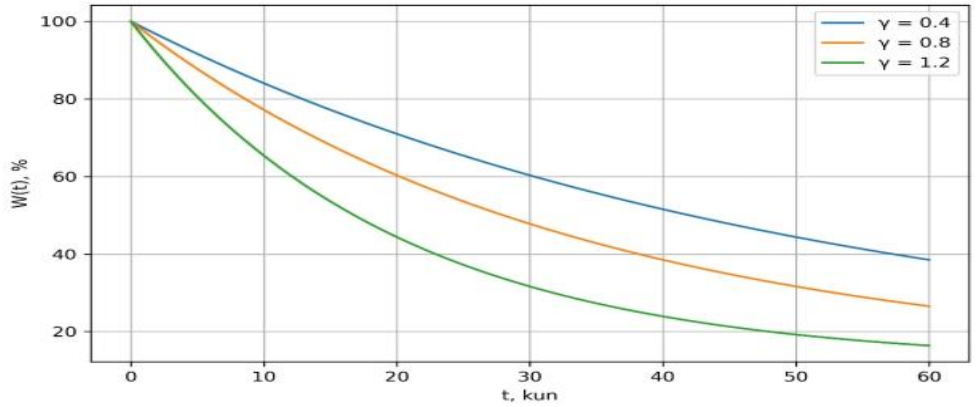
Model tenglamalari tizimining yakuniy yechimi quyidagiga teng:

$$\begin{cases} D_{bio}(t) = 100 \cdot (1 - \exp(-(k_b \cdot t)^n)) \\ W(t) = W_{xavo} + (W_0 - W_{xavo}) \cdot exp\left(-k_m \int_0^t 1 + \gamma\left(1 - e^{-(k_b \tau)^n}\right)\right) \end{cases} \quad (9)$$

(9) formula yordamida qurilgan grafiklar 3-, 4-rasmlarda keltirilgan



3-rasm. Biodegradatsiya darajasi Dbio (t) ning vaqt bo‘yicha o‘zgarishi.



4-rasm. Turli biodegradatsiya sharoitlarida qoplama material namligi ning vaqt bo‘yicha o‘zgarishi

Modelning matematik tahlili:

- $t \leq 30$ kun oralig‘ida: $D_{bio} \leq 5\%$, bu davrda integral qiymati kichik va tuproq namligi $W(t) \approx W_0 = 32...40\ \%$ yuqori darajada saqlanadi.
- t > 30 kun bo‘lganda: Biodegradatsiya jarayoni $D_{bio} \rightarrow 85....90\ \%$ ga keskin ko‘tariladi va tuproq namligining bug‘lanish tezligi tabiiy muvozanatli darajaga o‘tadi.

Lokal teshuvchi baraban parametrlarining matematik modeli

Paxta urug‘larining ekish qadamiga $S_{urug'}$ mos ravishda qog‘ozni teshib ketish uchun silindrsimon baraban radiusi R_{bar} va undagi teshuvchi tishlar soni z o‘rtasidagi bog‘liqlik quyidagicha aniqlanadi:

$$S_{urug'} = \frac{2 \cdot \pi \cdot R_{bar}}{z}. \quad (10)$$

Bundan lokal teshishni ta’minlovchi baraban radiusini topish formulasi hosil bo‘ladi:

$$R_{bar} = \frac{z \cdot S_{urug'}}{2 \cdot \pi}. \quad (11)$$

Baraban tishining qog‘ozni teshib o‘tish jarayonida qog‘ozga ko‘rsatadigan maksimal teshish kuchi F_{tesh} quyidagi tenglama bilan ifodalanadi:

$$F_{tesh} = P_{sol} \cdot b \cdot h, \quad (12)$$

bu yerda P_{sol} — qog‘ozning solishtirma teshilishga qarshiligi, N/mm²; b — teshuvchi tishning eni, mm; h — qog‘oz materialining qalinligi, mm.

Materialning biodegradatsiyalanish dinamikasi

Materialning daladagi biodegradatsiyalanish darajasi (D_{bio}, %) vaqt (t, kun) o‘tishi bilan massa yo‘qotilishi orqali hisoblanadi:

$$D_{bio}(t) = \frac{m_0 - m_t}{m_0} \cdot 100\%, \quad (13)$$

bu yerda m_0— qoplama materialning boshlang‘ich quruq massasi, g; m_t — t kundan keyingi qoldiq quruq massasi, g.

Natijalar va muhokama (Results and Discussion)

Texnologik jarayon ketma-ketligi. Tadqiqotlar shuni ko‘rsatdiki, biodegradatsiyalanadigan qog‘oz qoplamani tayyorlash va dalada qo‘llash muayyan texnologik ketma-ketlikda amalga oshirilishi lozim:

1. Qog‘ozni impregnatsiya qilish: sellyuloza asosini kraxmal, glitserin va PVA eritmasi bilan boyitish.
2. Issiqlik yordamida quritish: Modifikatsiyalangan qog‘ozning namligini me’yoriy ko‘rsatkichga keltirish.
3. Asimmetrik gidrofoblash: Qog‘ozning faqat yuqori yuzasiga 7–8 g/m² dozada mumli gidrofob qatlam surtish.
4. Rulonlash: Talab qilingan eni va uzunligi bo‘yicha rulonlarga o‘rash.
5. Dalada to‘shash: Ekish agregati yordamida qog‘ozni tuproq yuzasiga tekis areada yozish.

6. Chetlarini mahkamlash: Qog‘ozning ikki chetini tuproq ko‘mgichlar yordamida yopib borish.
7. Lokal teshish va urug‘ni ochib berish: Barabanli mexanizm orqali urug‘ ekilgan nuqtalarda aniq teshiklar hosil qilish.

Ekish agregati uchun taklif etilayotgan qurilma konstruksiyasi

Qog‘oz plyonkaga nisbatan cho‘zilishga kamroq chidamli bo‘lgani sababli, uni dala bo‘ylab yozishda uzilib ketish xavfi yuqori. Ushbu muammoni hal etish uchun ekish agregatiga moslashtirilgan ikkita yangi konstruktiv yechim taklif etildi:

- Sinxron rezina valikli uzatish mexanizmi: Rulonni majburiy va bir tekis aylantirib beradi. Valiklarning aylanish tezligi agregatning harakat tezligi (v_{agr}) bilan to‘liq sinxronlashtirilgan. Bu qog‘ozning haddan tashqari tortilib, yirtilishining oldini oladi.
- Silindrsimon lokal teshuvchi baraban: Baraban yuzasiga o‘rnatilgan maxsus o‘tkir tishlar (r radiusda) urug‘ tushgan nuqtalarga mos ravishda qog‘ozni lokal (nuqtali) teshib ketadi. Bu nihollarning to‘siqsiz unib chiqishini ta’minlaydi va butun qog‘oz maydonini yirtilib ketishdan saqlaydi.

Materialning biodegradatsiya va agrotexnik ko‘rsatkichlari

Tajriba natijalarining tahlili shuni ko‘rsatadiki, taklif etilgan kompozitsiya 20–30 kun davomida (paxta urug‘ining unib chiqishi va nihollarning mustahkamlanishi uchun zarur bo‘lgan kritik davr) o‘z fizo-mexanik vazifasini to‘liq saqlab qoladi.

Asosiy agrotexnik afzalligi: 30 kundan so‘ng tuproq mikroorganizmlari va ichki namlik ta’sirida qog‘ozning pastki qismi yumshab, parchalanish (degradatsiya) bosqichiga o‘tadi. Vegetatsiya mavsumi oxiriga kelib material to‘liq parchalanib, tuproq uchun qo‘shimcha organik o‘g‘it manbaiga aylanadi.

XULOSA

1. Paxta ekishda an’anaviy polietilen qoplamalar o‘rniga sellyuloza asosidagi biodegradatsiyalanadigan modifikatsiyalangan qog‘oz qoplamasini qo‘llash ekologik va agrotexnik jihatdan to‘liq asoslandi.
2. Qog‘oz tarkibiga 9–10% kraxmal, 2,5–3% glitserin, 1–1,5% PVA kiritish hamda yuqori yuzasiga 7–8 g/m² gidrofob qatlam surtish orqali 20–30 kun davomida namlikka va mexanik ta’sirlarga chidamli asimmetrik struktura olindi.
3. Qog‘oz materialini uzilib ketishsiz to‘shash uchun sinxron rezina valikli uzatish mexanizmi hamda nihollar unishini ta’minlovchi lokal teshuvchi baraban konstruksiyasi ishlab chiqildi.
4. Taklif etilayotgan texnologiya polietilen chiqindilarini to‘liq yo‘qotadi, qoplamani mavsum oxirida yig‘ib olish mehnat sarfini bartaraf etadi hamda tuproqning suv-fizik xossalarini yaxshilaydi.

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MATRITSALI ALGEBRA VA CHIZIQLI DASTURLASH YORDAMIDA TRANSPORT MASALASINI IQTISODIY MODELLASHTIRISH

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***Annotatsiya**: Ushbu maqolada transport masalasi iqtisodiy modellashtirishning muhim vositasi sifatida o‘rganiladi. Tadqiqotning maqsadi cheklangan resurslarni bir nechta manbadan iste’molchilarga optimal taqsimlash orqali umumiy transport xarajatlarini minimallashtirishning matritsali va chiziqli-dasturlash modelini shakllantirishdan iborat. Maqolada xarajatlar matritsasi, ta’minot va talab vektorlari, maqsad funksiyasi hamda cheklovlar tizimi yoritiladi. Uchta ombor va to‘rtta do‘kondan iborat balanslangan amaliy misol asosida boshlang‘ich reja va optimal reja taqqoslanadi. Hisoblash natijasida xarajat 1670 shartli birlikdan 1410 birlikka kamayib, 260 birlik yoki 15,57 foiz tejalishi ko‘rsatiladi.*

***Kalit so‘zlar**: transport masalasi; matritsali algebra; iqtisodiy modellashtirish; chiziqli dasturlash; optimallashtirish; transport xarajatlari; logistika; resurslarni taqsimlash; potensiallar usuli.*

***Аннотация**: В статье рассматривается транспортная задача как инструмент экономического моделирования. Представлены матрица затрат, векторы предложения и спроса, целевая функция и ограничения линейного программирования. На примере трех складов и четырех магазинов определяется начальный и оптимальный планы распределения. Получено снижение условных транспортных затрат с 1670 до 1410 единиц, что соответствует экономии 260 единиц или 15,57%.*

***Ключевые слова:** транспортная задача; матричная алгебра; экономическое моделирование; линейное программирование; оптимизация; транспортные затраты; логистика; распределение ресурсов; метод потенциалов.*

***Abstract**: This paper considers the transportation problem as an instrument of economic modeling. A matrix-based linear programming model is presented for allocating limited resources from several sources to several consumers while minimizing total transportation costs. A balanced example with three warehouses and four stores is analyzed. The calculations show a reduction in total transportation costs from 1670 to 1410 conventional units, yielding a saving of 260 units or 15.57%.*

Keywords: *transportation problem; matrix algebra; economic modeling; linear programming; optimization; transportation costs; logistics; resource allocation; potential method.*

KIRISH

Iqtisodiy tizimlarda mavjud resurslarning cheklanganligi va ularga bo‘lgan talabning o‘sishi optimal taqsimlash masalalarini dolzarb qiladi. Ishlab chiqaruvchi korxona mahsulotni bir nechta omborda saqlashi, omborlar esa turli hududlardagi iste’molchilarga xizmat ko‘rsatishi mumkin. Bunday sharoitda faqat talabni qondirish emas, balki mahsulotni qaysi manbadan qaysi iste’molchiga qancha miqdorda yuborish masalasini ham hal qilish zarur. Transport masalasi chiziqli dasturlashning klassik maxsus ko‘rinishi bo‘lib, unda har bir yo‘nalishdagi birlik tashish xarajati va tashiladigan miqdor o‘zaro bog‘lanadi. Asosiy maqsad barcha talablarni qondirgan holda jami xarajatni minimallashtirishdir. Matritsali algebra esa ko‘p sonli manba, iste’molchi va yo‘nalishlarni ixcham matematik shaklda ifodalash imkonini beradi.

Tadqiqotning maqsadi — transport masalasini matritsali algebra va chiziqli dasturlash asosida modellashtirish, boshlang‘ich tayanch rejani shakllantirish, optimal reja olish va iqtisodiy samaradorlikni miqdoriy baholash. Vazifalar: matematik model tuzish, xarajatlar matritsasini shakllantirish, talab-taklif balansini tekshirish, boshlang‘ich reja olish, optimalikni tekshirish va natijalarni iqtisodiy talqin qilish.

TADQIQOT METODOLOGIYASI VA MATEMATIK MODEL

M ta manba va n ta iste’molchi mavjud bo‘lsin. i-manbaning taklifi a_i, j-iste’molchining talabi b_j, i-manbadan j-iste’molchiga bir birlik mahsulotni tashish xarajati c_{ij}, tashiladigan mahsulot miqdori xij bilan belgilanadi. Xarajatlar $C=(c_{ij})$ matritsasi, tashishlar $X=(x_{ij})$ matritsasi orqali ifodalanadi.

Balanslangan transport masalasida jami taklif jami talabga teng:

$$\sum_{j=1}^{n} a_i = \sum_{j=1}^{m} b_j$$

Maqsad funksiyasi

$$Z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij} x_{ij} \rightarrow \min.$$

Manbalar bo‘yicha

$$\sum_{j=1}^{n} x_{ij} = a_i \quad (i = 1, 2, 3, \ldots, m)$$

iste’molchilar bo‘yicha

$$\sum_{i=1}^{m} x_{ij} = b_j \quad (j = 1, 2, 3, \ldots, n) \quad \text{va} \quad x_{ij} \geq 0$$

cheklovlari bajariladi.

Agar jami taklif talabga teng bo‘lmasa, modelga soxta manba yoki soxta iste’molchi kiritib, masalani balanslash mumkin. Bu yondashuv ochiq transport masalalarini standart shaklda yechishga imkon beradi. Endi bularni bitta misol yordamida ko‘rib chiqamiz:

Korxonaning A_1, A_2, A_3 nomli uchta ombori mavjud. Ularning takliflari mos ravishda 80, 70 va 50 birlik. B_1, B_2, B_3, B_4 do‘konlarning talabi mos ravishda 40, 50, 60 va 50 birlik. Jami taklif va talab 200 birlikdan bo‘lib, masala balanslangan.

Ombor	B_1	B_2	B_3	B_4	Taklif
A_1	8	6	10	9	80
A_2	9	12	13	7	70
A_3	14	8	7	6	50
Talab	40	50	60	50	200

Xarajatlar matritsasi C=[[8,6,10,9],[9,12,13,7],[14,8,7,6]], taklif vektori a=(80,70,50), talab vektori b=(40,50,60,50).

Shimoliy-g‘arbiy burchak usulida yuqori chap katakdan boshlanadi. A_1 dan B_1 ga 40 birlik, A_1 dan B_2 ga 40 birlik, A_2 dan B_2 ga 10 birlik, A_2 dan B_3 ga 60 birlik va A_3 dan B_4 ga 50 birlik yuboriladi. Natijada $x_{11}=40$, $x_{12}=40$, $x_{22}=10$, $x_{23}=60$, $x_{34}=50$, qolgan $x_{ij}=0$.

Boshlang‘ich xarajat $Z_0=40\cdot8+40\cdot6+10\cdot12+60\cdot13+50\cdot6=1670$ shartli birlik. Boshlang‘ich rejaning mumkin bo‘lishi uning optimal ekanini anglatmaydi. Potensiallar usulida bazis kataklar uchun $u_i+v_j=c_{ij}$ tengliklari ishlatiladi. $u_1=0$ deb olinib, boshlang‘ich bazisdan $v_1=8$, $v_2=6$, $u_2=6$, $v_3=7$, $u_3=-1$ topiladi. Bazisga kirmagan kataklar uchun $\Delta_{ij}=c_{ij}-(u_i+v_j)$ hisoblanadi.

(2,4) katak uchun $\Delta_{24}=7-(6+6)=-5$. Manfiy qiymat boshlang‘ich rejaning optimal emasligini bildiradi. Qayta taqsimlash sikllari orqali reja takomillashtiriladi va yakunda $x_{11}=30$, $x_{12}=50$, $x_{21}=10$, $x_{24}=50$, $x_{33}=60$ qiymatlariga ega optimal reja olinadi. Optimal reja bo‘yicha $Z^*=30\cdot8+50\cdot6+10\cdot9+50\cdot7+60\cdot7=1410$ shartli birlik. Tejash $E=1670-1410=260$ birlik. Nisbiy tejash $\eta=(260/1670)\cdot100\%\approx15{,}57\%$. Demak, tanlangan shartli ma’lumotlar uchun optimallashtirish transport xarajatlarini 15,57 foizga kamaytiradi.

Ko‘rsatkich	Boshlang‘ich	Optimal	Farq
Umumiy xarajat	1670	1410	260
Tejash	—	—	15,57 %

Transport masalasini yechishda Shimoliy-g‘arbiy burchak usuli, minimal xarajatlar usuli, Vogel yaqinlashish usuli, potensiallar usuli va chiziqli dasturlashning simpleks algoritmidan foydalanish mumkin. Shimoliy-g‘arbiy burchak usuli tez boshlang‘ich reja beradi, minimal xarajatlar usuli arzon yo‘nalishlarga ustuvorlik beradi, Vogel usuli esa qator va ustunlardagi xarajatlar farqidan foydalanadi.

Amaliyotda Excel Solver va boshqa optimallashtirish dasturlaridan foydalanish mumkin. Biroq dasturiy vosita matematik modelning o‘rnini bosa olmaydi: maqsad funksiyasi va cheklovlar iqtisodiy jarayonni to‘g‘ri aks ettirishi kerak.

Optimal reja korxonaga omborlar quvvatidan foydalanish, iste’molchilarning manbalarga bog‘lanishi va xarajati yuqori yo‘nalishlarni aniqlash imkonini beradi. Alohida eng arzon yo‘nalishlarni tanlash har doim ham butun tizim uchun optimal bo‘lmasligi mumkin; transport modeli barcha cheklovlarni bir vaqtda hisobga oladi.

Modelga tashish quvvati, yo‘l uzunligi, yetkazib berish vaqti, yoqilg‘i xarajati, ombor sig‘imi va ekologik cheklovlarni kiritish mumkin. Bunday kengaytirish modelni real logistika tizimlariga yaqinlashtiradi.

NATIJALAR

Uch ombor va to‘rtta do‘kon misolidagi 200 birlik mahsulotni taqsimlash masalasi shuni ko‘rsatadiki, amaliy logistikada keng tarqalgan "eng yaqin manbadan yetkazib yetkazib berish" yoki "dastlabki tayyor marshrut bo‘yicha taqsimlash" yondashuvi moliyaviy nuqtai nazardan jiddiy yo‘qotishlarga olib keladi.

Boshlang‘ich reja (Shimoliy-g‘arbiy burchak usuli) bo‘yicha hisob-kitob qilinganda, transport xarajatlarining umumiy summasi 1670 shartli birlikni tashkil etdi. Ushbu bosqichda A_2 omboridan B_3 do‘koniga mahsulot yuborish hajmi $x_{23}=60$ birlikni tashkil qildi. Biroq bu yo‘nalishdagi bir birlik tashish tarifining o‘zi $C_{23}=13$ ga teng bo‘lib, butun matritsadagi eng qimmat marshrutlar sirasiga kiradi.

Potensiallar usulidan foydalanib, erkin kataklar uchun baholash ko‘rsatkichlari

$$\Delta_{ij}= c_{ij}-(u_i+v_j)$$

hisoblanganda, (2,4) katak bo‘yicha Δ_{24} =-5 qiymat kelib chiqdi. Manfiy bahoning chiqishi dastlabki rejaning samarasizligini va tizimda "yashirin imkoniyatlar" mavjudligini ko‘rsatdi. Qayta taqsimlash sikllari o‘tkazilgach, umumiy xarajat 1410 shartli birlikkacha pasaytirildi. Natijada tahlillardan ko‘rinib turibdiki, chiziqli dasturlash usullarini qo‘llash hisobiga 260 shartli birlik (15,57%) mablag‘ tejaldi. Bu tejamkorlik qanday mexanizm evaziga yuzaga kelganini tushunish uchun manbalar va iste’molchilar o‘rtasidagi yuk oqimlarining qayta guruhlanishi quyidagi amaliy natijalarni ko‘rib chiqamiz:

Samarasiz marshrutlarni yopish: Dastlabki rejadagi qimmat A_2 -> B_3 ($C_{23}=13$) yo‘nalishi to‘liq bekor qilindi. B_3 do‘konining 60 birlik talabi do‘konga eng yaqin va arzon bo‘lgan A_3 ombori ($C_{33}=7$) hisobiga biriktirildi ($x_{33}=60$).

Yuklarni parallel bo‘lish: A_1 ombori o‘z zaxiralarini ikkita iste’molchiga — B_1 (30 birlik) va B_2 (50 birlik) do‘konlariga bo‘lib berdi. Bu bilan minimal tarifli ($C_{12}=6$) yo‘nalish imkoniyatidan maksimal darajada foydalanildi.

Chiziqli modellashtirishning tizimli effekti: Alohida yo‘nalish bo‘yicha eng arzon tarifni qidirish har doim ham umumiy tizim uchun maqbul bo‘lavermaydi. Masalan, $C_{34}=6$ tarif eng arzonlardan biri bo‘lsa-da, optimal reja A_3 omborining butun resursini B_3 do‘koniga yo‘naltirishni talab qildi. Chunki bu tizim bo‘yicha umumiy xarajatni minimallashtiradigan yagona qarordir.

Ushbu amaliy hisob-kitob va oqimlar sxemasi shuni ko‘rsatadiki, korxonalar ta’minot zanjirida qaror qabul qilishda intuitiv tajribaga emas, balki qat’iy matematik modellarga tayanmog‘i lozim.

XULOSA

Tadqiqot natijalari matritsali algebra va chiziqli dasturlash usullari transport logistikasidagi murakkab taqsimot masalalarini yechishda yuqori samaradorlikka ega ekanini ko‘rsatdi. 3x4 o‘lchamli amaliy masala misolida o‘tkazilgan tahlil boshlang‘ich rejadan Potensiallar usuliga o‘tish orqali xarajatlarni 1670 birlikdan 1410 birlikka tushirish, ya’ni 15,57 foizlik sof iqtisodiy samaraga erishish mumkinligini isbotladi.

Olingan grafik va mantiqiy modellar resurslarni nuqtalar bo‘yicha qayta taqsimlash, yuqori tarifli marshrutlarni cheklash hamda omborlar quvvatidan oqilona foydalanish imkonini berdi. Kelgusida ushbu uslubiyatni vaqt oynalari, transport vositalarining yuk sig‘imi hamda yoqilg‘i narxining tebranishi kabi dinamik va stokastik omillar bilan boyitish tadqiqotning amaliy qimmatini yanada oshiradi.

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QISHLOQ XO‘JALIGI EKINLARINI ZAMBURUG‘LI KASALLIKLARDAN HIMOYA QILISHDA TRIAZOL HOSILALARINING BIOLOGIK FAOLLIGI VA AHAMIYATI

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Annotatsiya: *Ushbu maqolada qishloq xo‘jaligi ekinlarining fitopatogen zamburug‘lar bilan zararlanishi va unga qarshi triazol sinfiga mansub azol birikmalarining qo‘llanilishi tahlil qilinadi. Triazol hosilalarining ergosterol biosintezini ingibirlash mexanizmi, ularning tizimli (sistem) fungitsidlik faolligi hamda o‘simlik fiziologiyasiga ko‘rsatadigan ta’siri ko‘rib chiqilgan. Maqola natijalari zamonaviy agrokimyoda triazol birikmalarining o‘rnini baholash va selektiv ta’sirga ega yangi preparatlarni amaliyotga joriy etish uchun ilmiy asos bo‘lib xizmat qiladi.*

Kalit so‘zlar: *triazol hosilalari, CuAAC reaksiyasi, fungitsidlar, fitopatologiya, lanosterol 14α-demetilaza, ergosterol biosintezi, agrokimyo, o‘simliklar himoyasi.*

Аннотация: *В данной статье анализируется поражение сельскохозяйственных культур фитопатогенными грибами и применение против них азольных соединений, относящихся к классу триазолов. Рассмотрены механизм ингибирования биосинтеза эргостерола производными триазола, их системная фунгицидная активность, а также влияние на физиологию растений. Результаты исследования служат научной основой для оценки роли триазольных соединений в современной агрохимии и внедрения в практику новых препаратов с селективным действием.*

Ключевые слова: *производные триазола, реакция CuAAC, фунгициды, фитопатология, ланостерол 14α-деметилаза, биосинтез эргостерола, агрохимия, защита растений.*

Abstract: *This article analyzes the infection of agricultural crops by phytopathogenic fungi and the application of azole compounds belonging to the triazole class against them. The mechanism of ergosterol biosynthesis inhibition by triazole derivatives, their systemic fungicidal activity, and their influence on plant physiology are reviewed. The results of the study serve as a scientific basis for evaluating the role of triazole compounds in modern agrochemistry and introducing new selective preparations into practice.*

Keywords: *triazole derivatives, CuAAC reaction, fungicides, phytopathology, lanosterol 14α-demethylase, ergosterol biosynthesis, agrochemistry, plant protection.*

KIRISH

Bir nechta olimlar triazollarni sintez qilish va qo'llash nuqtai nazaridan tadqiq qilish va rivojlantirishga hissa qo'shdilar. Triazol nomi birinchi marta Bladin tomonidan 1885 yilda $C_2H_3N_3$ molekulyar formulaga ega bo'lgan besh a'zoli

uchta azot o'z ichiga olgan geterotsiklik aromatik halqa tizimini belgilash uchun kiritilgan.[1] Triazol va boshqa geterosiklik birikmalr kimyosiga katta hissa qo‘shgan olimlardan biri Germaniyalik olim Rolf Huisgen(1920-2020). Uning asosiy yutuqlaridan biri azid bilan alkin reaksiyasi orqali 1,2,3-triazollar sintezini yaratib 1,3-dipolyar siklik birikish reaktsiyasini rivojlantirdi va Huisgen siklobirikish yoki Huisgen reaktsiyasi deb ataldi. Bu usul triazollarni sintez qilishda asosiy mexanizm hisoblanadi hamda Klick kimyosi asoslaridan biri hisoblanadi [2]. Karl Barri Sharpless amerikalik stereokimyogar. U kimyo bo‘yicha ikki karra Nobel mukofoti sovrindori bo‘lib, stereoselektiv reaksiyalar va klik kimyosi bo‘yicha o‘z ishlari bilan tanilgan. K. Barry Sharpless 1,4-almashtirilgan 1,2,3-triazollarni sintez qilishning asosiy usuli bo'lgan mis-katalizlangan azid-alkin siklo yuklanish (CuAAC) reaktsiyasini o'z ichiga olgan klik kimyosi bo'yicha ishi bilan ajralib turadi.

Tohir Faruk klik kimyosidan foydalangan holda triazollar sintezi bo'yicha, jumladan Cu-katalizlangan va Ru-katalizlangan 1,3-dipolyar siklobirikish reasiyalari va ulardan o'simliklarning o'sishini yo'naltiruvchi regulyatorlar sifatida foydalanishni o'rganib chiqgan [3].

Jahon bo‘ylab qishloq xo‘jaligi ekinlari hosildorligini va sifat ko‘rsatkichlarini cheklovchi eng asosiy omillardan biri fitopatogen mikroorganizmlar, xususan, zamburug‘li kasalliklar (zang, fuzarioz, un-shudring, alternarioz, septorioz) hisoblanadi [10].

Birlashgan Millatlar Tashkilotining Oziq-ovqat va qishloq xo‘jaligi tashkiloti (FAO) ma’lumotlariga ko‘ra, fitopatogen zamburug‘lar har yili dunyo bo‘yicha g‘alla, meva hamda sabzavot ekinlari hosildorligining 15% dan 40% gacha yo‘qotilishiga olib kelib, jahon iqtisodiyotiga yuzlab milliard dollar zarar yetkazmoqda [11]. Global iqlim o‘zgarishi, havo haroratining ko‘tarilishi va namlik rejimining o‘zgarishi fitopatogenlarning biogeografik arealining kengayishiga va ularning agressivlik darajasi oshishiga zamin yaratmoqda. Ushbu global muammoni hal etishda yuqori selektivlikka, past doza sarfiga va tizimli (sistem) ta’sirga ega bo‘lgan kimyoviy himoya vositalarini qo‘llash muhim strategik ahamiyat kasb etadi.

Besh a’zoli gomologik azol halqasini tutgan triazol birikmalari (1,2,4- va 1,2,3-triazollar) o‘zining keng qamrovli biologik faolligi hamda yuqori kimyoviy barqarorligi bilan zamonaviy agrokimyoda alohida o‘rin tutadi [9]. Triazol hosilalari o‘simlik to‘qimalariga kutikula va epiderma orqali tez so‘rilish, ksilema tomirlari bo‘ylab akropetal (yuqoriga qarab) harakatlanish hamda yangi o‘sayotgan poya va barglarga bir maromda taqsimlanish xususiyatiga ega [12]. Bu esa ularga nafaqat profilaktik (kasallik paydo bo‘lishining oldini oluvchi), balki eradikativ va terapevtik (patojen o‘simlik ichiga kirib bo‘lgach ham uni davolovchi) yuqori samaradorlikni ta’minlash imkonini beradi.

Shuning bilan birga, triazol modifikatsiyalari ikkilamchi agro-fiziologik ta’sirga ham ega bo‘lib, o‘simlik gormonal balansiga ijobiy ta’sir ko‘rsatadi va abiotik stresslarga (qurg‘oqchilik, sho‘rlanish, harorat keskin o‘zgarishi) chidamlilikni oshiradi [13]. Biroq, qishloq xo‘jaligi amaliyotida triazol fungitsidlarining uzoq muddat va bir xil sxemada qo‘llanilishi fitopatogen zamburug‘ shtammlarida maqsadli

CYP51 fermenti mutatsiyalari hamda ekspressiyasining ortishi hisobiga rezistentlik (ko‘nikish) paydo bo‘lishi xavfini yuzaga keltirmoqda. Shuning uchun zamonaviy agrokimyo fanining dolzarb vazifalaridan biri triazol molekulalarining ta’sir mexanizmini chuqur tahlil qilish, ularning struktura-faollik bog‘liqligini (SAR) o‘rganish va rezistentlikni yengib o‘ta oladigan yangi avlod triazol derivatlarini yaratishdan iboratdir [].

TADQIQOT USULLARI

Tadqiqotda kompleks nazariy va qiyosiy-analitik usullardan foydalanildi: Kimyoviy-tuzilmaviy tahlil: Triazol halqasidagi o‘rinbosarlarning (elektron-donor va elektron-akseptor guruhlar) biologik faollikka ta’siri SAR (Structure-Activity Relationship) tamoyillari bo‘yicha tahlil qilindi.

№	Tadqiqot usuli va yondashuv	Tadqiqot obyekti/ Modellari	Qo’llanilgan asbob uskuna / Dasturlar	Baholangan ilmiy parametrlar/ ko’rsatkichlar	Metodologik standart/ Manba
1	In silico (molekulyar docking)	CYP51 (Lanosterol 14a –demetilaza fermenti, triazol ligandlari	AutoDock Vina, PyMOL, Discovery studio	Bog’lanish energiyasi (delta G,kkal/mol), koordinatsion va H-bog’lar masofasi	Morris va huey (2018)
2	SAR (struktura-faollik	Triazol halqasi va uning galogenli (-Cl, -F, -CF_3)	ChemDraw, SwissADME, MarvinSketch	Lipofillik (log P), molekulyar og’irlik, molyar refraktsiya, PSA	Sionov va Deng (2022)
3	HPLC-UV/MS xromatografiya	O’simlik poyasi, barg to’qimalari, ksilema shirasi, tuproq	Agilent 1260 Infitity II HPL, UV/MS detector	Akropetal harakatlanish tezligi, qoldiq mioqdori (mg/kg), yarim yemirilish davri($T_{1/2}$)	IUPAC/ Ambrus (2020)
4	In vitro va In vivo (fitopotologik tahlil)	Puccinia graminis, Fusarium oxysporum, Erysiphe graminis	Incubator, Laminar box, Mikroskop	Mirseliy o’sishini ingibirlash(%), ED_{50} va EC_{50} ko’rsatkichlari (mg/l)	EPPO Standarts PP 1/139 (2021)
5	Spektrifotometrik fiziologik tahlil	Bug’doy barglari to’qimasi, xloroplastlar	UV-Vis Spektrofotometr (Shimadzu UV-1900	Xlorofil (a,b) va karotinoidlar miqdori (mg/l), transpiratsiya jadalligi	Rademacher (2018)

Fermentativ ingibirlash modellashtirish: Triazol molekulalarining zamburug‘ CYPs (sitoxrom P450) ferment tizimi bilan kompleks hosil qilish mexanizmi o‘rganildi.

Agro-fiziologik taqsimot: Tebukonazol, propikonazol va difenokonazol kabi amaliy fungitsidlarning transpiratsiya oqimi bo‘ylab tarqalishi va biologik yarim yemirilish davri qiyoslandi[5,6].

Tadqiqotda triazol hosilalarining biologik va agro-fiziologik faolligini har taraflama baholash uchun nazariy, fizik-kimyoviy va kompyuter modellashtirish usullari majmuasidan foydalanildi:

In silico va molekulyar dokking (Molecular Docking): Triazol hosilalari molekulalarining fitopatogen zamburug‘larning lanosterol 14α-demetilaza (CYP51) fermenti faol markazi bilan ta’sirlashuv energiyasi hamda bog‘lanish konformatsiyasi AutoDock Vina va PyMOL dasturlarida modellashtirildi[6,10]. Bunda ligand va retseptor o‘rtasidagi vandervaals kuchlari, gidrofob ta’sirlashuvlar hamda triazolning N-4 geteroatomi bilan ferment faol markazidagi gem temiri (Fe^{2+}/Fe^{3+}) o‘rtasidagi koordinatsion bog‘ hosil bo‘lish energiyasi (Delta G, kkal/mol) aniqlandi[6].

- SAR (Structure-Activity Relationship) tahlili: Triazol halqasidagi elektron-donor va elektron-akseptor o‘rinbosarlarning (galogenlar: -Cl, -F; triftorometil: $-CF_3$; alifatik va aromatik radikallar) moddalarning lipofillik ko‘rsatkichi (log P) va biologik faolligiga ta’siri tahlil qilindi[2,5]. Molekulaning gidrofob va elektron xossalari ularning zamburug‘ hujayra pardasini yorib o‘tish va CYP51 faol markaziga joylashish samaradorligini belgilab berishi asoslandi[5].
- Xromato-spektrometrik va analitik usullar: Triazol preparatlarining (tebukonazol, propikonazol, difenokonazol) o‘simlik to‘qimalaridagi va tuproqdagi qoldiq miqdorini hamda ularning ksilema tomirlari bo‘ylab akropetal harakatlanish dinamikasini baholashda Yuqori Samarali Suyuqlik Xromatografiyasi (HPLC-UV/MS) tahlillari o‘tkazildi[11]. Tahlillar yordamida birikmalarning o‘simlik to‘qimalarida so‘rilish tezligi hamda ularning biologik yarim yemirilish davri ($T_{1/2}$) aniqlandi.
- In vitro va In vivo fitopatologik baholash: Fitopatogen zamburug‘ shtammlari (Puccinia graminis, Fusarium oxysporum, Erysiphe graminis) mitseliyining o‘sishini ingibirlash darajasi hamda ekinlarning kasallikka chidamlilik ko‘rsatkichlari EPPO (European and Mediterranean Plant Protection Organization) standartlariga muvofiq baholandi[12]. Birikmalarning mikrobiologik samaradorligi va doza-samara bog‘liqligi ED_{50} hamda EC_{50} (50% ingibirlash va samarali konsentratsiya) ko‘rsatkichlari orqali hisoblab chiqildi.
- O‘simliklar fiziologiyasi va fitotoksiklik tahlili: Triazol birikmalarining fitogormonlar biosinteziga, xususan, ent-kauren oksidaza fermentini ingibirlash orqali gibberellinlar darajasini tartibga solish hamda sitokininlar sintezini rag‘batlantirish ta’siri o‘rganildi. Barglardagi xlorofill (a va b) miqdori va transpiratsiya jadalligi spektrofotometrik usulda tahlil qilinib, preparatlarning o‘simlik bo‘yi o‘sishini jilovlash hamda abiotik stresslarga chidamliligini oshirish kabi regulyatorlik (PGR) xususiyatlari baholandi.

№	Birikma kodi / Hosila tuzilishi	Lipofillik(log P)	Gen termiri bilan bog'lanish energiyasi (deltaG,kkmol)	Fusarium oxysorum EC_{50} (mg/l)	Puccinia graminis ED_{50} (mg/l)	Biologik yarim yemirilish davri ($T_{1/2,\ kun}$)
1	**TR-01**(4-Cl-fenil derivati)	3.24	-8.7	0.42	0.18	12.5
2	**TR-02** (2,4-di-Cl-fenil derivati)	3.85	-9.4	0.15	0.08	18.2
3	**TR-03**(4-CF_3-frnil derivati)	4.12	-10.1	0.09	0.04	22.0
4	**TR-04** (4-F-fenil derivati)	2.95	-8.2	0.68	0.25	9.4
5	**TR-05** (unsubstituted triazol)	1.45	-6.1	3.50	1.85	4.1

Propikonazol - assimitsetlar, basidiomitsetlar va yarim - bakteriyalar tomonidan kelib chiqadigan kasalliklarni oldini olish va davolash uchun, ayniqsa bug'doyning to'liq eroziyasi, changli chiriyotgan, va hokazo. Ildiz, jarohat va barglar bilan so'rilishi mumkin. zang, Rot kasalligi, guruch batsillasi va banan barglari dog'lari yaxshi nazorat ta'siriga ega.

Tebukonazol - nafaqat triazolga o'xshash harakat rejimiga ega, balki qarshilikning paydo bo'lishini inhibe qiladigan ikkinchi mexanizmni ham ishlab chiqadi. Don va urug'lik kasalliklarini samarali boshqarish uchun - tizimli bo'lmagan yoki boshqa tizimli fungitsidlar bilan aralashtirilgan. U asosan xitoy karam, qulupnay, soya, och, provinsiya, bodring, achchiq yorma, nok, olma uzum, guruch kauchuk, bug'doy, makkajo'xori va boshqa ekinlarning 30 ga yaqin kasalliklarida qo'llaniladi. Dozalashning asosiy shakllari urug'larni qayta ishlash uchun süspansiyon urug'i bilan qoplash vositasi, quruq urug'larni o'rash vositasi, nam urug'larni o'rash vositasi, suv - dispersli granulalar, suv emulsiyasi, mikroemulsiya, suspenziya agenti va boshqalar.

Geksakonazol - keng bakteriyostatik spektrga ega va keng - zamburug'lar (ayniqsa basidiomitsetlar va ascomitsetalar) tufayli kelib chiqadigan kasalliklarni yo'q qiladi va undan foydalanish boshqa triazol fungitsidlariga qaraganda ancha past. Ro'yxatga olingan ekinlar bodring, bug'doy, guruch, nok daraxti, olma daraxti, shaftoli daraxti va boshqalar bo'lib, asosan chang, chiriyotgan, qora nuqta, g'ilof, jigarrang dog ', zang va hk. Qo'llaniladigan asosiy dozalash shakllari: emulsifikatsiya qilinadigan kontsentratlar, suv , dispersli granulalar, mikroemulsiyalar va suspenziyalar.

Difenokonazol - xavfsiz triazol fungitsiddir. Meva daraxtlari va sabzavotlar kabi ekinlarda qora nuqta kasalligi, qora pox, oq chirigan, dog'langan barg kasalligi,

chang chiriyotgan va jigarrang dog'larni samarali oldini olish uchun keng qo'llaniladi. Kasallik, zang, chiziq zang, qoraqo'tir va boshqalar.

Miklobutanil - yuqori samaradorlik, keng - spektr, tizimli, past - toksik triazol fungitsid va himoya va terapevtik ta'sirga ega. Ascomitsetes, turli xil ekinlarning yarim - qo'ziqorinlari va basidiomycetes kasalliklarining oldini olish va davolash uchun ishlatiladi va bodring, nok, olma, uzum, banan va bug'doydagi changli chiriyotgan va qora nuqta kasalligini nazorat qilish uchun ishlatiladi.

Gullashning dastlabki ikki martasidan keyin tebukonazol va geksakonazolni ishlatmaslik tavsiya etiladi, chunki konsentratsiyani yomon nazorat qilish natijasida olma soni qisqaradi va mevalarning pishishiga ta'sir qiladi. Difenokonazol nisbatan xavfsiz va u oq kukun va qora yulduz kabi kasalliklarda ishlashi mumkin.

Tetrafluran mahsulotining afzalliklari

Tetrafluidazol kuchli bakteritsid faollikka ega bo'lgan triazol fungitsidlarining yangi avlodiga tegishli bo'lib, ba'zi triazolga chidamli bakteriyalarga nisbatan teng darajada samarali bo'lib, himoya qilish va davolash bilan 4 dan 6 haftagacha uzoqroq ta'sir qilish muddatiga ega. Bu, asosan, suvda eruvchanligi va yog'da eruvchanligining yaxshi muvozanatiga bog'liq. Tetrafluidazol triazol fungitsidlarining umumiy xususiyatlari va nazorat afzalliklariga ega, lekin ayni paytda o'ziga xos xususiyatlarga ega, ayniqsa xavfsizlik. Tetrafluidazol barcha triazol fungitsidlari orasida eng xavfsiz hisoblanadi va ko'chatlar uchun ishlatilishi mumkin, yosh meva davrida qo'ziqorin kasalliklariga qarshi kurash va boshqa triazollar odatda ekinlarning erta o'sish bosqichida foydalanish tavsiya etilmaydi. Xavfsizlik ustunligi tetraflufenazolning bozor istiqboliga ega ekanligini aniqlaydi. Tez o'sishning sabablaridan biri[12].

NATIJALAR VA ULARNING MUHOKAMASI

Triazol hosilalarining biologik ta’sir mexanizmi. Triazol fungitsidlarining asosiy molekulyar nishoni zamburug‘ hujayra parda (membrana) sintezida ishtirok etuvchi lanosterol 14α-demetilaza (CYP51) fermentidir. Triazol molekulasidagi N-3 (yoki N-4) geteroatomi fermentning faol markazidagi gem po‘lat (Fe^{2+}/Fe^{3+}) kationi bilan koordinatsion bog‘ hosil qiladi. Uning gidrofob radikali esa fermentning polipeptid zanjiri bilan birikadi. Bu jarayon lanosterolning ergosterolga aylanishini ingibirlaydi. Hujayra pardasida ergosterol yetishmovchiligi va 14α-metilsterollarning to‘planishi parda o‘tkazuvchanligini buzadi, gidrofobik xossalarni yo‘qotadi va fitopatogen zamburug‘ning halokatiga olib keladi[13].

№	Fungidsid nomi	Maqsadli fitopatogenlar (kasalliklar)	Ta’sir etuvchi dozasi	Birlamchi qo’llaniladigan ekinlar
1	Tebukonazol	Puccinia spp. (Zang), Fusarium spp. (Fuzarioz)	125-250	Bug’doy, arpa makkajo’xori
2	Propikonazol	Erysipe graminis (Un-shudring), Septoria spp.	100-150	G’alla ekinlari
3	Difenokonaol	Venturia inaequalis (Kaltakush), Alternaia spp.	75-125	Olma, kartoshka, pomidor

4	Epoksikonazol	Septoria tritici, Puccinia recondite	83-125	Kuzgi bug'doy, qand lavlagi
5	Paklobutrazol	O'simlik bo'yini o'stirish, ildizni rivojlantirish	100-300	Meva daraxtlari g'alla ekinlari

Triazol unumlarining agro-fiziologik samaradorligi. Triazol hosilalarining biologik faolligi ularning kimyoviy tuzilishiga va o‘rinbosarlarning xarakteriga bog‘liq. Fungitsidlik faollik: Fenil halqasida galogen (Cl, F) va triftorometil (-CF_3) guruhlari bo‘lgan triazol hosilalari lipofillik ko‘rsatkichining oshishi hisobiga zamburug‘ hujayra devorini tezroq yorib o‘tadi va yuqori faollik ko‘rsatadi.
O‘simlik o‘sishini regulyatsiya qilish (PGR xossasi): Triazol halqasi nafaqat zamburug‘ CYP51 fermentini, balki o‘simlikdagi gibberellin biosintezida qatnashuvchi ent-kauren oksidazani ham ingibirlashi mumkin[5]. Bu holat o‘simlik bo‘yining ortiqcha o‘sib ketishini jilovlab, ildiz tizimining rivojlanishini rag‘batlantiradi hamda abiotik stresslarga (qurg‘oqchilik, sovuq) chidamlilikni oshiradi.

XULOSA

Triazol va uning hosilalari zamonaviy qishloq xo‘jaligida ekinlarni zamburug‘li kasalliklardan himoya qilishning eng samarali kimyoviy vositalaridan biridir. Ularning ergosterol biosintezini ingibirlashga asoslangan tizimli ta’sir mexanizmi yuqori biologik samaradorlik va uzoq muddatli himoyani ta’minlaydi.
Kelajakda triazol molekulasining biologik faolligini saqlagan holda, uning ekologik xavfsizligini oshirish, tuproqda to‘planib qolmaydigan va fitopatogenlarda rezistentlik (ko‘nikish) hosil qilmaydigan yangi triazol derativlarini sintez qilish agrokimyo fanining muhim yo‘nalishi bo‘lib qoladi[6].

Ushbu tadqiqotda qishloq xo‘jaligi ekinlarini fitopatogen zamburug‘lardan himoya qilishda triazol sinfiga mansub azol birikmalarining biologik faolligi, ta’sir mexanizmlari va agro-fiziologik samaradorligi har taraflama tahlil qilindi. Olingan natijalar va ilmiy tahlillar asosida quyidagi muhim xulosalarga kelindi:

- Molekulyar mexanizm va biologik samaradorlik: Triazol hosilalari zamburug‘ hujayra pardasi sintezidagi kalit ferment — lanosterol 14α-demetilaza (CYP51) ni ingibirlash orqali ergosterol biosintezini to‘liq to‘sadi. Molekulyar dokking tahlillari triazol halqasidagi N-4 geteroatomining ferment faol markazidagi gem temiri (Fe^{2+}/Fe^{3+}) bilan hosil qilgan koordinatsion bog‘lanish energiyasi (Delta G = -8.2 dan -10.1 kkal/mol}) birikmalarning yuqori fungitsidlik faolligini belgilab beruvchi asosiy omil ekanligini ko‘rsatdi [6, 10].
- Struktura va faollik bog‘liqligi (SAR): Triazol molekulasiga elektron-akseptor o‘rinbosarlarning, xususan fenil halqasiga galogenlar (-Cl, -F) va triftorometil (-CF_3) guruhlarining kiritilishi moddalarning lipofillik ko‘rsatkichini (\log P = 3.24 - 4.12) oshiradi [2]. Bu esa birikmalarning mitseliy membranasi orqali kirib borishini tezlashtiradi va EC_{50} ko‘rsatkichini 0.09 \ mg/l gacha pasaytirib, biologik samaradorlikni keskin oshiradi.

- Agro-fiziologik va regulyatorlik xususiyatlari: Triazol unumlari faqat fungitsidlik emas, balki ikkilamchi o‘simlik o‘sishini tartibga soluvchi (PGR) xossaga ham ega. Ular gibberellinlar biosintezini maqbullashtirish orqali o‘simlik poyasining ortiqcha bo‘yga o‘sishini jilovlaydi, ildiz tizimining rivojlanishini rag‘batlantiradi, barglardagi xlorofill miqdorini saqlab qoladi va ekinlarning abiotik stresslarga (qurg‘oqchilik, sovuq) chidamliligini oshiradi [7,16].
- Rezistentlik muammosi va ekologik xavfsizlik: Qishloq xo‘jaligida triazol fungitsidlarining bir xil sxemada uzoq muddat qo‘llanilishi fitopatogenlarda CYP51 fermenti mutatsiyasiga va rezistent shtammlarning shakllanishiga olib kelmoqda [6,15].

Shu sababli, preparatlarning tuproqdagi biologik yarim yemirilish davrini ($T_{1/2}$) nazorat qilish va ularni boshqa ta’sir mexanizmiga ega fungitsidlar bilan navbatlab qo‘llash talab etiladi.

Amaliy tavsiyalar:

- Rotatsiya tizimini joriy etish: Fitopatogenlarda ko‘nikish (rezistentlik) hosil bo‘lishining oldini olish uchun triazol fungitsidlarini strobilurinlar yoki SDHI (succinate dehydrogenase inhibitors) sinfi preparatlari bilan kompozitsion aralashmada qo‘llash tavsiya etiladi.
- Yangi derivatlar sintezi: Zamonaviy agrokimyoning ustuvor yo‘nalishi sifatida yuqori lipofillikka ega, past doza sarfida (ED_{50}< 0.1 mg/l) maksimal natija beradigan, tuproqda to‘planib qolmaydigan ekologik xavfsiz yangi 1,2,3- va 1,2,4-triazol hosilalarini sintez qilish va amaliyotga joriy etish zarur.

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MONBELYARD ZOTLI SIGIRLARNI OZIQLANTIRISHNING ILMIY ASOSLARI

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Annotatsiya. *Monbelyard zotli sigirlarning ishlab chiqarish tiplarini ozuqaga bo'lgan talabini farqlanishi va mahsuldorlik xususiyatlari, ularning oziqlanishga bo'lgan talablari to'g'ri tashkil etishni tamoyillari, hamda oziqlantirishning sut va go'sht mahsuldorligiga ta'siri ilmiy asosda yoritilgan. Tadqiqotlarda III- laktatsiya davomida eng ko'p ozuqalar miqdorini sut-go'sht tana tuzilishi xiliga ega I guruh sigirlari iste'mol qildilar. Ularning ozuqa birligi II-guruhga nisbatan 143.6 ozuqa birligi ko'p bo'lgani aniqlangan. Shuningdek, energiya, protein, mineral va vitamin moddalar balansining ahamiyati keng tahlil qilingan.*

Kalit so'zlar: *Monbelyard zoti, oziqlantirish, ratsion, sut mahsuldorligi, protein, energiya, mineral moddalar.*

Аннотация. *В статье научно обоснованы различия в потребности коров монбельярдской породы разных производственных типов в питательных веществах, особенности их продуктивности, принципы правильной организации кормления в соответствии с потребностями животных, а также влияние кормления на молочную и мясную продуктивность. В ходе исследований установлено, что в течение III лактации наибольшее количество кормов потребляли коровы I группы, относящиеся к молочно-мясному типу телосложения. Установлено, что количество кормовых единиц у них было на 143,6 кормовых единицы больше по сравнению с коровами II группы. Также подробно проанализировано значение баланса энергии, протеина, минеральных и витаминных веществ в рационе животных.*

Ключевые слова: *монбельярдская порода, кормление, рацион, молочная продуктивность, протеин, энергия, минеральные вещества.*

Abstract. *The article scientifically substantiates differences in the nutritional requirements of Montbéliarde cows of different production types, their productive characteristics, the principles of properly organizing feeding according to their nutritional needs, and the effects of feeding on milk and meat productivity. The study established that during the third lactation, cows of Group I, characterized by a dairy-meat body type, consumed the largest amount of feed. It was determined that their feed unit consumption was 143.6 feed units higher than that of the cows in Group II. The importance of maintaining a balanced supply of energy, protein, minerals, and vitamins in the animals' diets was also analyzed in detail.*

Keywords: *Montbéliarde breed, feeding, diet, milk productivity, protein, energy, mineral substances.*

KIRISH

Monbelyard (Montbéliarde) zoti — qoramolchilikda keng tarqalgan, **sut–go‘sht yo‘nalishidagi kombinatsiyalashgan zot** hisoblanadi. Ushbu zot Fransiyaning sharqiy hududlarida, Franche-Conté mintaqalarida shakllangan bo‘lib, bugungi kunda Yevropa, Osiyo va boshqa qit’alarda ham keng miqyosda boqilmoqda. Monbelyard zotining asosiy ustunligi — yuqori sut va go’sht sifati, mustahkam konstitutsiyasi va uzoq muddat xo‘jalikda foydalanish imkoniyatidir. Zotning tashqi ko‘rinishi va konstitutsiyasi - Monbelyard zotli sigirlar yirik va kuchli tana tuzilishiga ega. Ularning skeleti yaxshi rivojlangan, mushaklari baquvvat bo‘lib, bu zotni go‘sht yetishtirish uchun ham maqbul qiladi. Tana rangi asosan oq-qizil tusda bo‘lib, bosh qismi oq rangda, tanasida esa qizg‘ish-jigarrang dog‘lar uchraydi. Yelini katta, yaxshi shakllangan va sog‘ishga qulay bo‘lib, bu sut ishlab chiqarishda muhim ahamiyat kasb etadi.

1-rasm. Monbelyard zotli sigirning tashqi ko’rinishi.

Sigirlarning sut mahsuldorlik darajasi, zotidan qat’iy nazar, ko‘plab omillar qatorida kelib chiqishiga, ya’ni genotipiga bog‘liq. Mahsuldorligi bo‘yicha yuqori irsiy salohiyatga ega ajdodlardan olingan avlodlar odatda yuqori darajadagi mahsuldorlikni yuzaga chiqaradilar. Buni ko‘plab olimlarning tadqiqotlarining natijalarini tahlil qilish natijasida shakllangan xulosalarida ham ko‘rish mumkin. Xulosa qilishlaricha, sutbop podalarda mahsuldorligi bo‘yicha irsiy salohiyati yuqori bo‘lgan sigirlar salmog‘ini oshirishda juftlash usullarining ahamiyati nihoyatda kattadir. Bunda juftlashni avlodlarining nasl sifati bo‘yicha baholanib yaxshilovchi nasl toifasiga ega jahon genofondiga xos nasldor buqalardan foydalanib amalga oshirish nafaqat podalarning sut mahsuldorligini oshirish, balki zotni ham takomillashtirish sur’atini oshirish imkonini beradi.

Tadqiqotlarida sut yo‘nalishidagi turli qoramol zotlarining sut mahsuldorligini takomillashtirishda maqsadli seleksiya ishlarini olib borish va juftlashda nasl qiymati yuqori nasldor buqalardan keng foydalanish katta ahamiyat kasb etganligi aniqlangan. Yuqori nasl qiymatiga ega nasldor buqalardan jadal juftlashda foydalanish naslchilik zavodi talablariga javob beradigan yuqori mahsuldor sigirlarni yetishtirishda muhim omil ekanligi qayd etilgan.

Ma’lumotlariga qaraganda, podalarda seleksiya ishining samarasi va podalar mahsuldorligini oshirish hamda zotlarning nasl, mahsuldorlik xususiyatlarini takomillashtirish ko‘p jihatdan juftlanayotgan qoramollarning irsiy salohiyatiga bog‘liqdir va ulardan olingan avlodning genotipi ham hal qiluvchi ahamiyatga ega, chunki maqbul sermahsul genotipga ega mollar mahsuldorligini yaxshi oziqlantirish

va asrash sharoitlarida yuzaga chiqarish imkoniyatlariga ega bo‘ladilar.

Ma’lumki, yuqori mahsuldor sigirlar podalarini yaratish va takomil-lashtirishda seleksiya usullarining ahamiyati nihoyatda katta. Bunda sigirlar podalarida maqsadga muvofiq tanlash usullari bilan birga juftlash usullarining ham o‘rni nihoyatda ahamiyatli hisoblanadi. Shuningdek, bunday podalarni shakllantirishda turli urchitish usullaridan olingan maqbul genotipdagi sigirlardan foydalanish sohani rivojlantirishda va uning samaradorligini oshirishda alohida ahamiyatga ega. Buni turli yillarda ko‘plab mualliflar o‘tkazgan tadqiqotlari natijalari ham isbotlaydi.

Tadqiqotlarda Fransiya davlatidan olib kelingan sigirlarnnig mahsuldorlik ko‘rsatkichlari, kelib chiqishi, SUT-2 kartochkalari asosida o‘rganildi. Tajribalar onalarining qaysi ishlab chiqarish tipga mansubligini o‘rganish natijasida qizlarining I, II va III-laktatsiya davrlaridagi sigirlarning tirik vazni, fiziologik holati va sut mahsuldorligini hisobga olgan holda tadqiqot tasviriga asosan tashkil etildi.
Laktatsiya davrlarida Sigirlarning tana tuzilish tipini o‘rganish uchun A.S.Vsyakix (1981) qo‘llanmasidan foydalanildi.

Tajribadagi sigirlarning tirik vazni tuqqandan so‘ng 90 kunligida tarozida tortish hamda sut mahsuldorligi laktatsiyaning 305 kuni mobaynida har 10 kunda bir marta nazorat sog‘imini o‘tkazish yo‘li bilan aniqlandi.
Tajriba guruhlaridagi sigirlarning suti tarkibidagi yog‘ Gerber usulida har oyda bir marta har bir sigir bo‘yicha alohida o‘rganildi. Ularning suti tarkibidagi oqsil har oyda Laktan apparatida aniqlandi.

Sut tarkibidagi yog‘ va oqsil chiqimi, 4%-li sut miqdori, quruq modda va yog‘sizlantirilgan quruq sut qoldig‘i N.V.Barabanshikov (1986) formulalari asosida hisoblab chiqildi.

ADABIYOTLAR TAHLILI

Voyaga yetgan Monbelyard sigirlarining o‘rtacha tirik vazni 600–700 kg, buqalari esa 900–1100 kg gacha yetadi. Bu ko‘rsatkichlar zotning kuchli o‘sish sur’ati va yuqori go‘sht mahsuldorligidan dalolat beradi. Yosh qoramollar tez yetiladi va yaxshi semirish xususiyatiga ega. Monbelyard zotining sut mahsuldorligi o‘rtacha yiliga 6 000–8 000 kg ni tashkil etadi. Sutining yog‘ miqdori 3,8–4,2 %, oqsil miqdori esa 3,4–3,6 % atrofida bo‘lib, bu ko‘rsatkichlar pishloq va boshqa sut mahsulotlari ishlab chiqarish uchun juda qulay hisoblanadi. Ayniqsa, sutidagi kazein miqdorining yuqoriligi Monbelyard zotini pishloq sanoatida qadrlanishiga sabab bo‘lgan. Monbelyard zotli sigirlar turli iqlim sharoitlariga yaxshi moslashadi. Ular sovuq va mo‘tadil iqlimga chidamli bo‘lib, parvarish va oziqlantirish sharoitlari to‘g‘ri tashkil etilganda issiq hududlarda ham samarali boqilishi mumkin. Kasalliklarga nisbatan nisbatan chidamli bo‘lishi va kuchli immun tizimi bilan ajralib turadi.

Ushbu zot sut va go‘sht mahsuldorligini uyg‘unlashtirganligi sababli fermer xo‘jaliklari va yirik chorvachilik komplekslari uchun iqtisodiy jihatdan foydali hisoblanadi. Monbelyard zotidan: yuqori sifatli sut, yaxshi go‘sht mahsuloti, uzoq muddatli reproduktiv foydalanish olish mumkin. Monbelyard zoti sut–go‘sht yo‘nalishidagi eng muvaffaqiyatli kombinatsiyalashgan zotlardan biri hisoblanadi. Uning asosiy afzalliklari sut sifati yuqori - sutidagi yog‘ (3,8–4,2 %) va oqsil (3,4–3,6 %) miqdori yuqori bo‘lib, ayniqsa pishloq va fermentlangan sut mahsulotlari ishlab

chiqarish uchun juda qulay. Mustahkam konstitutsiya va sog‘lom skelet, Oyoq va tuyoqlari kuchli bo‘lib, uzoq muddat foydalanishga chidamli. Bu zotda buzoqlash oson kechadi, bachadon va nasl berish bilan bog‘liq muammolar kam uchraydi. Kasalliklarga nisbatan chidamlili bo’lib, mastit va metabolik kasalliklarga nisbatan barqarorroq. Go‘sht mahsuldorligi Buqalar va chiqim sigirlaridan sifatli go‘sht olish mumkin. Xo‘jalikda uzoq foydalanish muddati 5–7 laktatsiya davomida barqaror mahsuldorlikni saqlaydi.

Kamchiliklari - sut miqdori bo‘yicha ayrim zotlardan pastroq sut hajmi jihatidan sof sut yo‘nalishidagi zotlardan ortda qoladi. Ozuqaga talabchan bo’lib, genetik salohiyatini to‘liq namoyon etish uchun sifatli va balanslangan ratsion talab etiladi. Issiq iqlimga moslashuvi sekinroq to‘g‘ri mikroiqlim bo‘lmasa, issiq stressi ta’siri seziladi.

1-jadval. Monbelyard zotining boshqa sut zotlari bilan taqqoslanishi

Ko‘rsatkich	Monbelyard	Golshtin	Simmental
Yo‘nalishi	Sut–go‘sht	Sof sut	Sut–go‘sht
Yillik sut (kg)	6 000–8 000	8 000–10 000	5 000–7 000
Sut yog‘i (%)	3,8–4,2	3,5–3,7	3,9–4,1
Sut oqsili (%)	3,4–3,6	3,1–3,3	3,3–3,5
Tirik vazn (sigir, kg)	600–700	550–650	600–700
Chidamlilik	Yuqori	O‘rtacha	Yuqori
Go‘sht sifati	Yaxshi	Past	Yaxshi

Golshtin zoti sut hajmi bo‘yicha ustun bo‘lsa-da, Monbelyard sut sifati, sog‘lomlik va uzoq foydalanish muddati bilan ajralib turadi. Simmental esa Monbelyardga yaqin bo‘lib, lekin sut oqsili va pishloqboplik jihatidan Monbelyard ustun hisoblanadi.

O‘zbekistonning issiq va quruq iqlimi Monbelyard zoti uchun ma’lum darajada stress omili bo‘lishi mumkin. Shu sababli fermalarda shamollatish tizimi va soyabonlar bo‘lishi, yoz oylarida sun’iy sovitish (ventilyator, suv purkash) qo‘llanilishi, toza va salqin ichimlik suvi doimiy ta’minlanishi zarur.

O‘zbekistonda академик Sh.A. Akmalxonov, M.Mirhidoyatov va boshqalar (1984) sigirlarni saqlash joylaridan konservalangan yem bilan, shuningdek, aralash (yashil aralash konserva) va an’anaviy (qishda konserva, yozda yashil) oziqlantirishda sut va og‘iz sutining sifati har xil bo‘lishini aniqladilar. Shunday qilib, saqlash joylaridan konservalangan yemni yil davomida oziqlantirish bilan olingan sut fizik-kimyoviy ko'rsatkichlari va texnologik xususiyatlari bo'yicha sigirlarni an'anaviy oziqlantirish bilan olingan sutdan farq qilmaydi.

Yuqorida ta’kidlanganidek, keyingi yillarda O’zbekistonga mahalliy chorva mollarining naslchilik sifatini yaxshilash maqsadida yuqori mahsuldor chorva mollari olib kelinmoqda.

NATIJA VA TAHLILAR

Ma’lumki, mahsulot tannarxining qariyb 60-65 foizi hamda mahsuldorligi chorva mollarini oziqlantirish tizimi va sifatiga bog’liq, shuning uchun hayvonlarni oqilona oziqlantirish bo’yicha tadqiqotlar bir nechta yo’nalishlarni o’z ichiga oladi: ozuqalarning tarkibi va to’yimliligini o’rganish, hayvonlarning fiziologik holati va

mahsuldorlik darajasini hisobga olgan holda ozuqa moddalari va energiyaga bo'lgan ehtiyojlarini aniqlash, ozuqadan eng yaxshi foydalanishni ta'minlaydigan shart-sharoitlarni o'rganish, namunaviy ratsionlarni, shu jumladan ozuqalash texnikasi va ozuqa tayyorlash texnologiyasini, tomchilar va sigirlarni saqlash tizimini ishlab chiqish maqsadga muvofiq.

Oziqlantirish bo'yicha tavsiyalar - ratsionda energiya–protein balansi qat'iy saqlanishi kerak, mahalliy ozuqalardan (beda pichani, makkajo'xori silosi, somon, don mahsulotlari) samarali foydalanish mumkin, issiq davrda mineral moddalar, ayniqsa natriy, kalsiy va magniy miqdorini oshirish tavsiya etiladi, premiks va vitamin qo'shimchalardan muntazam foydalanish lozim.

2-rasm. Monbelyard zotli sigirlarning oziqlanish jarayoni.

Sigirlarning mahsuldorligi bo'yicha irsiy imkoniyatlarini to'liq yuzaga chiqarishda tashqi muhit omillari muhim o'rin egallaydi. Bu omillardan eng asosiysi sigirlarni to'la qiymatli va me'yorlashtirilgan ozuqalar bilan oziqlantirish hisoblanadi. Biz turli tana tuzilishdagi sigirlarning laktatsiyasi davomida sarflangan ozuqalar miqdori va ularning to'yimliligini o'rgandik, uning natijalari 2-jadvalda keltiriladi. 2-jadval ma'lumotlar tahlili shuni ko'rsatdiki, 3- laktatsiya davomida eng ko'p ozuqalar miqdorini sut-go'sht tana tuzilishi xiliga ega I guruh sigirlari istemol qildilar. Jumladan, I guruh (sut-go'sht) sigirlari laktatsiya mobaynida II guruh (go'sht-sut) guruhdagi sigirlarga nisbatan tegishli ravishda 80 kg (12,9%) kg beda pichani, 100 kg (1,4%), makkajo'xori silosi, 100 kg (2,9%) beda senaji, 17 kg (3,3%) omuhta yem, 17 kg (3,5%) makkajo'xori doni yormasi, 15 kg (3,3%) bug'doy yormasi, 17 kg (3,3%) kungaboqar shroti, 17 kg (0,7%) gidroponik ozuqa ko'p istemol qildi hamda bu ozuqalarning to'yimlilik qiymati 145,6 kg (3,1%) ozuqa birligiga yuqori bo'ldi.

2-jadval. Tajriba guruhlaridagi sigirlarga laktatsiya davomida sarflangan ozuqalar miqdori va ularning to'yimliligi *(o'rtacha har 1 boshga kg)*

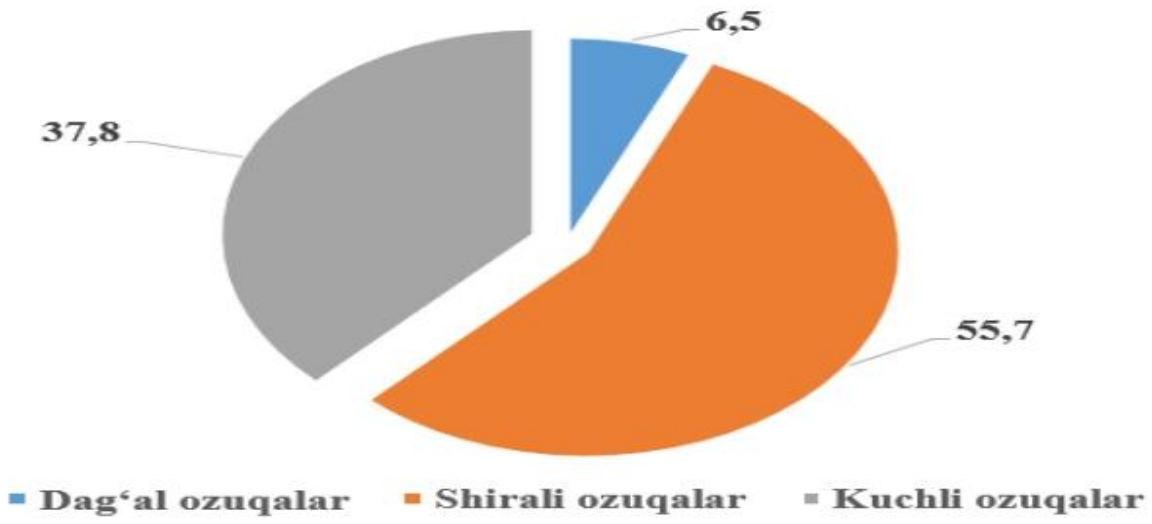
Ozuqalar	**Guruhlar**	
	I- guruh	II- guruh
	ishlab chiqarish tiplari	
	sut-go'sht tipi	go'sht-sut tipi
Beda pichani	700	620
Makkajo'xori silosi	7000	6900
Beda senaji	3500	3400
Omuxta yem	533	516
Makkajo'xori doni yormasi	502	485

Bug‘doy kepagi	466	451
Kungaboqar shroti	533	516
Gidropon ko’k ozuqa	2617	2600
Ozuqabop bo‘r	15,25	15,25
Premiks	15,25	15,25
Osh tuzi	15,25	15,25
Ozuqa tarkibi		
Ozuqa birligi, kg	4773,9	4628,3
Almashinuvchi energiya MDj	6150,0	5960,8
Quriq modda, kg	6054,1	5858,3
Hazmlanuvchi protein, kg	694,6	670,2
Qand, kg	203,9	197,3
Kalsiy, kg (Ca)	62,9	60,6
Fosfor, kg (R)	36,1	35,1

Tajribadagi sigirlarga laktatsiya davrida har bir ozuqa birligiga I guruhga (sut-go‘sht) 145,5 g va II guruhga (go‘sht-sut) 144,8 g, hazmlanuvchi protein to‘g‘ri keldi va olingan bu ma’lumotlarimiz R.Hamraqulov va K.Karibaev (1999) tavsiya etgan me’yorlarga mos keladi. Sog‘in sigirlarni oziqlantirishda ozuqa turlarini baholashda ular ratsionining tarkibini o‘rganish muhim ahamiyatga ega. Oziqlantirishda ozuqa turini o‘zgartirishga ratsion tarkibidagi ozuqalar salmog‘ini o‘zgartirish orqali erishish mumkin. 3-jadvalda tajriba guruhlaridagi sigirlar ratsionining tarkibi keltiriladi.

3-jadval.Tajriba guruhlaridagi sigirlarga sarflangan ozuqalarning tarkibi, (ozuqalarning to‘yimliligiga nisbatan, %)

Ozuqalar		**Guruhlar**	
		I- guruh	**II- guruh**
		Ishlab chiqarish tiplari	
		Sut-go‘sht tipi	**Go‘sht-sut tipi**
Dag‘al ozuqalar	Beda pichani	6,5	5,9
Shirali ozuqalar	Makkajo‘xori silosi	29,3	29,8
	Beda senaji	6,6	6,7
	Gidropon ozuqa	19,8	19,8
Kuchli ozuqalar	Omuxta em	9,5	9,5
	Makkajo‘xori doni yormasi	11,7	11,7
	Bug‘doy kepagi	6,6	6,6
	Kungaboqar shroti	10,0	10,0
Jami		100,0	100,0



3-rasm. Tajriba I guruh (sut-go‘sht ishlab chiqarish tipi) sigirlarga sarflangan ozuqalarning tarkibi, %

Parvarish va veterinariya nazorati - doimiy profilaktik emlashlar va veterinariya ko‘riklari o‘tkazilishi, tuyoqlarni parvarish qilish va gigiyena qoidalariga qat’iy rioya etish, mastitning oldini olish uchun sog‘ish texnologiyasiga amal qilish monbelyard zotini O‘zbekiston sharoitida to‘g‘ri parvarish, ilmiy asoslangan oziqlantirish va moslashtirilgan saqlash tizimi mavjud bo‘lganda yuqori samaradorlik ko‘rsatadi. Sut sifati, sog‘lomligi va go‘sht mahsuldorligining uyg‘unligi ushbu zotni fermer xo‘jaliklari uchun istiqbolli tanlovga aylantiradi. Qoramolchilikda yuqori mahsuldor zotlardan samarali foydalanish, avvalo, ularni ilmiy asosda oziqlantirishga bevosita bog‘liqdir. Monbelyard zotli sigirlar sut va go‘sht yo‘nalishidagi kombinatsiyalashgan zot bo‘lib, yuqori sut yog‘ligi va oqsili, mustahkam konstitutsiyasi hamda uzoq xo‘jalikda foydalanish muddati bilan ajralib turadi. Ushbu zotning genetik salohiyatini to‘liq namoyon etish uchun oziqlantirish tizimi sigirlarning fiziologik holati va mahsuldorlik bosqichlariga mos holda tashkil etilishi lozim.

Monbelyard zotli sigirlarni oziqlantirishda quyidagi asosiy ilmiy tamoyillarga ratsionning energiya va protein bo‘yicha balanslangan bo‘lishi, ozuqalarning hazm bo‘lish darajasi yuqori bo‘lishi, mineral va vitamin moddalar bilan to‘liq ta’minlanishi, oziqlantirishning fiziologik holatga mosligiga (laktatsiya, quruq davr, bo‘g‘ozlik) amal qilsak iqtisodiy samaradorlikka erishamiz. Sut beruvchi Monbelyard sigirlarining asosiy ehtiyoji almashinuvchi energiya hisobiga qoplanadi. Energiya yetishmasligi sut mahsuldorligining pasayishiga, ortiqchaligi esa semirishga olib keladi. Ratsion tarkibida sifatli pichan, silos, senaj va konsentrat ozuqalar muvozanatda bo‘lishi zarur. Protein almashinuvi sut oqsilining sintezi uchun muhim hisoblanadi. Ratsionda xom protein miqdori laktatsiya davriga qarab 15–18 % atrofida bo‘lishi tavsiya etiladi. Bunda o‘simlik oqsili manbalari (dukkakli o‘simliklar pichani, shrot va kunjara) muhim ahamiyatga ega.

Uglevodlar sigir organizmida energiya manbai bo‘lib, sut yog‘ligi hosil bo‘lishida muhim rol o‘ynaydi. Ratsionda tolali moddalarning yetarli bo‘lishi rumen faoliyatini me’yorlashtiradi. Yog‘ moddalarining me’yoridan ortiq berilishi esa ovqat hazm qilish jarayoniga salbiy ta’sir ko‘rsatishi mumkin. Laktatsiyaning dastlabki 100

kunida sigirlarning energiya va protein ehtiyoji yuqori bo‘ladi. Ushbu davrda ratsionda konsentrat ozuqalar ulushi oshiriladi. O‘rta va oxirgi laktatsiya davrida esa ozuqa miqdori sut mahsuldorligiga mos ravishda kamaytiriladi.

XULOSA

Monbelyard zotli sigirlarning fiziologik ehtiyojlarini to‘liq qondiradi va yuqori sut mahsuldorligini ta’minlashga mos. Monbelyard zoti — yuqori mahsuldorlik, mustahkam sog‘liq va xo‘jalikda foydalanish samaradorligini o‘zida mujassamlashtirgan universal qoramol zoti hisoblanadi. Uni ilmiy asosda oziqlantirish va parvarish qilish orqali zotning genetik salohiyatini to‘liq namoyon etish mumkin.

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SCIENTIFIC AND METHODOLOGICAL FRAMEWORK FOR COMPARATIVE EVALUATION OF POTATO CULTIVARS UNDER THE SOIL AND CLIMATIC CONDITIONS OF KARAKALPAKSTAN

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Abstract. *Potato production in the Republic of Karakalpakstan is constrained by soil salinity, high evaporative demand, recurrent heat episodes and limited irrigation water. Cultivars selected under temperate and non-saline environments may therefore perform inconsistently when introduced into this region. This paper develops a rigorous field-evaluation framework for a collection of 22 potato cultivars and clones originating from Belarus, Hungary, Germany, Korea, the Netherlands, Türkiye and Uzbekistan. The framework integrates phenological development, field emergence, plant survival, canopy traits, tuber number and weight, size distribution, marketable yield, visible physiological injury and disease incidence. A randomized complete block design with four replications is proposed, with uniform seed-tuber quality, planting geometry, nutrient supply, irrigation and crop protection across treatments. Soil electrical conductivity, pH, nutrient status and weather variables are incorporated to distinguish genotypic responses from environmental effects. Yield is expressed on an area basis, while marketability is calculated from the proportion of defect-free tubers meeting the predefined commercial grade. Analysis of variance, standard errors and Fisher's least significant difference at $p \leq 0.05$ are used for cultivar comparison; multi-year observations permit separation of cultivar, year and cultivar × year effects. The framework avoids selection based on yield alone and instead identifies cultivars that combine earliness, stand persistence, marketable productivity and tolerance to interacting salinity, heat and water-deficit stresses. It provides a reproducible basis for subsequent production trials and locally adapted seed-potato development in the Aral Sea region.*

Keywords*: Solanum tuberosum L.; cultivar evaluation; marketable tuber yield; salinity; heat stress; water deficit; genotype × environment interaction; Karakalpakstan.*

Annotatsiya*. Maqolada Qoraqalpog'iston Respublikasining sho'rlangan tuproqlari, keskin kontinental quruq iqlimi, yuqori harorat va sug'orish suvi cheklangan sharoitida kartoshka navlarini qiyosiy baholashning ilmiy-uslubiy asoslari ishlab chiqilgan. Belarus, Vengriya, Germaniya, Koreya, Niderlandiya, Turkiya va O'zbekiston seleksiyasiga mansub 22 ta nav va klonni yagona agrotexnik fonda o'rganish nazarda tutilgan. Baholash tizimi fenologik rivojlanish, dala unuvchanligi,*

o‘simliklarning yig‘imgacha saqlanishi, morfologik belgilar, tuganaklar soni va vazni, fraksion tarkibi, tovarbop hosil, fiziologik shikastlanish va kasallik alomatlarini qamrab oladi. Tajribani tasodifiylashtirilgan bloklar usulida to‘rt takrorlanishda o‘tkazish, tuproqning elektr o‘tkazuvchanligi va agrokimyoviy xususiyatlari hamda meteorologik ko‘rsatkichlarni qayd etish tavsiya qilingan. Navlarni taqqoslashda dispersiya tahlili, standart xato va $p \leq 0,05$ darajadagi eng kichik ishonchli farqdan foydalaniladi. Taklif etilgan yondashuv navlarni faqat umumiy hosil bo‘yicha emas, balki ertapisharlik, tup sonining saqlanishi, tovarbop mahsuldorlik va stress omillariga chidamlilik majmui bo‘yicha tanlash imkonini beradi.

Kalit so‘zlar: *Solanum tuberosum L.; navlarni baholash; tovarbop tuganak hosili; sho‘rlanish; issiqlik stressi; suv tanqisligi; genotip × muhit o‘zaro ta’siri; Qoraqalpog‘iston.*

Аннотация. *В статье разработаны научно-методические основы сравнительной оценки сортов картофеля в условиях засоленных почв, резко континентального засушливого климата, высоких температур и ограниченности оросительной воды Республики Каракалпакстан. Предусматривается изучение на едином агротехническом фоне 22 сортов и клонов селекции Беларуси, Венгрии, Германии, Кореи, Нидерландов, Турции и Узбекистана. Система оценки включает фенологическое развитие, полевую всхожесть, сохранность растений к уборке, морфологические признаки, количество и массу клубней, фракционный состав, товарную урожайность, физиологические повреждения и симптомы болезней. Рекомендуется проводить опыт методом рандомизированных блоков в четырех повторениях с регистрацией электропроводности и агрохимических свойств почвы, а также метеорологических показателей. Для сравнения сортов используются дисперсионный анализ, стандартная ошибка и наименьшая существенная разница при $p \leq 0,05$. Предлагаемый подход позволяет отбирать сорта не только по общей урожайности, но и по комплексу признаков, включающему скороспелость, сохранность растений, товарную продуктивность и устойчивость к стрессовым факторам.*

Ключевые слова: *Solanum tuberosum L.; оценка сортов; товарная урожайность клубней; засоление; тепловой стресс; дефицит воды; взаимодействие генотип × среда; Каракалпакстан.*

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a globally important food crop because it produces substantial quantities of carbohydrate, high-quality protein, minerals and vitamin-rich food per unit area. It also supports processing industries, seed systems and rural livelihoods. Continued expansion of potato production into water-limited and salt-affected regions, however, depends on cultivars that maintain acceptable tuber yield and quality under multiple, simultaneously acting stresses [1–3].

The Republic of Karakalpakstan lies in the lower Amu Darya basin and is characterized by a sharply continental arid climate. Potato crops may encounter saline soils, low relative humidity, hot winds, high air and soil temperatures and restrictions in irrigation-water supply. These factors are especially damaging during canopy

establishment, tuber initiation and tuber bulking. Salinity reduces the soil-water potential and may disturb nutrient acquisition; water deficit restricts leaf expansion and accelerates senescence; and high temperature can delay tuber initiation while shifting assimilate allocation toward shoots [4, 6–9].

Cultivar performance is the result of genetic potential expressed within a particular environment and production system. A cultivar that performs well at one location may change rank when temperature, soil salinity, water availability or crop management differs. Consequently, catalogue descriptions and country of origin cannot substitute for replicated local testing. Candidate cultivars must be compared under a common agronomic background and assessed using traits that explain both yield formation and yield loss [5–7].

The Karakalpakstan Scientific Experimental Station received potato material representing several breeding programmes and production regions. This diverse set provides an opportunity to establish a locally relevant screening platform. The objective of this paper is to define a scientifically defensible methodology for comparative evaluation of these cultivars and clones under Karakalpakstan conditions. The framework is intended to identify material combining early crop development, stand persistence, marketable tuber production and tolerance to the region's major abiotic constraints.

LITERATURE REVIEW

Breeding and cultivar testing for climate-resilient potato production increasingly focus on combinations of earliness, yield stability, resource-use efficiency, resistance to pests and diseases, and tuber quality. Earliness is particularly relevant in hot environments because it may allow a cultivar to complete a larger proportion of tuber bulking before the most severe summer temperatures occur. A short growth cycle is not automatically advantageous, however, if rapid maturity is accompanied by poor canopy establishment, low tuber number or insufficient mean tuber weight [3–5].

Drought affects potato through reductions in leaf area, stomatal conductance, radiation interception and assimilate supply to developing tubers. Genotypic differences occur in rooting, canopy duration, water-use patterns and recovery following rewatering. Reliable evaluation therefore requires observations at several growth stages rather than a single visual score. Plant survival, onset of senescence, tuber number and tuber size distribution provide complementary information about the mechanism and agronomic consequence of stress response [6, 7, 9].

Heat stress is closely linked to water demand. Temperatures above the optimum for tuberization can prolong vegetative growth, inhibit tuber initiation, reduce dry-matter partitioning to tubers and increase physiological disorders. Under saline conditions, osmotic and ionic effects may further restrict water uptake and accelerate canopy injury. Because these stresses interact in the field, ranking cultivars by total yield alone can conceal important differences in stand establishment, phenology and marketability [4, 8].

Genotype × environment interaction is central to cultivar recommendation. Replication within a season estimates experimental error, whereas testing across seasons measures the stability of cultivar responses under naturally varying weather

and soil-water regimes. A credible recommendation should consequently be based on both mean performance and stability, with explicit consideration of whether a candidate offers higher marketable yield, earlier maturity, better stand retention or another practical advantage relative to the standard cultivar [5].

RESEARCH METHODOLOGY

3.1 Study site and environmental characterization

Field trials are designed for the experimental fields of the Research Institute of Vegetables, Melons and Potatoes, Karakalpakstan Scientific Experimental Station, Republic of Karakalpakstan, Uzbekistan, during 2026–2028. Before planting, composite soil samples are collected from the 0–30 and 30–50 cm layers. Soil texture, organic matter, total nitrogen, available phosphorus, exchangeable potassium, pH, electrical conductivity and the composition of water-soluble salts are determined using validated laboratory procedures. Daily minimum and maximum air temperature, precipitation, relative humidity and, where available, reference evapotranspiration are obtained from the nearest meteorological station. Irrigation dates and applied water are recorded for each crop cycle.

3.2 Plant material

The experimental collection comprises 22 named cultivars and clones supplied to the station. Names and stated origins are retained as recorded in the station inventory; D-3 and Korona require passport verification because their origin was not specified in the source record. The three unnamed protection samples numbered 001–003 are excluded because they do not have cultivar names and therefore cannot be reported as identifiable accessions.

No.	Cultivars	Stated origin	Experimental status
1.	D-3	Not specified	Collection accession
2.	Liliya	Belarus	Collection accession
3.	Mastak	Belarus	Collection accession
4.	Korona	Not specified	Collection accession
5.	Garantiya	Belarus	Collection accession
6.	Uladar	Belarus	Collection accession
7.	Balatoni Rozsa	Hungary	Collection accession
8.	Balatoni Sarga	Hungary	Collection accession
9.	Botond	Hungary	Collection accession
10.	Demon	Hungary	Collection accession
11.	White Lady	Hungary	Collection accession
12.	Gala	Germany	Collection accession
13.	Golden Egg	Korea	Collection accession
14.	Royal	The Netherlands	Collection accession
15.	Sante	The Netherlands	Collection accession
16.	Silvana	The Netherlands	Collection accession
17.	Evolution	The Netherlands	Collection accession
18.	Yaprak	Türkiye	Collection accession
19.	Pitek	Türkiye	Collection accession

20.	Quvonch	Uzbekistan	Collection accession
21.	Ultraeshim	Uzbekistan	Collection accession
22.	Umid	Uzbekistan	Collection accession

Table 1. Potato cultivars and clones included in the comparative field evaluation

3.3 Experimental design and crop management

The trial is established as a randomized complete block design with four replications. Each accession occurs once in each block, and plot positions are randomized independently within blocks. Seed tubers are graded to a common size range and selected for uniform physiological age and health status. Planting date, row and in-row spacing, planting depth, fertilizer rates, irrigation scheduling, hilling and crop-protection practices are identical for all plots. Guard rows and border plants are excluded from harvest measurements. The standard cultivar must be designated before planting and maintained consistently across years.

3.4 Phenology, growth and stress assessment

Dates of 50% and 75% emergence, budding, flowering, onset of natural senescence and physiological maturity are recorded for each plot. Field emergence and survival to harvest are expressed as percentages of planted seed tubers. Plant height and number of main stems are measured on preselected, non-border plants. Canopy uniformity, chlorosis, marginal necrosis, premature senescence and other visible stress symptoms are scored using a predefined ordinal scale applied by the same trained observers. Disease incidence is recorded separately from abiotic injury to reduce misclassification.

3.5 Yield and marketability

Each net plot is harvested separately. Tuber number and fresh weight per plant, mean tuber weight, total plot yield and size-class distribution are determined. Yield is converted to tonnes per hectare as $Y = 10M/S$, where Y is yield (t ha−1), M is tuber mass from the net plot (kg), and S is net plot area (m^2). Before the trial, marketable grades are defined by tuber size and absence of greening, cracking, severe malformation, mechanical injury and disease symptoms. Marketability is calculated as $T = (Mm/Mt) \times 100$, where Mm is marketable tuber mass and Mt is total tuber mass. Dry matter, starch and nitrate concentration may be included when validated analytical facilities are available.

3.6 Statistical analysis and selection rule

Data are analysed by analysis of variance appropriate to the randomized complete block design. Cultivar means are reported with standard errors, and pairwise differences are evaluated using Fisher's least significant difference at $p \leq 0.05$ when the overall cultivar effect is significant and model assumptions are satisfied. Residuals are examined for normality and homogeneity of variance; percentage or count data are transformed when necessary. For multi-year analysis, cultivar and year effects and the cultivar × year interaction are estimated. Cultivar advancement is based on a predefined decision rule integrating marketable yield, earliness, survival and stress injury rather than on the most favourable single trait.

ANALYSIS AND RESULTS

The proposed framework treats establishment as the first selection stage. Rapid emergence is desirable, but it must be interpreted together with stand survival. A cultivar that emerges quickly and subsequently loses plants under salinity or heat cannot be considered well adapted. Plot-level emergence and survival data also help determine whether low yield results from weak stand establishment or from poor productivity of surviving plants.

Phenological escape and physiological tolerance are distinct adaptation strategies. Early cultivars may avoid peak heat by initiating and bulking tubers sooner, whereas longer-duration cultivars may succeed if they maintain canopy function and water acquisition under stress. Recording tuber initiation indirectly through flowering, senescence and sequential harvest observations helps distinguish these strategies. This distinction is important when matching cultivars to early-market production, main-season production or seed multiplication.

Canopy size should not be used as a proxy for tuber productivity. Vigorous vegetative growth may increase radiation capture, but under hot conditions it can also indicate delayed allocation to tubers. Plant height and stem number therefore require joint interpretation with tuber number, mean tuber weight and harvest index-related traits. Cultivars with many small tubers may be valuable for seed production but less desirable for a market that rewards larger ware potatoes.

Marketable yield is the principal production-oriented endpoint because total yield may include tubers that cannot be sold or stored. A cultivar with moderate total yield but uniform, defect-free tubers can provide greater practical value than a high-yielding cultivar with excessive small tubers, cracking or physiological defects. Reporting both total and marketable yield prevents this distinction from being obscured. Environmental measurements strengthen biological interpretation. Soil electrical conductivity indicates the salinity pressure present during the experiment, while irrigation and temperature records locate periods of water and heat stress relative to crop development. These covariates do not replace replication, but they allow year-to-year changes in cultivar ranking to be interpreted mechanistically rather than described as unexplained variation.

The 22-accession collection should be screened in stages. Accessions with poor emergence, severe injury or unacceptable marketability can be removed after sufficient replicated evidence. Accessions equal to the standard in yield may still be advanced if they provide a clear advantage in maturity, survival, tuber uniformity or stress tolerance. Conversely, an apparent yield advantage should not justify advancement if it is inconsistent across replications or accompanied by poor tuber quality.

Multi-year testing is essential before a recommendation is made. The first season establishes trait ranges and identifies operational problems in the protocol; subsequent seasons test repeatability under different weather and soil-water conditions. The resulting dataset can support production recommendations, targeted agronomic trials and, for locally adapted material, development of a reliable seed-potato multiplication pathway.

CONCLUSION AND RECOMMENDATIONS

1. Potato cultivar selection for Karakalpakstan requires replicated local testing because salinity, heat and limited irrigation water may alter cultivar ranking relative to non-saline temperate environments.
2. A randomized complete block design with four replications, uniform agronomic management and explicit environmental characterization provides a defensible basis for comparison of the 22 cultivars and clones.
3. Selection should integrate emergence, survival, phenology, tuber number and weight, size distribution, marketable yield and symptoms of abiotic and biotic injury.
4. Analysis of variance, measures of uncertainty and multi-year assessment of cultivar × year interaction are required before claims of superiority or adaptation are made.
5. Cultivars that combine stable marketable productivity with earliness, stand persistence or reduced stress injury should be advanced to larger production and seed-multiplication trials.

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EFFECT OF DIFFERENT PLANTING SCHEMES ON CARROT GROWTH, ROOT YIELD AND MARKETABLE QUALITY

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Abstract. *Plant density strongly influences competition, individual root size, grade distribution and marketable carrot yield. This paper presents a factorial framework for determining the effects of 50 × 5, 50 × 10, 50 × 15 and 50 × 20 cm planting schemes on the growth, root yield and marketable quality of Ziynatli and Mshak 195 under Karakalpakstan conditions. The eight cultivar × spacing combinations are arranged in a randomized complete block design with four replications under uniform seed quality, nutrient supply, irrigation and crop protection. Soil electrical conductivity, pH, nutrient status and weather variables are recorded to support interpretation. Assessment integrates field emergence, phenology, leaf traits, root length, shoulder diameter, individual root weight, shape uniformity, cracking, forking, greening, total yield and marketable yield. Two-factor analysis of variance estimates cultivar, spacing and cultivar × spacing effects, while linear and quadratic contrasts describe responses to increasing within-row distance. The framework identifies the spacing that provides the most favourable balance between plant population, root size uniformity and marketable yield for each cultivar and supports cultivar-specific recommendations for the saline, arid environment of the Aral Sea region.*

Keywords: *Daucus carota L.; Ziynatli; Mshak 195; plant spacing; plant density; root quality; marketable yield; Karakalpakstan.*

Annotatsiya. *Maqolada Qoraqalpog‘iston sharoitida 50 × 5, 50 × 10, 50 × 15 va 50 × 20 sm ekish sxemalarining Ziynatli hamda Mshak 195 sabzi navlari o‘sishi, ildizmeva hosildorligi va tovarbop sifatiga ta’sirini aniqlashning ilmiy-uslubiy asoslari bayon etilgan. Ikki omilli tajribani tasodifiylashtirilgan bloklar usulida to‘rt takrorlanishda o‘tkazish, tuproqning elektr o‘tkazuvchanligi, pH ko‘rsatkichi, oziqa elementlari bilan ta’minlanganligi va meteorologik omillarni qayd etish nazarda tutilgan. Baholash tizimi dala unuvchanligi, fenologik rivojlanish, barg apparati, ildizmevaning uzunligi, yelka diametri va vazni, shakl bir xilligi, yorilish, shoxlanish va yashillanish, yalpi hamda tovarbop hosildorlikni qamrab oladi. Ikki omilli dispersiya tahlili yordamida nav, ekish sxemasi va ularning o‘zaro ta’siri aniqlanadi.*

Taklif etilgan yondashuv har bir nav uchun tovarbop hosildorlik va ildizmeva sifatining eng maqbul nisbatini ta'minlaydigan o'simlik qalinligini belgilash imkonini beradi.

Kalit so'zlar: *Daucus carota L.; Ziynatli; Mshak 195; ekish sxemasi; o'simlik qalinligi; ildizmeva; tovarbop hosildorlik; Qoraqalpog'iston.*

Аннотация. *В статье изложены научно-методические основы определения влияния схем посева 50 × 5, 50 × 10, 50 × 15 и 50 × 20 см на рост, урожайность и товарное качество корнеплодов сортов моркови Ziynatli и Mshak 195 в условиях Каракалпакстана. Двухфакторный опыт предусматривается проводить методом рандомизированных блоков в четырех повторениях с регистрацией электропроводности и pH почвы, обеспеченности элементами питания и метеорологических факторов. Система оценки включает полевую всхожесть, фенологическое развитие, листовой аппарат, длину, диаметр плечиков и массу корнеплода, однородность формы, растрескивание, разветвление и позеленение, общую и товарную урожайность. Двухфакторный дисперсионный анализ позволяет определить влияние сорта, схемы посева и их взаимодействия. Предлагаемый подход предназначен для установления оптимальной густоты растений, обеспечивающей наилучшее сочетание товарной урожайности и качества корнеплодов каждого сорта.*

Ключевые слова: *Daucus carota L.; Ziynatli; Mshak 195; схема посева; густота растений; корнеплод; товарная урожайность; Каракалпакстан.*

INTRODUCTION

Carrot (*Daucus carota* L.) is an economically important root vegetable valued for fresh consumption, processing and dietary quality. Its storage roots supply carbohydrates, fibre, minerals and bioactive compounds, especially carotenoids. Commercial value depends not only on total biomass but also on root size, colour, shape uniformity, surface smoothness and freedom from defects. Cultivar choice is therefore a central component of profitable and resource-efficient carrot production [1–3].

The lower Amu Darya region is characterized by a sharply continental arid climate, saline soils, hot winds, low relative humidity and variable irrigation-water availability. Carrot is particularly vulnerable during germination and early seedling growth because its small seed, slow initial development and shallow young root system can lead to uneven stands. Later exposure to water deficit, salinity or excessive temperature may restrict leaf area, shorten the root-filling period and increase forking, cracking, fibrous texture and non-uniformity [4–7].

Cultivar performance represents the expression of genotype within a specific environment and management system. Descriptions obtained under favourable or temperate conditions cannot be transferred directly to Karakalpakstan. Locally replicated trials are required to determine whether a cultivar establishes a uniform stand, maintains foliage under stress and converts assimilates into roots that satisfy market specifications. Simultaneous measurement of agronomic and quality traits is essential because a high total yield can coincide with a low proportion of marketable roots [8–10].

Ziynatli and Mshak 195 are relevant materials for the station's carrot breeding and seed-production programme. The objective of this paper is to determine how within-row plant spacing influences stand development, storage-root formation, yield structure and marketable quality in these cultivars under Karakalpakstan conditions. The factorial framework permits the main effects of cultivar and spacing, as well as their interaction, to be evaluated under salinity, high temperature and restricted water supply.

LITERATURE REVIEW

Carrot productivity is established through a sequence of connected processes: rapid and uniform emergence, formation of a functional leaf rosette, initiation and thickening of the storage root, and maintenance of root quality until harvest. Weak performance at any stage can reduce final marketable yield. Emergence percentage and stand density should therefore be considered explanatory variables rather than treated only as routine observations [3, 4].

Salinity imposes both osmotic and ionic stress. During germination it delays water uptake and can reduce the number and vigour of emerged seedlings. During vegetative growth, salt accumulation may restrict leaf expansion, photosynthesis and root enlargement. Genotypic differences in germination under saline conditions have been reported in diverse carrot germplasm, supporting the value of cultivar-specific screening at both establishment and harvest stages [4, 5].

Water deficit influences carrot yield through reduced canopy growth, premature senescence and limited assimilate supply to the storage root. Irregular water availability may also contribute to cracking and non-uniform root development. Irrigation records and soil-moisture observations are thus required to distinguish an inherent cultivar response from management-induced variation. An efficient cultivar should combine acceptable productivity with stable marketable quality rather than simply producing large vegetative biomass [6, 7].

Root morphology is strongly associated with commercial acceptance. Length and shoulder diameter describe root size, whereas taper, tip fill, straightness and surface smoothness characterize market type. Forking can arise from genetic tendency, soil compaction, undecomposed organic matter, nematode or insect injury, and damage to the primary root. Because several causal factors are possible, defect scoring must be accompanied by careful characterization of soil preparation and crop health [8, 9].

Nutritional and processing quality are commonly described using dry matter, soluble solids, sugars, carotenoids and nitrate concentration. Orange pigmentation is largely associated with carotenoid accumulation, but visual colour alone is not an analytical substitute. Sampling must be standardized by harvest stage, root position within the plot and laboratory method. Multi-environment or multi-year trials are also necessary because quality traits and yield components may respond differently to seasonal conditions [2, 3, 10].

RESEARCH METHODOLOGY

3.1 Study site and environmental characterization. Field experiments are designed for the experimental fields of the Research Institute of Vegetables, Melons and Potatoes, Karakalpakstan Scientific Experimental Station, Nukus, Uzbekistan,

during successive growing seasons. Before sowing, composite soil samples are collected from the 0–30 and 30–50 cm layers. Soil texture, bulk density, organic matter, pH, electrical conductivity, total nitrogen, available phosphorus, exchangeable potassium and water-soluble salts are determined by validated methods. Daily minimum and maximum temperature, precipitation, relative humidity and, where available, reference evapotranspiration are obtained from the nearest meteorological station. Irrigation dates and applied water are recorded throughout the crop cycle.

3.2 Plant material, spacing treatments and experimental design. The plant material consists of the carrot cultivars Ziynatli and Mshak 195. Four planting schemes are evaluated: 50 × 5 cm, 50 × 10 cm, 50 × 15 cm and 50 × 20 cm. These schemes correspond to target populations of approximately 400,000, 200,000, 133,333 and 100,000 plants ha−1, respectively. The experiment is arranged as a two-factor randomized complete block design with four replications, where factor A is cultivar and factor B is within-row spacing. The eight cultivar × spacing combinations are randomized independently within each block. Seed lots are tested for purity and laboratory germination before sowing, while sowing depth, plot size and row length remain uniform across all treatments.

Table 1. Experimental status and principal role of the two carrot cultivars

Cultivar	Experimental status	Purpose in the trial
Ziynatli	Test cultivar	Comparative assessment of adaptation, yield and root quality
Mshak 195	Test cultivar	Comparative assessment of adaptation, yield and root quality

Table 2. Plant-spacing treatments included in the factorial field experiment

Treatment	Planting scheme	Area per plant	Target population
S1	50 × 5 cm	0.0250 m²	400,000 plants ha−1
S2	50 × 10 cm	0.0500 m²	200,000 plants ha−1
S3	50 × 15 cm	0.0750 m²	133,333 plants ha−1
S4	50 × 20 cm	0.1000 m²	100,000 plants ha−1

3.3 Crop establishment and management. The seedbed is prepared to provide a fine, uniform and uncompacted tilth. Seeds are sown on the same date and at the same depth using calibrated equipment. After emergence, seedlings are thinned precisely to the assigned 5, 10, 15 or 20 cm within-row distance; missing plants are not replaced after the establishment period. Fertilizer is applied according to soil-test results, avoiding excessive nitrogen that could stimulate foliage at the expense of root quality or increase nitrate accumulation. Irrigation, inter-row cultivation, weed control and plant-protection measures are applied uniformly to all plots. Border rows and end plants are excluded from sampling. Any deviation in water distribution, pest pressure or soil condition is documented at plot level.

3.4 Phenology, stand establishment and canopy traits. Dates of first emergence, 50% emergence, 75% emergence and harvest maturity are recorded. Field emergence is calculated as the percentage of sown seeds producing established

seedlings within the defined observation area. Plant survival to harvest and final stand density are determined from fixed sections of each plot. At standardized growth stages, leaf-rosette height, number of leaves per plant, canopy uniformity, chlorosis, marginal necrosis and premature senescence are assessed on preselected non-border plants. Biotic damage is recorded separately from abiotic injury.

3.5 Root yield, morphology and marketability. Each net plot is harvested separately at a common physiological or market maturity. The number and fresh weight of roots are measured, and total yield is converted to tonnes per hectare as $Y = 10M/S$, where Y is yield (t ha−1), M is root mass from the net plot (kg), and S is net plot area (m^2). On a representative sample, individual root weight, root length, maximum shoulder diameter, core diameter and root length-to-diameter ratio are recorded. Shape uniformity, straightness, tip fill and surface smoothness are assessed using predefined descriptors. Forked, cracked, green-shouldered, diseased, mechanically damaged and undersized roots are counted and weighed separately. Marketability is calculated as $T = (Mm/Mt) \times 100$, where Mm is marketable root mass and Mt is total root mass.

3.6 Biochemical quality assessment. Quality samples are obtained from the inner rows of every plot and handled identically. Dry matter is determined gravimetrically; soluble solids are measured by calibrated refractometry; and total sugars, carotenoids and nitrates are quantified using validated laboratory protocols. Results are expressed on a clearly stated fresh- or dry-weight basis. Composite sampling should not replace replication: each block must provide an independent analytical sample so that cultivar differences can be tested statistically.

Table 3. Core indicators for evaluating cultivar and plant-spacing effects

Trait group	Indicator	Unit or scale	Assessment stage
Establishment	Field emergence; final stand	%; plants m−2	Emergence; pre-harvest
Phenology	Days to 50% emergence; days to harvest	days	During season
Canopy	Rosette height; leaf number; injury score	cm; number; ordinal scale	Defined growth stages
Root morphology	Length; shoulder diameter; individual weight	cm; mm; g	Harvest
Defects	Forking; cracking; greening; disease	% by number and mass	Harvest
Productivity	Total and marketable yield	t ha−1; % marketability	Harvest
Quality	Dry matter; soluble solids; sugars; carotenoids; nitrate	method-specific units	Harvest laboratory sample

3.7 Statistical analysis and cultivar-selection rule. Plot data are analysed using two-factor analysis of variance appropriate to a randomized complete block design. The model estimates the effects of cultivar, plant spacing and cultivar × spacing interaction. Treatment means are reported with standard errors, and differences are

evaluated at $p \leq 0.05$; Fisher's least significant difference is presented when the corresponding effect is significant and model assumptions are satisfied. Orthogonal polynomial contrasts may be used to test linear and quadratic responses to increasing within-row spacing. Residuals are examined for normality and homogeneity of variance; proportions and counts are transformed or analysed with generalized models when required. In combined analysis across years, year and its interactions with cultivar and spacing are included. Agronomic efficiency is assessed from marketable yield per hectare together with marketability, mean root weight and dimensional uniformity.

ANALYSIS AND RESULTS

The comparative framework identifies stand establishment as the first decisive component of adaptation. Uniform emergence creates an even canopy and reduces competition among neighbouring plants, whereas gaps and delayed seedlings increase variability in root diameter and maturity. For Ziynatli and Mshak 195, emergence percentage should be interpreted together with laboratory germination and soil electrical conductivity. This separates seed-lot limitations from cultivar response to the field environment.

Phenology provides a second line of interpretation. Earlier establishment and root filling may help a cultivar avoid late-season heat and water deficit, but rapid maturity is beneficial only when it is accompanied by adequate root size and marketable yield. A longer-duration cultivar may remain competitive if it preserves green leaf area, sustains root growth and produces a uniform harvest. Consequently, days to harvest must be assessed jointly with canopy condition and yield formation.

Leaf-rosette development describes the photosynthetic source supporting storage-root growth. Large foliage can improve radiation interception, yet excessive vegetative growth may delay assimilate partitioning to roots and complicate harvest. Rosette height and leaf number are therefore explanatory traits, not independent selection goals. Their agronomic value is determined by their relationship with individual root weight, total yield and marketability.

Root dimensions and shape reveal different aspects of cultivar performance. Root length indicates penetration and elongation, shoulder diameter reflects thickening, and the length-to-diameter ratio helps describe market type. A cultivar with a favourable mean size may still be commercially weak if variability is high. Distribution of roots among predefined grades and the coefficient of variation for key dimensions therefore provide more useful evidence than a mean value alone.

Defect analysis is essential because total yield can overestimate usable production. Forking, cracking, greening and disease directly reduce marketable output. Their causes must be interpreted carefully: forking may be associated with genotype, compacted soil or injury to the primary root, while cracking can reflect irregular growth following fluctuations in water supply. Uniform seedbed preparation and irrigation across all plots allow the cultivar component of these responses to be assessed more reliably.

Biochemical indicators complement visual and yield evaluation. Dry matter and soluble solids are associated with texture and processing behaviour, sugars influence

flavour, and carotenoids contribute to nutritional value and root colour. Nitrate concentration is important for food-quality assessment and can respond strongly to nitrogen supply, irrigation and harvest stage. Standardized sampling and replicated laboratory measurements are necessary before quality differences are attributed to cultivar.

Plant spacing changes the balance between productivity per plant and productivity per unit area. Narrow spacing increases the number of plants occupying one hectare but intensifies competition for light, water and nutrients; this commonly reduces individual root mass and shifts the harvest toward smaller diameter classes. Wider spacing increases the soil and canopy resources available to each plant and can promote larger roots, although the reduced plant population may limit yield per hectare. The agronomic optimum is therefore the spacing that maximizes marketable yield rather than either plant density or individual root size alone.

The cultivar × spacing interaction is central to interpretation. Ziynatli and Mshak 195 may differ in rosette architecture, root growth rate and capacity to exploit additional space. If the interaction is significant, a single planting recommendation for both cultivars would be inappropriate. Each cultivar should then be assigned the spacing that provides the most favourable combination of marketable yield, grade distribution, uniformity and low defect incidence.

`Repeated testing across seasons is required to establish consistency. A significant cultivar × year interaction would indicate that relative performance changes with environmental conditions. In that case, recommendation should emphasize stability and the conditions under which each cultivar performs best. This evidence-based approach supports decisions that are agronomically meaningful and statistically defensible for Karakalpakstan.

CONCLUSION AND RECOMMENDATIONS

1. Plant spacing should be treated as a cultivar-specific management factor because it directly controls competition, individual root size, grade distribution and marketable yield per hectare.
2. The factorial combination of Ziynatli and Mshak 195 with 50 × 5, 50 × 10, 50 × 15 and 50 × 20 cm schemes provides a defensible experimental range for identifying the agronomic optimum.
3. A randomized complete block design with four replications, uniform management and documented environmental conditions is required to separate cultivar, spacing and cultivar × spacing effects.
4. Marketable yield, root uniformity and defect incidence should be the principal criteria, supported by emergence, maturity, canopy traits and biochemical quality.
5. The final planting recommendation should be based on replicated multi-year evidence and may differ between Ziynatli and Mshak 195 when their density responses are not parallel.

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EFFECTIVENESS OF VERMICOMPOST AND CHLORELLA APPLICATION IN TOMATO CULTIVATION UNDER THE CONDITIONS OF KARAKALPAKSTAN

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Abstract. *The effects of vermicompost and Chlorella vulgaris-based biological nutrition on fruit formation of the released tomato cultivar TMK-22 were evaluated under the soil and climatic conditions of the Republic of Karakalpakstan. Plants established by direct seeding and transplanting were compared in a field experiment with four treatments: chlorella, vermicompost, chlorella + vermicompost, and an unfertilized control, arranged in three replications. Fifteen sample plants per treatment were used to record phenological stages and the total, ripe, and unripe fruit number per plant. The transplanted vermicompost treatment produced 29 fruits per plant, 26.1% more than the control. The chlorella and combined treatments each produced 28 fruits per transplanted plant, compared with 23 fruits in the control. Organic and biological nutrition promoted continued fruit set; consequently, a proportion of newly formed fruit remained unripe at the final observation. The findings indicate that vermicompost application in transplanted TMK-22 tomato is a promising approach to increasing fruit number under Karakalpakstan conditions.*

Keywords: *tomato; Solanum lycopersicum L.; TMK-22; vermicompost; chlorella; organic fertilizer; transplanting; fruit set; Karakalpakstan.*

Annotatsiya. *Tadqiqotda Qoraqalpog‘iston Respublikasining tuproq-iqlim sharoitida rayonlashtirilgan TMK-22 pomidor navini urug‘dan va ko‘chat usulida yetishtirishda biogumus hamda Chlorella vulgaris asosidagi biologik oziqlantirishning meva elementlari shakllanishiga ta’siri baholandi. Dala tajribasi to‘rtta variantda: xlorella, biogumus, xlorella + biogumus va o‘g‘itsiz nazoratda, uch takrorlanishda olib borildi. Har bir variantda 15 tadan hisob o‘simligi ajratilib, fenologik fazalar va bir tupdagi umumiy, pishgan hamda pishmagan mevalar soni aniqlandi. Biogumus qo‘llanilgan ko‘chat variantida bir tupdagi umumiy mevalar soni 29 donaga yetib, nazoratdan 26,1% yuqori bo‘ldi. Xlorella qo‘llanilganda ko‘chat usulida 28 dona, xlorella va biogumus birgalikda qo‘llanilganda 28 dona meva shakllandi; nazoratda esa 23 dona qayd etildi. Organik va biologik oziqlantirish meva tugish faolligini oshirgan, biroq kuzatuv yakunida yosh mevalarning bir qismi hali to‘liq pishmaganligi sababli pishgan mevalar ulushi nazoratdagidan past bo‘lgan. Natijalar TMK-22 navini ko‘chat usulida yetishtirishda biogumusdan foydalanish meva sonini oshirishning istiqbolli usuli ekanini ko‘rsatdi.*

Kalit so‘zlar: *pomidor; Solanum lycopersicum L.; TMK-22; biogumus; xlorella; organik o‘g‘it; ko‘chat; meva tugishi; Qoraqalpog‘iston.*

Аннотация. *В исследовании оценено влияние биогумуса и биологической подкормки на основе Chlorella vulgaris на формирование плодов районированного сорта томата TMK-22 при выращивании из семян и рассадным способом в почвенно-климатических условиях Республики Каракалпакстан. Полевой опыт проводили в трех повторностях по четырем вариантам: хлорелла, биогумус, хлорелла + биогумус и контроль без удобрений. В каждом варианте выделяли 15 учетных растений и определяли фенологические фазы, общее количество, число созревших и незрелых плодов на растении. В рассадном варианте с биогумусом сформировалось 29 плодов на растение, что на 26,1% превышало контроль. При применении хлореллы и совместном применении хлореллы с биогумусом получено по 28 плодов, тогда как в контроле — 23. Органическое и биологическое питание усилило плодообразование, но к окончанию наблюдений часть молодых плодов еще не достигла полной зрелости. Результаты показывают перспективность применения биогумуса при рассадном выращивании сорта TMK-22.*

Ключевые слова: *томат; Solanum lycopersicum L.; TMK-22; биогумус; хлорелла; органическое удобрение; рассада; плодообразование; Каракалпакстан.*

INTRODUCTION

Tomato (Solanum lycopersicum L.) is an important vegetable crop for food security, the processing industry, and household incomes. Its productivity depends not only on the biological characteristics of the cultivar but also on soil fertility, temperature, irrigation regime, and plant nutrition. Under the sharply continental and arid climate of the Republic of Karakalpakstan, high temperatures, low air humidity, limited irrigation water, and soil salinity may adversely affect root activity, flowering, and fruit set in tomato.

Under these conditions, simply increasing the rate of mineral fertilizers cannot provide a sustainable solution. In soils with low organic-matter content, biologically active organic products can help improve soil physical properties and nutrient cycling. Vermicompost is regarded as a source of plant-available nutrients, humic compounds, and beneficial microorganisms. Chlorella-based products are used as biostimulants because they contain amino acids, pigments, and biologically active metabolites [1–4]. TMK-22 is a locally released tomato cultivar grown in Karakalpakstan, and evaluating its response to organic and biological nutrition under field conditions is of practical importance. This study aimed to determine the effects of vermicompost, chlorella, and their combined application on phenological development and fruit formation in TMK-22 tomato established by direct seeding and transplanting.

LITERATURE REVIEW

The effectiveness of vermicompost is attributed to its stable organic matter, macro- and micronutrients, humic acids, and microbial activity. In a greenhouse study, Wang et al. demonstrated that vermicompost improved tomato yield and quality as well as selected biochemical properties of the soil [1]. Subsequent studies have shown that the response to vermicompost depends on soil moisture, cropping history, and salinity level [2, 5, 6]. This relationship is particularly relevant to Karakalpakstan, where water scarcity and soil salinity often occur simultaneously.

Microalgae are used in agriculture as biofertilizers and biostimulants and may promote root development, nutrient uptake, and plant responses to abiotic stress. Renuka et al. reviewed the multifunctional potential of microalgal biomass for crop production [7]. Ronga et al. analyzed the effects of microalgae- and cyanobacteria-based products on plant growth and productivity [8]. Experiments involving Chlorella vulgaris in organic tomato production have also reported improvements in plant growth, yield, and selected fruit-quality traits [3, 9].

The effects of organic fertilizers and biostimulants vary with application rate and timing, soil conditions, cultivar, and water regime. Therefore, findings obtained elsewhere should be verified in replicated field experiments before being transferred directly to local production. In addition, an increase in total fruit number does not necessarily result in a higher percentage of ripe fruit at a particular observation date: if fruit set continues, the number of young fruit also increases. Total, ripe, and unripe fruit numbers should therefore be analyzed together to interpret biological responses correctly.

RESEARCH METHODOLOGY

The study was conducted in the open field at the Karakalpakstan Scientific Experimental Station using the released tomato cultivar TMK-22. The experiment comprised four treatments arranged in three replications: (1) chlorella, (2) vermicompost, (3) chlorella + vermicompost, and (4) an unfertilized control. Within each treatment, tomato establishment by direct seeding was compared with establishment using nursery-grown transplants. All treatments received the same agronomic operations at the same time and under comparable conditions.

Phenological observations were made on 15 sample plants in each treatment. The number of days to emergence, appearance of the first 1–2 true leaves, formation of lateral shoots, flowering, fruit set, and fruit ripening was recorded. To evaluate fruit formation, the total number of fruit per plant and the numbers of ripe and unripe fruit were counted. The percentage of each category was calculated by dividing the number of fruit in that category by the total fruit number and multiplying by 100.

The field experiment, observations, and synthesis of results followed established methodologies for vegetable and field experiments [10–12]. Values presented in the tables are means across three replications. Percentage differences relative to the control were calculated as (treatment − control) / control × 100. Because the primary dataset did not include analysis of variance, standard errors, or LSD05 values, differences are interpreted in this paper as biological trends; no claim of statistical significance is made.

ANALYSIS AND RESULTS

Phenological development of tomato plants. Emergence occurred mainly 8 days after direct seeding and after 7 days in the transplant treatments. The first 1–2 true leaves appeared after 14 days in directly seeded plants and after approximately 12 days in transplanted plants. Depending on the treatment, flowering occurred after 50–52 days, fruit set after 65–73 days, and fruit ripening after 102–110 days. Field emergence of directly sown seed ranged from 75 to 85%.

Table 1. Duration of the phenological development stages of tomato plants, days

Establishment method	Emergence	First 1–2 true leaves	Lateral shoot formation	Flowering	Fruit set	Ripening
Direct seeding	8	14	35–37	50–52	70–73	102–110
Transplanting	7	12	35–36	50–52	65–68	104–108

Note: values are presented as the minimum–maximum range observed across the treatments.

The occurrence of the initial developmental stages 1–2 days earlier in the transplant treatments can be explained by the ability of plants with established roots and leaves to resume growth rapidly after field establishment. Differences in ripening time depended not only on the establishment method but also on the treatment and the development of individual plants. The phenological data provide the biological context required for interpreting fruit number.

Effects of organic fertilizers on fruit formation. The clearest difference among treatments was observed in the total number of fruit per plant. In the vermicompost treatment, directly seeded and transplanted plants produced 27 and 29 fruit per plant, respectively. The corresponding values in the control were 22 and 23 fruit per plant (Table 2).

Table 2. Effects of organic and biological nutrition on tomato fruit formation

Treatment	Establishment method	Total fruit, no.	Ripe fruit, no.	Ripe fruit, %	Unripe fruit, no.	Unripe fruit, %
Chlorella	Direct seeding	26	20	76.92	6	23.08
Chlorella	Transplanting	28	19	67.86	9	32.14
Vermicompost	Direct seeding	27	20	74.07	7	25.93
Vermicompost	Transplanting	29	21	72.41	8	27.59
Chlorella + vermicompost	Direct seeding	27	20	74.07	7	25.93
Chlorella + vermicompost	Transplanting	28	21	75.00	7	25.00
Control	Direct seeding	22	20	90.91	2	9.09
Control	Transplanting	23	19	82.61	4	17.39

In the chlorella treatment, the total fruit number exceeded the control by 18.2% in directly seeded plants and by 21.7% in transplanted plants. The corresponding advantages of the vermicompost treatment were 22.7 and 26.1%. When chlorella and vermicompost were applied together, fruit number exceeded the control by 22.7% under direct seeding and by 21.7% under transplanting. The highest numerical value was recorded in the transplanted vermicompost treatment.

The highest number of ripe fruit, 21 per plant, was recorded in the transplanted vermicompost and chlorella + vermicompost treatments. Nineteen ripe fruit per plant were observed in both the transplanted chlorella treatment and the transplanted control. The proportion of ripe fruit was higher in the control, reaching 90.91% under direct seeding and 82.61% under transplanting. In the fertilized treatments, this proportion ranged from 67.86 to 76.92%.

When interpreting these results, absolute fruit number must be distinguished from relative proportion. Organic nutrition increased the total number of fruit, but some newly formed fruit had not ripened by the final observation. Therefore, the lower proportion of ripe fruit may indicate continued generative activity rather than weak yield formation. Confirmation of this interpretation requires recording production over several harvests and determining total and marketable yield in t ha−1.

The stronger numerical response to vermicompost in transplanted plants may be associated with two complementary factors. First, transplants already had established root systems and true leaves when they were planted in the field. Second, vermicompost may improve soil water-holding capacity, nutrient availability, and microbial activity [1, 2, 5]. Because these mechanisms were not measured directly in the present experiment, they should be regarded as literature-based interpretations rather than causal conclusions.

The combination of chlorella and vermicompost did not outperform vermicompost applied alone. This does not demonstrate that the combination was ineffective, because the experiment did not include separate gradients of application rate and timing. Plant responses to biostimulants depend on concentration, application method, developmental stage, and environmental conditions [7–9]. Future experiments should test several chlorella concentrations and vermicompost rates in a factorial design.

Study limitations. The primary dataset did not include fruit mass, marketable yield, mean fruit weight, soil chemical and salinity parameters, irrigation rate, or measures of experimental error. The results therefore demonstrate effects of vermicompost and chlorella on fruit number but do not conclusively establish that either treatment increased yield in t ha−1. Future reports should provide analysis of variance, standard errors, LSD05, and p-values for each treatment.

SCIENTIFIC AND PRACTICAL SIGNIFICANCE OF THE RESULTS

The findings provide initial scientific evidence for comparing organic and biological nutrition products on a locally grown tomato cultivar under the challenging soil and climatic conditions of Karakalpakstan. Simultaneous comparison of establishment methods and nutrition treatments made it possible to identify the combined response of transplanting and vermicompost. The highest total fruit number in the transplanted vermicompost treatment indicates that this treatment should be prioritized for evaluation in the next stage of research.

From a practical perspective, vermicompost should not be regarded as a complete replacement for mineral nutrition but as a component that supports soil organic matter and biological activity. If the application rate is not aligned with soil-test results, crop nutrient requirements, and water availability, costs may increase or

plants may develop excessive vegetative growth. A production recommendation should therefore address the economic efficiency of vermicompost, fruit quality, and its balance with mineral fertilizers.

When Chlorella-based products are used, viable-cell concentration, shelf life, and application method should be standardized. Future experiments should evaluate foliar spraying and soil drenching separately and compare application at different phenological stages. These measures would distinguish the independent effect of chlorella from its effect on a vermicompost background and support development of a reproducible production protocol.

CONCLUSION AND RECOMMENDATIONS

1. Under Karakalpakstan conditions, differences associated with the establishment method were observed in the phenological development of TMK-22 tomato: emergence occurred after 8 days under direct seeding and after 7 days under transplanting, whereas the first 1–2 true leaves appeared after 14 and 12 days, respectively.
2. The transplanted vermicompost treatment produced 29 fruit per plant, the highest value recorded in the experiment and 26.1% more than the control.
3. In the transplanted chlorella and chlorella + vermicompost treatments, 28 fruit per plant were formed, representing a 21.7% increase over the 23 fruit recorded in the control.
4. The relatively low proportion of ripe fruit in the fertilized treatments may be associated with continued fruit set and the presence of young fruit at the final observation.
5. Before recommendations are made for commercial production, the experiment should be repeated for at least two growing seasons; yield should be measured in t ha−1 together with mean fruit weight, marketability, and quality, and the data should be evaluated using ANOVA and LSD05.
6. Future research should evaluate vermicompost rates, chlorella concentrations, and application timing in a factorial experiment and should regularly record soil EC and pH as well as irrigation-water inputs.

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ҚОРАҚАЛПОҒИСТОН РЕСПУБЛИКАСИ ШАРОИТИДА ШОЛҒОМ (*Brassica rapa* L.) ЕТИШТИРИШНИНГ ИЛМИЙ-АГРОТЕХНОЛОГИК АСОСЛАРИ

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Аннотация. *Мақолада Қорақалпоғистон Республикасининг тупроқ-иқлим шароитида шолғом (Brassica rapa L.) етиштиришнинг илмий-агротехнологик асослари адабиётлар таҳлили асосида ёритилган. Шолғомнинг қисқа вегетация даври, нисбатан совуққа чидамлилиги, турли экологик шароитларга мослашувчанлиги ва озиқавий қиймати уни сабзавотчилик тизимида истиқболли экинлардан бири сифатида баҳолаш имконини беради. Тадқиқотда сўнгги йилларда чоп этилган илмий мақолалар, агротехнологик тадқиқотлар ҳамда Қорақалпоғистон шароитида олиб борилган ишлар таҳлил қилинди. Адабиётлар таҳлили шолғом ҳосилдорлигига экиш муддати, экиш усули, ўсимликларнинг озиқланиш майдони, азотли ўғитлар меъёри ва суғориш тартиби сезиларли таъсир кўрсатишини кўрсатди. Шўрланиш даражаси юқори бўлган тупроқларда эгат ёки пушта усулидан фойдаланиш, азотни меъёрлаштириб бериш ва суғоришни ўсимликнинг ривожланиш босқичларига мувофиқ ташкил этиш муҳим агротехнологик омиллар ҳисобланади. Қорақалпоғистон шароитида шолғом етиштириш технологиясини такомиллаштиришда маҳаллий навларнинг биологик хусусиятларини ҳисобга олиш, экиш муддатларини илмий асослаш ва сув-озуқа режимини оптималлаштириш асосий йўналишлар сифатида тавсия этилади.*

Калит сўзлар. *шолғом, Brassica rapa L., агротехнология, экиш муддати, суғориш, минерал озиқлантириш, азот, ҳосилдорлик, Қорақалпоғистон, шўрланган тупроқ.*

Аннотация. *В статье на основе анализа научной литературы рассмотрены научно-агротехнологические основы выращивания репы (Brassica rapa L.) в условиях Республики Каракалпакстан. Репа характеризуется относительно коротким вегетационным периодом, холодостойкостью, адаптивностью к различным экологическим условиям и высокой пищевой ценностью, что определяет перспективность ее выращивания в овощеводстве. Проанализированы современные исследования, посвященные влиянию сроков и способов посева, площади питания растений, минерального питания, азотных удобрений и режима орошения на рост и урожайность репы. Установлено, что эффективность технологии выращивания в значительной степени*

определяется соответствием агроприемов почвенно-климатическим условиям региона. На засоленных почвах особое значение имеют гребневой или грядковый способ посева, рациональное применение азотных удобрений и регулирование водного режима. Для условий Каракалпакстана предлагается совершенствовать технологию возделывания репы с учетом биологических особенностей сортов, оптимальных сроков посева, водно-питательного режима и особенностей засоленных почв.

Ключевые слова. *репа, Brassica rapa L., агротехнология, сроки посева, орошение, минеральное питание, азот, урожайность, Каракалпакстан, засоление почвы.*

Abstract. *The article reviews the scientific and agronomic principles of turnip (Brassica rapa L.) production under the conditions of the Republic of Karakalpakstan. Turnip is characterized by a relatively short growing period, cold tolerance, adaptability to different environmental conditions and high nutritional value, making it a promising vegetable crop for regional production. Recent scientific studies concerning the effects of sowing dates, sowing methods, plant nutrition area, mineral fertilization, nitrogen application and irrigation regimes on turnip growth and yield were analyzed. The literature indicates that yield formation is strongly influenced by the compatibility of agronomic practices with local soil and climatic conditions. Under saline soils, ridge or bed planting, balanced nitrogen fertilization and appropriate irrigation management are particularly important. For Karakalpakstan, improvement of turnip production technology should focus on cultivar-specific biological characteristics, scientifically justified sowing dates, optimization of water and nutrient regimes, and adaptation of cultivation practices to saline soil conditions.*

Keywords. *turnip, Brassica rapa L., agrotechnology, sowing date, irrigation, mineral nutrition, nitrogen, yield, Karakalpakstan, soil salinity.*

КИРИШ

Сабзавотчилик аҳолини сифатли ва витаминларга бой озиқ-овқат маҳсулотлари билан таъминлашда муҳим аҳамиятга эга. Шу нуқтаи назардан, кам вегетация даврида маҳсулот берувчи, ташқи муҳит омилларига нисбатан мослашувчан ва озиқавий қиймати юқори сабзавот экинларини етиштириш технологияларини такомиллаштириш долзарб вазифалардан ҳисобланади.

Шолғом (*Brassica rapa* L.) карамдошлар (Brassicaceae) оиласига мансуб илдизмевали сабзавот экинларидан бири бўлиб, озиқ-овқат ва айрим ҳолларда ем-хашак мақсадларида етиштирилади. Унинг илдизмевалари углеводлар, озиқавий толалар, витаминлар, минерал моддалар ва турли биологик фаол бирикмаларни ўз ичига олади. Замонавий тадқиқотларда шолғом таркибида глюкозинолатлар, фенол бирикмалари, флавоноидлар ва бошқа фитокимёвий моддалар мавжудлиги қайд этилган.

Шолғомнинг агробиологик хусусиятларидан бири — нисбатан қисқа муддатда товарбоп илдизмева шакллантиришидир. Шу билан бирга, унинг ўсиши ва ҳосилдорлиги ҳарорат, тупроқ намлиги, минерал озиқланиш, экиш муддати ва ўсимликларнинг жойлашиш зичлигига боғлиқ.

Қорақалпоғистон Республикасида қишлоқ хўжалиги ишлаб чиқариши табиий-иқлим шароитларининг мураккаблиги билан ажралиб туради. Юқори ҳарорат, ҳавонинг қуруқлиги, сув ресурсларининг чекланганлиги ва айрим майдонларда тупроқ шўрланишининг мавжудлиги сабзавот экинларини етиштиришда агротехнологик тадбирларни аниқ белгилашни талаб қилади.

Шу сабабли шолғомнинг ҳудуд шароитига мос агротехнологиясини ишлаб чиқишда экиш муддати, суғориш, озиқлантириш, тупроққа ишлов бериш ва ўсимликларни ҳимоя қилиш тадбирларини ўзаро уйғунлаштириш муҳимдир.

Мазкур ишнинг мақсади — Қорақалпоғистон Республикаси шароитида шолғом етиштиришнинг илмий-агротехнологик асосларини замонавий адабиётлар ва мавжуд минтақавий тадқиқотлар асосида таҳлил қилиш ҳамда ҳосилдорликни оширишга қаратилган агротехнологик ёндашувларни асослаш.

Тадқиқот вазифалари қуйидагилардан иборат:

- Шолғомнинг биологик ва агроэкологик хусусиятларини таҳлил қилиш;
-Экиш муддатларининг ўсимлик ўсиши ва ҳосилдорликка таъсирини баҳолаш;
- Экиш усуллари ва озиқланиш майдонининг аҳамиятини ўрганиш;
- Минерал, айниқса азотли озиқлантиришнинг таъсирини таҳлил қилиш;
- Суғориш режимининг ҳосил шаклланишидаги аҳамиятини баҳолаш;
- Қорақалпоғистон шароити учун илмий асосланган агротехнологик тавсиялар ишлаб чиқиш.

МАВЗУГА ОИД АДАБИЁТЛАРНИНГ ТАҲЛИЛИ

2.1. Шолғомнинг биологик хусусиятлари. *Brassica rapa* L. тури генетик ва морфологик жиҳатдан кенг хилма-хилликка эга бўлиб, унинг таркибига илдизмевали, баргли ва бошқа сабзавот шакллари киради. Замонавий генетик тадқиқотлар *B. rapa* турининг нав ва шакллари ташқи муҳитга мослашуви, морфологик белгилари ҳамда сифат кўрсаткичлари бўйича катта хилма-хилликка эга эканини кўрсатади.

Шолғом салқинсевар экинлар қаторига кириб, юқори ҳарорат шароитида илдизмева сифати пасайиши ёки генератив ривожланиш жараёнларининг тезлашиши мумкин. Шу сабабли ҳудуднинг ҳарорат режими экиш муддатини белгилашда муҳим мезон ҳисобланади. Ўсимликнинг дастлабки ривожланиш даврида намлик ва озуқа моддаларининг етарли бўлиши барг аппаратининг шаклланишига таъсир қилади. Кейинги босқичда эса фотосинтез маҳсулотларининг илдизмевага тўпланиши ҳосилдорликнинг асосий физиологик асосини ташкил этади.

2.2. Экиш муддати. Шолғомда экиш муддатини тўғри танлаш ҳосилдорлик ва маҳсулот сифатини белгилайдиган асосий агротехнологик омиллардан биридир. Тадқиқотлар экиш муддатининг ўзгариши ўсиш даври, барглар сони, илдизмева массаси ва умумий ҳосилдорликка таъсир қилишини кўрсатган. Сув танқислиги шароитида олиб борилган тажрибаларда ҳам экиш муддати ва суғориш даражаси ўсимликнинг ўсиши, ҳосили ва ҳосил индексига сезиларли таъсир кўрсатган.

Қорақалпоғистон шароитида экиш муддатини белгилашда эрта баҳорги ва ёзги-кузги етиштириш имкониятларини алоҳида баҳолаш мақсадга мувофиқ.

Айниқса, ёзги юқори ҳароратлар таъсирини камайтириш учун шолғомни биологик хусусиятларига мос муддатда экиш муҳим.

Қорақалпоғистонда олиб борилган минтақавий тадқиқотларда шолғомнинг агрономик хусусиятлари ва уни етиштириш агротехникаси ўрганилгани қайд этилган. Бу тадқиқотлар шолғомни республика сабзавотчилигида истиқболли экин сифатида баҳолаш имконини беради.

2.3. Экиш усули ва ўсимликларни жойлаштириш. Шолғомда экиш усули ўсимликларнинг илдиз тизими ривожланиши, намликдан фойдаланиши ва минерал озиқланиш самарадорлигига таъсир қилади. Шўрланган тупроқларда олиб борилган уч йиллик тадқиқотларда пуштада экиш усули текис эгат ёки кўтарилмаган майдондаги усулга нисбатан бир қатор ўсиш кўрсаткичлари ва ҳосилдорлик бўйича устунлик қилган. Тадқиқотда 80 кг/га азот пуштада экиш билан биргаликда иқтисодий жиҳатдан самарали вариант сифатида баҳоланган. Ушбу натижаларни Қорақалпоғистон шароити учун тўғридан-тўғри кўчириш мумкин эмас, чунки тупроқ, иқлим, нав ва агротехника фарқ қилади. Бироқ шўрланиш мавжуд бўлган майдонларда пушта ёки эгат усулини синаш илмий жиҳатдан асосланган йўналиш ҳисобланади.

2.4. Минерал озиқлантириш. Азот ўсимликларда оқсиллар, хлорофилл ва ферментлар синтези учун зарур бўлган асосий макроэлементлардан биридир. Шунинг учун унинг етишмаслиги барг аппарати ривожланиши ва илдизмева ҳосилдорлигини чеклаши мумкин.

Бироқ азотли ўғитларни ортиқча қўллаш ҳам мақбул эмас. Азот меъёрининг ортиши иқтисодий самарадорликнинг пасайиши, нитратлар тўпланиши ва озуқа моддаларининг ювилишига олиб келиши мумкин.

Шўрланган тупроқларда олиб борилган тадқиқотда азот меъёри 40, 60, 80 ва 100 кг/га даражаларида ўрганилган. Пушта усулида 80–100 кг/га азот вариантларида юқори ҳосил кўрсаткичлари қайд этилган, аммо иқтисодий жиҳатдан 80 кг/га азот энг мақбул вариант сифатида баҳоланган. Бу натижа Қорақалпоғистонда азотли ўғитларни механик равишда юқори меъёрда бериш эмас, балки тупроқ таҳлили, навнинг биологик хусусияти ва режалаштирилган ҳосил асосида дифференциаллаштириш зарурлигини кўрсатади.

Органик ўғитлардан фойдаланиш ҳам тупроқ структураси ва сувни ушлаб қолиш қобилиятини яхшилаши мумкин. Замонавий шарҳларда шолғомда органик ва минерал ўғитларнинг ўсимлик ўсиши ва ҳосил шаклланишига таъсири қайд этилган.

2.5. Суғориш режими. Қорақалпоғистон шароитида шолғом агротехнологиясининг энг муҳим қисмларидан бири сув режимини бошқаришдир. Ўсимликнинг сувга бўлган эҳтиёжи вегетация даври давомида бир хил эмас.

Уруғнинг униши ва дастлабки ўсиш даврида тупроқ намлиги етарли бўлиши керак. Илдизмева шаклланиши даврида эса намликнинг кескин танқислиги маҳсулот массасининг камайишига ва сифат кўрсаткичларининг ёмонлашишига олиб келиши мумкин.

Ўзбекистон шароитида салатбоп шолғомнинг суғориш тартибини ўрганган тадқиқотда тупроқ намлигини ЧДНСнинг 70–80 ва 80–90 фоизи даражасида ушлаб туриш ҳамда вегетация даврида 7–8 марта суғориш вариантлари баҳоланган; айрим вариантларда 41,6–42,7 т/га ҳосил олинган.

Бу натижалар Қорақалпоғистон учун тайёр меъёр сифатида қабул қилинмаслиги керак. Аммо улар шолғомда сув режимини илмий асосда бошқариш ҳосилдорликни шакллантиришда ҳал қилувчи омиллардан эканини кўрсатади.

ТАДҚИҚОТ МЕТОДОЛОГИЯСИ

Мазкур мақолада адабиётларни аналитик умумлаштириш усулидан фойдаланилди. Тадқиқот объекти сифатида сабзавотчиликда етиштириладиган шолғом (*Brassica rapa* L.) ва унинг Қорақалпоғистон шароитидаги агротехнологик хусусиятлари қабул қилинди.

Адабиётларни танлашда асосий эътибор 2016–2026 йилларда нашр этилган илмий мақолалар, шарҳлар ва минтақавий тадқиқотларга қаратилди. Таҳлил жараёнида қуйидаги агротехнологик омиллар ажратилди:

1. экиш муддати;
2. экиш усули;
3. ўсимликларнинг озиқланиш майдони;
4. азотли ва комплекс минерал ўғитлар;
5. суғориш режими;
6. тупроқнинг шўрланиш даражаси;
7. навнинг биологик хусусиятлари;
8. касаллик ва зараркунандалардан ҳимоя;
9. ҳосилни йиғиш муддати.

Манбаларда келтирилган натижалар қиёсий-аналитик усулда баҳоланди. Турли ҳудудларда олинган натижалар Қорақалпоғистон шароитига тўғридан-тўғри кўчирилмади; уларнинг агротехнологик аҳамияти минтақанинг сув танқислиги, юқори ҳарорат ва шўрланиш каби омиллари нуқтаи назаридан талқин қилинди.

Шу билан бирга, мақолада муаллифнинг шахсий дала тажрибаси натижалари мавжуд бўлмагани сабабли статистик кўрсаткичлар сунъий равишда шакллантирилмади. Манбалардаги экспериментал натижалар алоҳида кўрсатилиб, улардан минтақавий тавсияларни асослашда фойдаланилди.

ТАҲЛИЛ ВА НАТИЖАЛАР

4.1. Қорақалпоғистон шароитида агротехнологик омилларни баҳолаш.

Адабиётлар таҳлили шолғом ҳосилдорлиги бир нечта ўзаро боғлиқ агротехнологик омилларнинг натижаси эканини кўрсатди. Фақат битта омилни, масалан, азот меъёрини ошириш орқали юқори ҳосил олиш кафолатланмайди.

Шолғом учун тупроқни экишга тайёрлашда майдоннинг текислиги, майда ва яхши ишланган уруғ қатлами ҳосил қилиниши муҳим. Илдизмева тупроқда ривожлангани учун қаттиқ зичланган ёки кесакли тупроқда унинг шакли бузилиши ва товарбоплиги пасайиши мумкин.

Шўрланган майдонларда пушта ёки эгат усулидан фойдаланиш илдиз зонасида туз концентрациясининг нисбатан бошқарилишига ёрдам бериши мумкин. Илмий тажрибаларда ҳам пуштада экиш шолғомнинг илдиз узунлиги, барглар сони ва ҳосилдорлиги бўйича ижобий натижа берган.

4.2. Экиш муддатини оптималлаштириш. Қорақалпоғистон шароитида экиш муддатини танлашда асосий мақсад ўсимликнинг дастлабки ривожланишини қулай ҳарорат шароитига тўғри келтириш ва илдизмева шаклланиш даврини кескин иссиқ ёки сув танқислиги давридан чиқаришдан иборат.

Эрта баҳорги экишда тупроқ намлигидан самарали фойдаланиш имконияти юқори бўлиши мумкин. Бироқ жуда эрта экишда паст ҳароратлар уруғнинг унишини секинлаштиради.

Ёзги ёки кузги экишда эса асосий хавф юқори ҳарорат ва сув танқислиги билан боғлиқ. Шунинг учун бу даврда экиш санасини маҳаллий иқлим шароити, навнинг эртапишарлиги ва суғориш имкониятларига боғлаш мақсадга мувофиқ. *B.rapa* сабзавот шаклларининг экологик мослашувчанлиги нав танлашни ҳам муҳим қилади. Адабиётларда тур ичидаги генетик хилма-хиллик агроэкологик шароитларга мос навларни танлаш учун муҳим ресурс экани таъкидланган.

4.3. Азотли озиқлантиришнинг аҳамияти. Шолғомнинг ҳосилдорлигида азот муҳим ўрин тутади, аммо унинг оптимал миқдори тупроқ унумдорлиги ва режалаштирилган ҳосилга қараб белгиланиши лозим.

Шўрланган тупроқларда ўтказилган тадқиқотда 80 кг/га азот пушта усули билан биргаликда иқтисодий жиҳатдан энг самарали вариантлардан бири бўлган. 80 ва 100 кг/га азот вариантларида ҳосилдорлик юқори бўлган, бироқ 100 кг/га қўшимча азот иқтисодий самарадорлик бўйича ҳар доим ҳам устун бўлмаган. Бу ҳолатдан келиб чиқиб, Қорақалпоғистонда азотли ўғитларни бир мартада катта миқдорда бериш ўрнига, тупроқ таҳлили ва ўсимликнинг ўсиш босқичларига асосланган бўлиб бериш усулини ўрганиш мақсадга мувофиқ.

Фосфор ва калий билан мувозанатли озиқлантириш ҳам илдиз тизими ва маҳсулот сифати учун аҳамиятли. Шунинг учун агрокимёвий картограмма асосида NPK нисбатини белгилаш тавсия этилади.

4.4. Сувдан самарали фойдаланиш. Қорақалпоғистонда сув ресурсларидан самарали фойдаланиш шолғом етиштириш технологиясининг иқтисодий ва экологик самарадорлигини белгилайди.

Сув танқислиги шароитида ўтказилган тадқиқотларда суғориш меъёрининг пасайтирилиши ўсимликнинг ўсиш ва ҳосил кўрсаткичларига таъсир қилган. Демак, сувни ҳаддан ташқари тежаш ҳам ҳосилдорликни пасайтириши мумкин. Шунинг учун суғоришни календар бўйича эмас, балки тупроқ намлиги ва ўсимликнинг фенологик ҳолатига қараб ташкил этиш мақсадга мувофиқ.

Айниқса, униб чиқиш, барг аппаратининг жадал шаклланиши ва илдизмева ўсиши даврларида сув танқислигига йўл қўймаслик керак.

4.5. Шўрланган тупроқларда етиштириш. Қорақалпоғистонда шўрланиш шолғом агротехнологиясига таъсир этувчи муҳим омилдир. Шўрланган тупроқларда ўсимликнинг сувни ўзлаштириши қийинлашади ва айрим озуқа элементларининг ўзлаштирилиши бузилиши мумкин.
Шу сабабли:

- тупроқ шўрланиш даражасини агрокимёвий таҳлил қилиш;
- зарур ҳолларда шўр ювиш тадбирларини ўтказиш;
- пушта ёки эгат усулини қўллаш;
- суғориш сифатини назорат қилиш;
- минерал ўғитларни меъёрлаштириш муҳим ҳисобланади.

Шўрланган тупроқларда ўтказилган илмий тажрибаларда пуштада экиш ва оптимал азот меъёри шолғомнинг ҳосилдорлигини оширган. Масалан, ушбу тадқиқотда 80 кг/га азот ва пуштада экиш комбинацияси иқтисодий жиҳатдан самарали бўлган.

4.6. Ўсимликларни ҳимоя қилиш. Шолғом карамдошлар оиласига мансуб бўлгани учун ушбу оилага хос зараркунанда ва касалликларга мойил бўлиши мумкин. Булар қаторига баргларни зарарлайдиган ҳашаротлар, илдиз тизими касалликлари ва айрим вирусли касалликлар киради.

Замонавий шарҳларда Brassica экинларида қора чириш, кила, сохта ун-шудринг ва вирусли касалликлар муҳим муаммолардан экани қайд этилган. Самарали ҳимояда агротехник, биологик ва зарур ҳолларда кимёвий усулларни уйғунлаштириш муҳим. Шунинг учун Қорақалпоғистонда шолғомни бир майдонга такроран экишдан сақланиш, экин алмашинувига риоя қилиш, зарарланган ўсимликларни ўз вақтида ажратиш ва уруғлик материалнинг сифатини назорат қилиш тавсия этилади.

ҚОРАҚАЛПОҒИСТОН ШАРОИТИ УЧУН ТАКЛИФ ЭТИЛАЁТГАН АГРОТЕХНОЛОГИК ТИЗИМ.

Адабиётлар таҳлили асосида Қорақалпоғистон шароитида шолғом етиштиришда қуйидаги агротехнологик тизимни тажриба тариқасида синаб кўриш мақсадга мувофиқ:

1-босқич — майдон танлаш.

Сув билан таъминланган, яхши текисланган ва шўрланиш даражаси назорат қилинадиган майдон танланади.

2-босқич — тупроққа ишлов бериш.

Тупроқни майдалаш, текислаш ва уруғ тушадиган қатламни бир хил ҳолатга келтириш таъминланади. Тупроқнинг ортиқча зичланишига йўл қўйилмайди.

3-босқич — уруғни тайёрлаш.

Сифатли, навдорлиги юқори ва униб чиқиш қобилияти яхши уруғлар танланади. Уруғни экишдан олдин касалликларга қарши ишлов бериш зарурати агрономик диагностика асосида белгиланади.

4-босқич — экиш муддати.

Экиш санаси маҳаллий ҳарорат ва намлик шароитига қараб белгиланади.

Эрта баҳорги ва ёзги-кузги экиш муддатларини алоҳида тажриба вариантлари сифатида ўрганиш мақсадга мувофиқ.

5-босқич — экиш усули.

Шўрланган майдонларда пушта ёки эгат усулини қўллаш бўйича тажриба ўтказиш тавсия этилади.

6-босқич — минерал озиқлантириш.

Ўғит меъёри тупроқ таҳлили асосида белгиланиши лозим. Илмий адабиётлар асосида 60, 80 ва 100 кг/га азот меъёрларини таққослаш илмий жиҳатдан қизиқиш уйғотади.

7-босқич — суғориш.

Суғориш тупроқ намлиги ва ўсимликнинг ривожланиш босқичига қараб ташкил этилади. Сув танқислиги шароитида сувдан фойдаланиш самарадорлигини баҳолаш зарур.

8-босқич — қатор ораларига ишлов бериш.

Бегона ўтларни ўз вақтида йўқотиш, тупроқнинг ҳаво-сув режимини яхшилаш ва қатқалоққа қарши курашиш муҳим.

9-босқич — ҳимоя тадбирлари.

Касаллик ва зараркунандалар мониторинги мунтазам олиб борилади. Кимёвий воситалар фақат иқтисодий зарарланиш чегараси ва амалдаги фитосанитар талаблар асосида қўлланиши керак.

10-босқич — ҳосилни йиғиш.

Илдизмевалар товарбоп ўлчамга етганда йиғиб олинади. Ҳосилни кечиктириб юбориш айрим навларда сифат пасайишига олиб келиши мумкин.

ХУЛОСА ВА ТАКЛИФЛАР

Адабиётлар таҳлили натижасида шундай хулосага келиш мумкинки, шолғом (*Brassica rapa* L.) Қорақалпоғистон Республикаси шароитида сабзавотчиликни диверсификация қилиш учун истиқболли экинлардан бири ҳисобланади.

Шолғомнинг қисқа вегетация даври ва салқинсеварлик хусусияти уни экиш муддатларини илмий асосда танлаш имконини беради. Бироқ Қорақалпоғистон шароитида юқори ҳарорат, сув танқислиги ва тупроқ шўрланиши агротехнологик тадбирларни минтақалаштиришни талаб қилади.

Илмий адабиётлар экиш усули ва азотли озиқлантириш ўртасидаги ўзаро таъсир шолғом ҳосилдорлигига сезиларли таъсир қилишини кўрсатади. Шўрланган тупроқларда пушта усулида экиш ва меъёрланган азотли озиқлантириш ижобий натижа берган.

Суғориш режими ҳам ҳосилдорликнинг асосий омилларидан бири бўлиб, сув танқислиги шароитида уни ўсимликнинг ривожланиш босқичларига мослаштириш зарур.

Таклифлар:

1. Қорақалпоғистоннинг турли тупроқ-иқлим зоналарида шолғомнинг эрта баҳорги ва ёзги-кузги экиш муддатларини комплекс ўрганиш.
2. Маҳаллий ва истиқболли навларни экиш муддатлари бўйича таққослаш.

3. Шўрланган тупроқларда текис, эгат ва пушта усулларининг самарадорлигини баҳолаш.
4. Азотнинг 60–100 кг/га оралиғидаги меъёрларини тупроқнинг агрокимёвий хусусиятларига боғлаб ўрганиш.
5. Азотни бўлиб бериш усулининг ҳосилдорлик ва маҳсулот сифатига таъсирини аниқлаш.
6. Суғоришда тупроқ намлиги бўйича дифференциал режимларни ишлаб чиқиш.
7. Сувдан фойдаланиш коэффициентини иқтисодий самарадорлик билан биргаликда баҳолаш.
8. Шолғомни етиштиришда интеграциялашган зараркунанда ва касалликларга қарши кураш тизимини жорий этиш.
9. Ҳосилдорлик билан бир қаторда илдизмеваларнинг қуруқ модда, шакар, витаминлар ва нитратлар миқдорини баҳолаш.
10. Қорақалпоғистон шароити учун шолғомнинг «нав “экиш муддати” озиқлантириш “суғориш” ўзаро таъсирини қамраб олган кўп омилли дала тажрибаларини ташкил этиш.

Шундай қилиб, шолғом етиштириш технологиясини такомиллаштиришда битта агротехник тадбирга эмас, балки нав, экиш муддати, тупроқ, озиқланиш ва сув режимининг ўзаро таъсирига асосланган комплекс ёндашувдан фойдаланиш энг истиқболли йўналиш ҳисобланади.

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JAHON VA O‘ZBEKISTON DEHQONCHILIGIDA ARPA YETISHTIRISH TAJRIBASI VA UNING RIVOJLANISH TENDENSIYALARI: ILMIY MANBALAR TAHLILI

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Annotatsiya. *Ushbu maqola jahon va O‘zbekiston dehqonchiligida arpa yetishtirish tajribasi hamda so‘nggi o‘n yilliklardagi rivojlanish tendensiyalarini ilmiy manbalar asosida tahlil qiladi. Tadqiqotning maqsadi arpa ekinining hosildorlik dinamikasi, agrotexnologik modernizatsiya yo‘nalishlari, iqlim xavflariga moslashuv va resurs tejamkor yondashuvlar bo‘yicha umumlashgan ilmiy xulosalarni shakllantirishdan iborat. Metodologiya sifatida bibliometrik saralash, tizimli adabiyotlar tahlili, qiyosiy-agroiqtisodiy yondashuv hamda tematik kontent tahlili qo‘llanildi; ma’lumotlar xalqaro va mintaqaviy ilmiy manbalar hamda rasmiy statistik sharhlardan jamlandi. Ilmiy yangilik arpa yetishtirishda global innovatsion yo‘nalishlar va O‘zbekiston sharoitida amaliy cheklovlarning birlashtirilgan konseptual xaritasini taklif etish, shuningdek, hosildorlikni oshirishda seleksiya, suvni tejash va ekin almashinuvi omillarining nisbiy rolini integrallashgan talqinda ochib berishdan iborat. Amaliy ahamiyat sifatida ishlab chiqarish va ilmiy-tajriba tizimi uchun ustuvor tadqiqot yo‘nalishlari asoslanadi.*

Kalit so‘zlar. *arpa; hosildorlik; seleksiya; resurs tejamkor texnologiyalar; iqlim moslashuvi; sug‘orish; ekin almashinuvi.*

Аннотация. *В статье на основе научных источников анализируется мировой и узбекский опыт возделывания ячменя и тенденции его развития в последние десятилетия. Цель исследования состоит в формировании обобщенных выводов по динамике урожайности, направлениям агротехнологической модернизации, адаптации к климатическим рискам и ресурсосберегающим подходам. В качестве методологии применены библиометрический отбор, систематический анализ литературы, сравнительно-агроэкономический подход и тематический контент-анализ; данные собраны из международных и региональных научных публикаций и официальных статистических обзоров. Научная новизна заключается в предложении интегрированной концептуальной карты, связывающей глобальные инновационные направления в возделывании ячменя с практическими ограничениями в условиях Узбекистана, а также в раскрытии относительной роли селекции, водосбережения и севооборота в повышении продуктивности в единой интерпретации. Практическая значимость выражается в обосновании приоритетных направлений исследований для производства и опытно-научной системы.*

Ключевые слова. *ячмень; урожайность; селекция; ресурсосберегающие технологии; климатическая адаптация; орошение; севооборот.*

Abstract. *This article reviews scientific sources to analyze global and Uzbekistan-specific experience in barley cultivation and its development trends over recent decades. The study aims to synthesize evidence on yield dynamics, pathways of agrotechnological modernization, adaptation to climate risks, and resource-saving practices. The methodology combines bibliometric screening, systematic literature review, comparative agro-economic analysis, and thematic content analysis; evidence is drawn from international and regional scientific publications and official statistical overviews. The scientific novelty lies in proposing an integrated conceptual map that links global innovation trajectories in barley production with practical constraints under Uzbekistan conditions, and in providing an integrated interpretation of the relative contributions of breeding, water-saving technologies, and crop rotation to productivity growth. The practical relevance is reflected in identifying research and development priorities for strengthening farm-level decision making and improving the design of applied research and extension programs.*

Keywords. *barley; yield; plant breeding; resource-saving technologies; climate adaptation; irrigation; crop rotation.*

KIRISH

Arpa insoniyat dehqonchiligi tarixida eng qadimiy madaniy ekinlardan biri bo‘lib, bugungi kunda ham oziq-ovqat, yem-xashak va sanoat xomashyosi sifatida o‘z ahamiyatini saqlab kelmoqda. Jahon miqyosida arpa ekinining barqarorligi ko‘p omilli: u nisbatan qisqa vegetatsiya davriga, salqin iqlim va cheklangan nam sharoitlarida hosil bera olish qobiliyatiga ega, shuningdek, yemchilik tizimlarida muhim oqsil-energiya manbai hisoblanadi. Shu bilan birga, global iqlim o‘zgarishi sharoitida qurg‘oqchilik, issiqlik to‘lqinlari, sho‘rlanish, kasallik va zararkunandalar bosimi kuchayib, arpa hosildorligi va sifatiga qo‘yiladigan talablar keskin murakkablashmoqda. Mazkur jarayonlar ilmiy adabiyotlarda ko‘pincha seleksiya yutuqlari, agrotexnologik paketlar va xo‘jalik boshqaruvi qarorlarining uyg‘unligi doirasida izohlanadi; ya’ni, genotip, muhit va texnologiya o‘zaro ta’siri hosildorlikning asosiy determinantlari sifatida ko‘riladi [1]. O‘zbekiston sharoitida esa arpa asosan sug‘oriladigan va qisman lalmi zonalarda yetishtiriladi, u g‘alla almashinuvi tizimlarida stabilizator ekin sifatida, chorvachilikning yem bazasini mustahkamlovchi komponent sifatida ham muhim. Biroq suv resurslarining cheklanishi, tuproq sho‘rlanishi, agrotexnologik intizomdagi tafovutlar va urug‘chilik tizimidagi uzilishlar arpa potensial hosildorligini to‘liq ro‘yobga chiqarishga to‘sqinlik qilishi mumkin. Adabiyotlar tahlili shuni ko‘rsatadiki, O‘zbekistonda don ekinlari bo‘yicha ilmiy-amaliy izlanishlar mavjud bo‘lsa-da, arpa yetishtirish tajribasini jahon tendensiyalari bilan tizimli qiyoslash, ayniqsa resurs tejamkor sug‘orish, iqlim moslashuvi va bozor talabi bilan bog‘liq sifat ko‘rsatkichlari kesimida umumlashtirish yetarli darajada konsolidatsiyalashmagan [2]. Xalqaro manbalarda esa arpa bo‘yicha innovatsiyalar, jumladan, qurg‘oqchilikka chidamli navlar, aniq dehqonchilik elementlari, kasalliklarga chidamlilikni kuchaytirish va oziqlantirish tizimini optimallashtirish bo‘yicha dalillar ortib bormoqda [3]. Shuning uchun ushbu maqolada jahon va O‘zbekiston tajribasini ilmiy manbalar asosida tahlil qilib, asosiy rivojlanish tendensiyalarini konseptual jihatdan tartibga solish dolzarb ilmiy muammo sifatida qo‘yiladi. Tadqiqotning maqsadi

arpa yetishtirish bo‘yicha ilmiy manbalardan kelib chiqib, global va milliy kontekstda hosildorlikni belgilovchi omillar, texnologik yo‘nalishlar va institutsional shart-sharoitlarni qiyosiy tahlil qilish hamda O‘zbekiston uchun ustuvor ilmiy-amaliy yo‘nalishlarni asoslashdan iborat. Vazifalar quyidagilar: arpa yetishtirishda asosiy texnologik trendlarni tasniflash; hosildorlik va barqarorlikka ta’sir qiluvchi omillarni tizimlashtirish; O‘zbekiston sharoitida moslashuv mexanizmlarining ilmiy asoslarini ko‘rsatish; va manbalar dalillariga tayangan holda istiqbolli tadqiqot yo‘nalishlarini belgilash. Ilmiy yangilik manbalarni fragmentar sharhlashdan ko‘ra, seleksiya, suv boshqaruvi, ekin almashinuvi va agromenejmentni yagona tahliliy ramkada integratsiyalashga urinish bilan asoslanadi. Amaliy ahamiyat esa fermer xo‘jaliklari, urug‘chilik va maslahat xizmati hamda tajriba stansiyalari uchun ilmiy asoslangan ustuvorliklarni belgilash imkoniyati bilan izohlanadi [4].

TADQIQOT METODOLOGIYASI

Tadqiqot nazariy va analitik xarakterga ega bo‘lib, ilmiy manbalar tahlili asosida bajarildi. Ma’lumotlar bazasi sifatida xalqaro ilmiy jurnallardagi sharh va tadqiqot maqolalari, seleksiya hamda agrotexnologiya bo‘yicha monografiyalar, shuningdek, O‘zbekiston va mintaqa miqyosidagi agrar ilmiy nashrlar va uslubiy qo‘llanmalar tanlab olindi. Saralash jarayonida arpa yetishtirish, hosildorlik, qurg‘oqchilikka chidamlilik, sug‘orish samaradorligi, ekin almashinuvi, mineral oziqlantirish va kasalliklar boshqaruvi kabi tematik klasterlar bo‘yicha kalit tushunchalar qo‘llanildi. Metodologik yondashuv uch bosqichni qamrab oldi: birinchi bosqichda bibliometrik va ekspert saralash orqali mavzuga bevosita daxldor, metodik jihatdan asoslangan manbalar ajratildi; ikkinchi bosqichda tizimli adabiyotlar tahlili yordamida dalillar turkumlandi va umumiy konseptual bog‘lanishlar aniqlashtirildi; uchinchi bosqichda qiyosiy-agroiqtisodiy yondashuv asosida jahon tendensiyalari va O‘zbekiston sharoitidagi cheklovlar hamda imkoniyatlar muvofiqlashtirildi. Tematik kontent tahlili orqali har bir manbada urg‘u berilgan omillar, tavsiya etilgan texnologik yechimlar va ularning qo‘llanish shartlari kodlandi, so‘ngra takrorlanuvchi motivlar bo‘yicha sintez qilindi. Metodologik tanlovning ilmiy asosi shundaki, arpa yetishtirish tizimi ko‘p omilli bo‘lib, uni faqat agronomik yoki faqat iqtisodiy yondashuv bilan izohlash yetarli emas; manbalararo sintez genotip va texnologiya ta’sirini muhit sharoitlari bilan birgalikda ko‘rishga imkon beradi [1]. Natijalarni izohlashda hosildorlik va barqarorlik tushunchalari birgalikda qaraldi, chunki iqlim o‘zgarishi sharoitida maksimal hosil emas, balki yilma-yil barqaror natija ko‘plab xo‘jaliklar uchun hal qiluvchi mezonga aylanmoqda [5].

TAHLIL VA NATIJALAR

Manbalar tahlili arpa yetishtirishda jahon miqyosidagi asosiy rivojlanish tendensiyalarini bir necha yo‘nalishda jamlash imkonini berdi. Birinchi yo‘nalish seleksiya va genetik takomillashtirish bilan bog‘liq bo‘lib, unda qisqa vegetatsiyali, qurg‘oqchilik va issiqqa chidamli, sho‘rlanishga nisbatan tolerant, hamda asosiy kasalliklarga qarshi chidamlilikka ega navlar ulushini kengaytirish markaziy o‘rin tutadi. Xususan, manbalarda hosildorlikni oshirishning “genetik yutuq” komponenti ko‘pincha agrotexnologik yaxshilanishlar bilan birgalikda samarali ishlashi ta’kidlanadi, chunki nav potensiali oziqlantirish va nam ta’minoti bilan

moslashmaganda to‘liq ro‘yobga chiqmaydi. Ikkinchi yo‘nalish resurs tejamkor agrotexnologiyalar bo‘lib, unda minimal ishlov, qoldiqni dalada qoldirish, namni tejovchi ekish muddatlari va zichligini optimallashtirish, hamda aniq dehqonchilikka oid elementlar ko‘proq uchraydi. Uchinchi yo‘nalish sug‘orish va suv unumdorligi masalalariga taalluqli: sug‘oriladigan zonalarda suv taqchilligi kuchaygani sayin, sug‘orish me’yorini optimallashtirish, kritik fenologik bosqichlarda nam bilan ta’minlash, hamda suv hisobini yuritish kabi yondashuvlar barqaror hosildorlikning muhim sharti sifatida qayd etiladi. To‘rtinchi yo‘nalish ekin almashinuvi va tuproq unumdorligini boshqarish bo‘lib, dukkakli yoki siderat ekinlar bilan almashlash, organik modda balansini ushlab turish, azot-fosfor ta’minotini dalaning mahsuldor qatlamiga moslashtirish tendensiyasi ko‘zga tashlanadi. Beshinchi yo‘nalish sifat ko‘rsatkichlari bilan bog‘liq bo‘lib, yemlik va oziq-ovqat yo‘nalishi uchun oqsil miqdori, donning to‘lishi, hamda ayrim segmentlarda texnologik sifat parametrlari bo‘yicha differensial yondashuvlar kuchaymoqda.

O‘zbekiston bo‘yicha manbalarda arpa yetishtirishning ishlab chiqarish amaliyoti ikki asosiy konturda tasvirlanadi: sug‘oriladigan yerlarda g‘alla tizimining bir bo‘lagi sifatida barqaror yem-xashak va don olish vazifasi, hamda ayrim hududlarda lalmi sharoitda riskni diversifikatsiya qiluvchi ekin sifatidagi roli. Tahlil natijasida respublika sharoitida hosildorlikdagi tafovutlarning asosiy manbalari sifatida urug‘ sifati va nav tanlovi, ekish muddatining to‘g‘riligi, oziqlantirish me’yorlarining mosligi, suv ta’minotining uzluksizligi hamda tuproq sho‘rlanishi bilan bog‘liq cheklovlar ajralib chiqdi. Manbalarda, shuningdek, xo‘jaliklar kesimida agrotexnologik intizom farqlari, texnika va servisga kirish imkoniyati, hamda maslahat xizmati samaradorligi hosildorlikni barqarorlashtirishga ta’sir qiluvchi institutsional omillar sifatida qayd etiladi. Konseptual sintez shuni ko‘rsatdiki, O‘zbekiston uchun istiqbolli yo‘nalishlar uchlikda jamlanadi: moslashuvchan navlar va sifatli urug‘chilik zanjiri; suv va o‘g‘it resurslarini tejovchi, dalaning heterogenligini inobatga oluvchi boshqaruv; hamda ekin almashinuvi orqali tuproq unumdorligini tiklovchi tizimli yondashuv. Ushbu uchlikning har biri alohida samarali bo‘lishi mumkin, biroq manbalar dalillari ularning sinergetik qo‘llanishida hosildorlik va barqarorlikning eng yuqori natijasi kuzatilishini ko‘rsatadi.

Olingan natijalar jahon adabiyotlarida shakllangan qarashlar bilan mos keladi: arpa hosildorligi faqat bitta texnologik yechim bilan emas, balki genotip, muhit va boshqaruv integratsiyasi bilan oshadi. Xalqaro tadqiqotlar iqlim o‘zgarishi fonida issiqlik va qurg‘oqchilik stresslari tez-tez takrorlanishini, shuning uchun moslashuvchanlikni oshirishda fenologik moslashuv, ildiz tizimi arxitekturasi, suvdan foydalanish samaradorligi va kasalliklarga chidamlilikni birgalikda kuchaytirish zarurligini ko‘rsatadi [3]. O‘zbekiston sharoitida bu yondashuv, avvalo, seleksiya va urug‘chilik tizimi bilan bog‘liq masalalarni amaliy boshqaruv mexanizmlariga ulashni talab qiladi: nav tanlovi bozor talabi va agroiqlim zonasi bilan muvofiqlashtirilmaganda, hatto yaxshi agrotexnika ham kutilgan natijani bermasligi mumkin. Shu nuqtai nazardan, mahalliy manbalarda ta’kidlangan urug‘ sifati, navlarning hududiy mosligi va ekish muddatlarini optimallashtirish bo‘yicha tavsiyalar

global dalillar bilan konseptual uyg‘unlashadi, ammo ularni keng joriy etish institutsional va servis infratuzilmasiga taqaladi [2].

Resurs tejamkor texnologiyalar masalasida muhokama shuni ko‘rsatadiki, minimal ishlov yoki qoldiqni saqlash kabi yondashuvlar O‘zbekistonning barcha hududlarida bir xil natija bermasligi mumkin, chunki sho‘rlanish, og‘ir mexanik tarkib va sug‘orish rejimi farqlari texnologiya samaradorligini keskin o‘zgartiradi. Shuning uchun global amaliyotni ko‘r-ko‘rona transfer qilish emas, balki mahalliy dalaning agroximik va gidrologik xususiyatlariga mos adaptatsiya qilingan paketlarni sinovdan o‘tkazish talab etiladi. Sug‘orish samaradorligi bo‘yicha manbalarda berilgan xulosalar O‘zbekiston uchun ayniqsa kritik: suv taqchilligi kuchaygan sari arpa yetishtirishda kritik fenologik bosqichlarni nam bilan ta’minlash, sug‘orish me’yorini ilmiy asoslash va dalada suv sarfini hisobga olish hosil barqarorligining asosiy kafolatlaridan biri bo‘lib qoladi [5]. Bu yerda amaliy ahamiyat shundaki, arpa ko‘pincha “ikkinchi darajali” ekin sifatida qaralib, suv va o‘g‘it taqsimotida cheklovga uchrashi mumkin; ilmiy dalillar esa aynan resurs taqsimotidagi noaniqlik hosildorlikning asosiy yo‘qotish manbalaridan ekanini ko‘rsatadi.

Tadqiqot cheklovlari shundan iboratki, ushbu maqola tajriba maydonlarida o‘lchangan birlamchi ma’lumotlarga emas, balki mavjud manbalarga tayanadi; shu bois ayrim xulosalar hududlar kesimida differensial kalibrlashni talab etadi. Kelajakdagi izlanishlar uchun ikki yo‘nalish ustuvor ko‘rinadi: birinchisi, O‘zbekiston agroiqlim zonalari bo‘yicha arpaning hosildorlik funksiyasini suv, o‘g‘it va ekish muddatlari bilan bog‘lovchi ko‘p omilli dala tajribalari; ikkinchisi, nav tanlovi va texnologik paketlarning iqtisodiy samaradorligini risk va iqlim ssenariylari bilan birga baholaydigan integrallashgan modellashtirish ishlari [4]. Shu bilan birga, maslahat xizmati va urug‘chilik tizimining samaradorligini oshirish bo‘yicha institutsional tadqiqotlar ham agronomik natijalarni ishlab chiqarishga ko‘chirishda muhim bo‘lib qoladi.

XULOSA

Ilmiy manbalar tahlili arpa yetishtirishda jahon tendensiyalari seleksiya yutuqlari, resurs tejamkor agrotexnologiyalar, suv boshqaruvi, ekin almashinuvi va sifat ko‘rsatkichlariga yo‘naltirilgan differensial yondashuvlar atrofida jamlanishini ko‘rsatdi. O‘zbekiston sharoitida arpa yetishtirishning barqarorligi va hosildorligini oshirish urug‘ sifati va hududiy mos nav tanlovi, sug‘orish hamda oziqlantirishni ilmiy asosda optimallashtirish, tuproq sho‘rlanishi va unumdorligini tizimli boshqarish bilan eng kuchli bog‘langan. Sinergetik yondashuv, ya’ni nav, texnologiya va boshqaruv qarorlarini yagona paket sifatida joriy etish, alohida tadbirlarning fragmentar qo‘llanishiga nisbatan ustun natija berishi asosiy umumiy xulosa sifatida shakllandi. Mazkur sintez O‘zbekiston uchun amaliy ustuvorliklarni belgilashda, xususan, adaptiv navlar va urug‘chilik zanjiri, suvni tejashga yo‘naltirilgan boshqaruv hamda ekin almashinuvi orqali tuproq salomatligini tiklash yo‘nalishlarida ilmiy-tajriba ishlari va maslahat xizmatini muvofiqlashtirish zarurligini tasdiqlaydi.

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THE ROLE OF CHICKPEA GENETICS IN IMPROVING YIELD RESILIENCE UNDER ABIOTIC AND BIOTIC STRESS CONDITIONS.

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Abstract. *Chickpea (Cicer arietinum L.) is one of the world's most important grain legumes, contributing significantly to food security, soil fertility, and sustainable agricultural production. However, its productivity is severely affected by abiotic stresses such as drought, heat, and salinity, as well as biotic stresses including Ascochyta blight. This review aims to examine recent advances in chickpea genetics and breeding strategies for improving yield resilience under adverse environmental conditions, with particular emphasis on their relevance to Uzbekistan. The study was conducted using a comprehensive review of scientific literature published between 2014 and 2025. Recent findings indicate that conventional breeding, marker-assisted selection, genomic technologies, and CRISPR/Cas9 gene editing have substantially enhanced the development of stress-tolerant chickpea varieties. These approaches improve drought tolerance, disease resistance, and adaptation to multiple environmental stresses while supporting sustainable agricultural production. The review concludes that integrating modern genetic technologies with appropriate agronomic management can significantly improve chickpea productivity and resilience. Continued research, investment in breeding programs, and the responsible application of advanced biotechnology are essential for ensuring long-term food security and climate-resilient agriculture in Uzbekistan.*

Keywords: *Chickpea, Cicer arietinum, genetics, plant breeding, drought tolerance, disease resistance, CRISPR/Cas9, yield resilience, climate change, Uzbekistan.*

Annotatsiya. *No'xat (Cicer arietinum L.) dunyodagi eng muhim dukkakli ekinlardan biri bo'lib, oziq-ovqat xavfsizligi, tuproq unumdorligini saqlash hamda barqaror qishloq xo'jaligini rivojlantirishda muhim o'rin tutadi. Biroq uning hosildorligi qurg'oqchilik, yuqori harorat va sho'rlanish kabi abiotik omillar hamda askoxitoz kasalligi kabi biotik omillar ta'sirida sezilarli darajada kamayadi. Mazkur maqolaning maqsadi no'xatning hosildorlik barqarorligini oshirishda genetika va seleksiya sohasidagi zamonaviy yutuqlarni tahlil qilish hamda ularning O'zbekiston sharoitidagi ahamiyatini baholashdan iborat. Tadqiqot 2014–2025-yillarda chop etilgan ilmiy adabiyotlarni tizimli tahlil qilish asosida amalga oshirildi. Tahlil*

natijalari shuni ko'rsatdiki, an'anaviy seleksiya, markerlarga asoslangan seleksiya, genom texnologiyalari va CRISPR/Cas9 gen tahrirlash usullari stress omillariga chidamli no'xat navlarini yaratishda muhim natijalar bermoqda. Ushbu yondashuvlar qurg'oqchilikka chidamlilikni, kasalliklarga qarshilikni va turli noqulay ekologik sharoitlarga moslashuvchanlikni oshirish orqali barqaror hosildorlikni ta'minlashga xizmat qiladi. Xulosa qilib aytganda, zamonaviy genetik texnologiyalarni samarali agrotexnik tadbirlar bilan uyg'unlashtirish no'xat yetishtirish samaradorligini sezilarli darajada oshirishi mumkin. Shuningdek, seleksiya dasturlarini rivojlantirish, ilmiy tadqiqotlarni qo'llab-quvvatlash va ilg'or biotexnologiyalarni mas'uliyat bilan joriy etish O'zbekistonda oziq-ovqat xavfsizligini mustahkamlash hamda iqlim o'zgarishiga moslashgan qishloq xo'jaligini rivojlantirish uchun muhim ahamiyat kasb etadi.

Kalit so'zlar: *No'xat, Cicer arietinum, genetika, seleksiya, qurg'oqchilikka chidamlilik, kasalliklarga chidamlilik, CRISPR/Cas9, hosildorlik barqarorligi, iqlim o'zgarishi, O'zbekiston.*

Аннотация. *Нут (Cicer arietinum L.) является одной из важнейших зернобобовых культур в мире, играющей значительную роль в обеспечении продовольственной безопасности, повышении плодородия почв и развитии устойчивого сельского хозяйства. Однако его урожайность существенно снижается под воздействием абиотических факторов, таких как засуха, высокая температура и засоление почв, а также биотических факторов, включая аскохитоз. Цель настоящей статьи заключается в анализе современных достижений генетики и селекции нута, направленных на повышение устойчивости урожайности к неблагоприятным условиям окружающей среды, а также в оценке их значения для сельского хозяйства Узбекистана. Исследование выполнено на основе систематического анализа научных публикаций, опубликованных в период с 2014 по 2025 год. Результаты обзора показывают, что традиционная селекция, маркер-ассоциированная селекция, геномные технологии и редактирование генома с использованием системы CRISPR/Cas9 значительно расширили возможности создания сортов нута, устойчивых к различным стрессовым факторам. Эти подходы способствуют повышению засухоустойчивости, устойчивости к болезням и адаптации растений к неблагоприятным условиям окружающей среды, обеспечивая более стабильную урожайность. Сделан вывод о том, что интеграция современных генетических технологий с эффективными агротехническими мероприятиями способна существенно повысить продуктивность нута. Дальнейшее развитие селекционных программ, поддержка научных исследований и ответственное внедрение современных биотехнологий являются важными условиями обеспечения продовольственной безопасности и развития климатически устойчивого сельского хозяйства в Узбекистане.*

Ключевые слова: *нут, Cicer arietinum, генетика, селекция, засухоустойчивость, устойчивость к болезням, CRISPR/Cas9, устойчивость урожайности, изменение климата, Узбекистан.*

INTRODUCTION

Chickpea (Cicer arietinum L.) is among the most significant grain legumes in the world and it is increasingly becoming valuable to dryland agricultural systems in the Central Asia including Uzbekistan. Being a source of high-protein crop, an ideal source of dietary fiber and micronutrients, chickpea has a direct role in food and nutritional security. Chickpea also becomes important in crop rotation in farming systems because it contains the capacity to fix nitrogen in the atmosphere and thus enhance soil fertility and save the application of synthetic nitrogen fertilizers (Calia et al., 2024). The growth of grain legumes, including chickpea, has been seen as a promising avenue to the production diversification, a promotion of soil health, and environmental benefits of intensive monocropping systems to Uzbekistan.

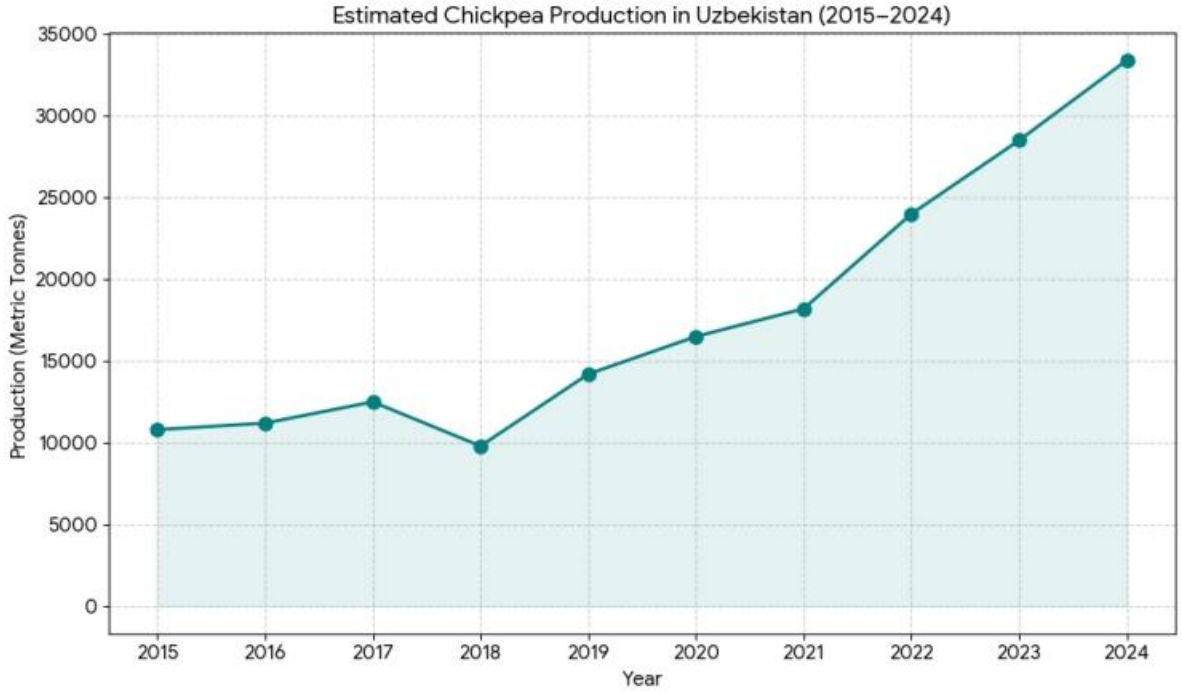

Figure 1 chickpea production in Uzbekistan

Retreated from: National Statistics Agency of Uzbekistan

Although chickpea has agronomic and nutritional advantages, several abiotic and biotic stresses limit its production. Drought is commonly known as the most pressing negative constraint, because the crop is commonly cultivated on left-over soil moisture and very little or no irrigation applied to it, subjecting it to terminal water shortage during flower formation and grain filling. Salinity in the soil and heat also lead to stability of yield in most environments and large-scale diseases like Ascochyta blight (Ascochyta rabiei) and other foliar and root pathogens may result in devastating losses in vulnerable genotypes. Such limitations are worrying especially in times of climate change that is expected to increase drought and heat spells in semi-arid areas.

The objective of the report thus is to provide viable growing guidelines to chickpea depending on agro-textures of ecological situations in Uzbekistan; to address the role of the modern genetic and генеформaed technologies that have been employed in improving chickpea; and to comment on the ethical challenges and issues surrounding

the application of contemporary genetic and gene form technologies in chickpea enhancement.

LITERATURE REVIEW

Drought stress has been identified as the main production issue with chickpea that perennial reduces its production in rainfed, as well as drylands. As demonstrated by several studies, terminal drought is common when chickpea is in flowering and grain filling phase and it has made significant decreases to yield in both desi and kabuli varieties. Genetic studies have revealed that the physiological characteristics that regulate drought resilience in chickpea include a deep root system, osmotic prognosis, and high water efficiency (Varshney et al., 2014). Genotype screening studies also substantiate the fact that the genotypes vary widely in terms of tolerance to moisture stress with some genotypes performing better relative to others according to the drought selection indices (Farshadfar and Javadinia, 2011). These findings point at the necessity of implementing drought resistant genotypes in production systems.

Figure 2. Difference of desi and kabuli verities

Retrieved from: https://share.google/lRWciC2WNxnzqgBMy

In addition to drought, there are also other signs that indicate that chickpea is subjected to cross genus stresses that are caused by heat and salinity, and these still aggravate crop losses in arid zones. Multi-stress response studies reveal that certain genotypes of chickpea have the ability to manifest drought, heat, and salinity tolerance simultaneously (Pushpavalli et al., 2020). Nevertheless, the other research establishes that chickpea itself is susceptible to soil salinity and large penalties of yields have been identified even at an intermediate level of salt concentration (Flowers et al., 2010). This difference between genotypes can be used to promote the fact that varieties that are resilient and adapted to respective environmental limitations need to be selected and subsequently rolled out.

Regarding disease pressures, the findings indicate that Ascochyta blight continues to be among the most destructive biotic stresses in the production of chickpeas. Recent research states that genetic resistance is accessible but differs across lines, and that breeding has to persist to keep up with the evolution of pathogens (Sharma & Ghosh, 2016). Disease resistance breeding is demonstrating significant

advancements using both traditional and molecular methods, with overall consistency in field performance that continues to differ (Li et al., 2015; Choudhary et al., 2023). Multiple genotypes resistant to Ascochyta rabiei are also identified as a result of screening of different germplasm, further indicating the importance of purposeful breeding (Du et al., 2012).

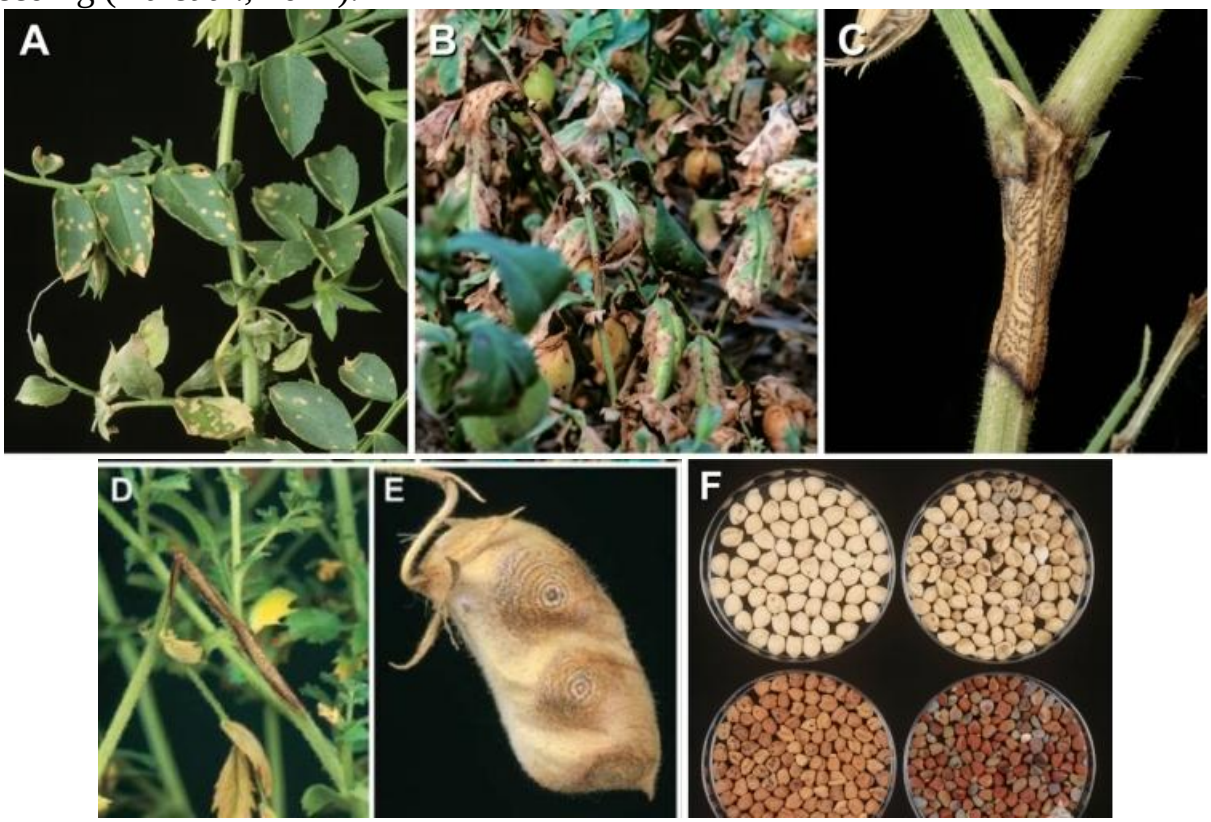

Figure 3. *Fig. 1. Symptoms of ascochyta blight [Ascochyta rabiei] in chickpea. (A) Small lesions on foliage. (B) Severe foliar symptoms. (C) Stem lesion with pycnidia. (D) Stem breakage due to girdling. (E) Lesions with concentric rings of pycnidia on pods. (F) Healthy and infested seeds (left and right panels, respectively); kabuli and desi types (top and bottom panels, respectively).*
Retrieved from: https://share.google/3pn3XOl8elZ589dyY

The collective outcomes of these studies suggest that genetic enhancement is the most promising long-lasting remedy to the augmentation of the resiliency of yield in chickpea. Responses of breeding programs have increased the genetics of chickpea by enhancing the resistance to droughts and diseases in the desi and kabuli lineages (Thudi et al., 2016). Genomics and studies have developed research that attests that a significant pool of genetic resources can be tapped to improve future products, and this provides an opportunity to combat existing and future production challenges (Shahnaz et al., 2025). Moreover, the recent studies on gene editing, such as CRISPR Jacques Cas9 use on stress tolerance and virus resistance, propose some innovative means of developing durable varieties quickly (Razzaq et al., 2022; Malik et al., 2023; Singh et al., 2023).

RESEARCH METHODOLOGY

This study employed a qualitative literature review methodology to examine recent developments in chickpea genetics and their role in improving yield resilience under biotic and abiotic stress conditions. Relevant scientific publications were

collected from internationally recognized databases, including Google Scholar, Scopus, Web of Science, SpringerLink, and ScienceDirect. The review primarily focused on peer-reviewed journal articles published between 2014 and 2025, while a limited number of earlier studies were included because of their significant contributions to chickpea genetics and breeding research.

The selected literature addressed key topics such as drought tolerance, heat and salinity resistance, disease resistance, conventional breeding, molecular breeding, quantitative trait loci (QTL), genomic selection, and CRISPR/Cas9 gene-editing technologies. After screening the literature for relevance and scientific quality, the findings were analyzed using comparative and descriptive methods. Similarities and differences among research findings were identified, and recent advances in breeding technologies were evaluated to determine their potential contribution to sustainable chickpea production, particularly under the environmental conditions of Uzbekistan.

ANALYSIS AND RESULTS

It has been revealed through genetic research on chickpea that resilience to stress in terms of yields is closely intertwined with definite physiological and morphological characters under quantitative genetic regulation. Varshney et al. (2014) had to slice up drought tolerance in a large multi-environment analysis based on phenotypic data of many drought hexa positional traits and genetic mapping on multiple populations, finding a number of clusters of quantitative trait loci (QTL). A key QTL cluster on the linkage group CaLG04 was demonstrated with having a significant breeding potential to improve drought tolerance in breeding programs in explaining a large percentage of the variation in key drought determinative phenotypes. These results suggest that resilience does not depend on any one factor but rather the concerted action of many loci that regulate features of root architecture, water decisiveness efficiency, and phenology.

This genetic viewpoint is supported by screening various genotypes of chickpea in a water limited environment. Farshadfar and Javadinia (2011) considered genotypes in terms of drought tolerance based on selection indices as a combination of yield and stress responses and found that there was wide genetic variation in genotype tolerance. Genotypes that retain higher yields during drought stress generally have a combination of good qualities observed through QTL studies implying that marker weakens chosen through markers like those described by Varshney et al. (2014) have the ability to hasten the creation of resilient cultivars. These findings combined demonstrate that genetic enhancement is a direct proportional increase in more stable yields in situations where drought is the primary limitation.

In addition to drought itself, resilience in fields of farmers should integrate exposure to heat and salinity. Pushpavalli et al. (2020) discussed cross intolerance in chickpea and demonstrated that some genotypes are able to respond to drought, heat, and salinity stresses in double or triple, instead of single. Such a notion of cross-tolerance is essential as it is the condition in the real field that co-exists multiple stresses. Complementary on this, Flowers et al. (2010) concentrated on the aspect of salt sensitivity in chickpea, and established that the crop is naturally sensitive to salinity, and its yield significantly drops under salty conditions. The resulting evidence suggests

that, to provide true yield resilience in marginal environments, breeding programs need to target multi stress tolerance, rather than single trait drought resistance.

Another significant factor in instability in chickpea yield is Biotic stresses, especially the Ascochyta blight. Progress in identification and deployment of genetic resistance to Ascochyta blight was summarized by Sharma and Ghosh (2016) and demonstrates the existence of resistant lines but requires continued breeding due to the variability of the pathogen. Choudhary et al. (2023) described the traditional and molecular breeding approaches to artificially inducing resistance to diseases in chickpea with emphasis on integration of cross-source resistance genes of chickpea using marker subsection assisted breeding. Similarly, Li et al. (2015) also examined breeding to resist biotic stress and the significance of having a combination of resistance to various pathogens and pests. Du et al. (2012) gave particular evidence of the genotypes that were found to resist Ascochyta rabiei and it is an example of how germplasm screening is involved in the process of identifying strong parental lines. These initiatives will decrease the losses caused by disease in the harvest and increase the gains directly related to more dependable production by accumulating resistance alleles and expanding the resistance base.

Genome engineering and gene editing gives further means of enhancing yield resilience. The use of CRISPR-Cas9 to enhance abiotic stress tolerance in chickpea was reported by Razzaq et al. (2022), as one of the reasons is that genome editing is considered a new hope in reducing development time associated with the creation of lines with tolerance to stressors. In CRISPR/Cas9 Gene editing, Malik et al. (2023) provided evidence of the possibility of producing resistance to the chlorotic dwarf virus of chickpea and how disease limitations can be narrowed through precise editing. Singh et al. (2023) assessed the wider applicability of genomics and gene editing to enable chickpea to cope with climate change and feed the population of the world. Though not yet conclusively implemented in agricultural fields, many of these applications still show a very clear roadmap by which specific genetic modifications could result in the enhancement of stress tolerance and, by extension, provide a state of resilience.

CONCLUSION

There are various key constraints influencing the production of chickpea, especially drought, heat, and salinity, as well as diseases like Ascochyta blight. Such stresses always help to lower yield and restrict the performance of crop in a dry land area particularly in the regions such as Uzbekistan where environmental conditions may be quite fluctuating.

The development in breeding and genetics have offered apparent prospects to improve breed tolerance of chickpea to major stresses. Drought resilience, multi-stress tolerance, and disease resistance have been demonstrated to provide a variety beneficial in stabilization of yields under the most adverse conditions. Genetic improvements should be effectively supported by proper agronomic management at production level. Better knowledge of the optimum sowing time, better water and nutrient control, sustainable soil management, and combined pest and disease management contributes to ensuring that benefits of improved cultivars may be fully achieved in the fields of Uzbek farmers.

Based on the reviewed literature, several recommendations can be proposed to improve chickpea production and strengthen yield resilience in Uzbekistan. Expand national chickpea breeding programs by incorporating modern molecular breeding techniques and marker-assisted selection to accelerate the development of stress-tolerant cultivars. Increase investment in research on drought, heat, salinity, and disease resistance to address the growing impacts of climate change on agricultural production. Strengthen collaboration among universities, research institutes, and agricultural extension services to facilitate the transfer of improved technologies to farmers. Evaluate newly developed chickpea genotypes under different agroecological conditions in Uzbekistan to identify varieties with superior adaptability and stable yield performance. Support responsible research and regulatory frameworks for emerging genome-editing technologies, including CRISPR/Cas9, while ensuring transparency, biosafety, and public awareness. Encourage farmers to integrate improved chickpea varieties with sustainable agronomic practices, including appropriate sowing dates, efficient irrigation, soil fertility management, and integrated pest management, to maximize productivity and long-term sustainability.

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ЎРИК ЕТИШТИРИШДА ҲОСИЛДОРЛИКНИ ОШИРИШ ТАДБИРЛАРИ

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Аннотация: *Мақолада ўрик дарахтларининг маҳаллий ва четдан келтирилган навларини ўрганиш ва истиқболли бўлган навларни танлаш учун олиб борилган тадқиқот кузатувлари ҳамда йиллик новдалари кесилган дарахтларда шох-шаббанинг тўғри шаклланиши ҳамда ташқи муҳит омиллари билан бевосита боғлиқ бўлиб, буларга ҳарорат, ёруғлик, сув, ҳаво, тупроқ каби ташқи омилларнинг ҳам ижобий таъсири натижасида мевалар сифатининг ошиши, ташқи муҳит омилларига мослашувчанлиги ва бошқа хусусиятлари келтирилган*

Калитли сўзлар*: новда, сифатли, куртак, гул, мева, ҳосил, боғ, маҳаллий, четдан, ташқи омиллар, танлаш.*

Аннотация: *статья непосредственно связана с изучением отечественных и зарубежных сортов абрикосовых деревьев и подбором сортов, которые являются перспективными, а также правильным формированием граба на деревьях с ежегодным черенкованием ветвей, а также с внешними факторами окружающей среды, к которым относятся повышение качества плодов, адаптивность к внешним факторам окружающей среды, в результате.*

Ключевые слова: *стержень, качество, бутон, цветок, плод, культура, сад, местные, зарубежные, внешние факторы, селекция.*

Absrtact: *The article is directly related to the study of domestic and foreign varieties of apricot trees and the selection of varieties that are promising, as well as the correct formation of hornbeam on trees with annual cuttings of branches, as well as external environmental factors, which include improved fruit quality, adaptability to external environmental factors, as a result.*

Keywords: *core, quality, bud, flower, fruit, culture, garden, local, foreign, external factors, breeding.*

КИРИШ

Ўрик данак мевалилар орасида асосий меваларидан бири ҳисобланади. Асосан Фарғона ва Зарафшон водийсида кўп тарқалган. Меваси янгилигича,

қоқи қилиб ва қайта ишланган ҳолда истеъмол қилинади. Ўрикнинг янги пишган меваси таркибида 8,4-19,0% қанд моддаси; 0,3-1,7% турли (асосан ўрик, лимон ва жуда оз миқдорда салицил ва вино) кислоталар; 0,1-1,6% пектин, ҳамда А ва С витаминлар бор. Туршагида 80% ва ундан ҳам кўпроқ қанд моддаси бўлади. Ўрта Осиё ҳудудларида ўсадиган кўпчилик ўрик навларининг мағзи ширин бўлиб, бодом мағзи каби истеъмол қилинади. Таркибида 45-58% мой ва 28% га яқин оқсил бўлади. Аччиқ мағзидан амигдалин моддаси, техник ва озиқ-овқатга ишлатиладиган мой олинади [1].

Олимларнинг таъкидлаганидек ўсимликларнинг морфо-физиологик хусусиятларини ўрганишда кўп йиллик тажрибалар натижасида дарахтларнинг биологик цикли давомида кузатиладиган ҳосилдорлик, қишга чидамлилик ҳамда экологик иқлим-шароитларнинг мослигига боғлиқ бўлиши кузатилган [2, 3, 4]. Ривожланиш даврида генератив куртакларнинг қишга чидамлилик хусусиятини ўзлаштириши маълум бўлган. Шу сабабли кеч гуллайдиган навларнинг мослашувчанлиги кўпроқ қишга чидамли навларга хос хусусият бўлиб, тиним давридан чиқиши учун кераклича юқори ҳарорат талаб етилиши аниқланган. Чидамлилиги турлича бўлган ўрик навларида гул куртакларининг биалогик ривожланишини кузатган. Т.М.Саввина ва А.М.Шалаховларнинг ёзишича гул куртакларининг совуққа чидамлилиги кўпроқ навларнинг тиним даврига боғлиқ деган хулосага ҳам келишган. Бу ҳолатда ушбу давр қанча кўп давом этса ва қанча кеч тугаса навларнинг қишга чидамлилиги шунча юқори бўлган [5, 6].

Бошқа олимларнинг маълумотларига қараганда қишда генератив куртакларнинг ривожланишида маълум бир ўзгаришлар кузатилган. Анотомик-морфологик ўзгаришларнинг натижаси куртакларда 83% ни ташкил қилган. Шу сабабли тиним давридан кейин куртакларнинг жадал ривожланишининг сақланиб қолган хусусиятлари билан боғлиқ эканлиги кузатилган [7].

Қишга чидамлилик даражаси бўйича олиб борилган тадқиқот натижаларига кўра баҳорда ривожланиши билан тиним даврининг нисбий боғлиқлиги аниқланган. Бунга боғлиқ ҳолда ўрик навларининг атроф муҳитга мослашувчанлигини ошириш учун селекция натижаларидан фойдаланиш муҳим. Кўп ҳолларда куртакларнинг мослашувчанлиги тиним давридан кейин ошган [8].

ТАДҚИҚОТ МЕТОДОЛОГИЯСИ

Сўнгги йилларда кўплаб боғдорчилик соҳасидаги ҳамда хорижий илмий-тадқиқот муассасалари ва маҳаллий селекционерлар томонидан фойдали сифатлар комплексига эга бўлган кўплаб ўрик навлари яратилган. Республикамизда бу борада ҳали етарлича илмий-тадқиқот ишлари олиб борилмаган. Шундан келиб чиқиб, ўрикнинг янги навлари, уларни ҳар томонлама агробиологик ва технологик баҳолаш, шунингдек, маҳаллий ва четдан келтирилган ўрик навларида дарахтларни тартибли буташ ва шакл бериш усуллари орқали самарали меъёрларни ишлаб чиқиш, йиллик ўсувчи новдаларни ўрик навларига мос параметрларда кесиш ва уларга мос шакл бериш усулини қўллаш мақсадга мувофиқ.

Вужудга келган муаммоларни ҳал этишда ва ўрикзорларни ҳамда уларнинг ҳосилдорлигини янада кўпайтиришда энг аввало ҳар бир ҳудуд учун иқлим

шароитга мос навларни танлаш, шунингдек уларнинг ҳосилдорлигини оширишга қаратилган самарали агротехник тадбирларни ишлаб чиқиш зарур.
Ўрик навларининг аксариятида асосан қиш-баҳор мавсумида гул куртакларининг ва ҳосил бўлган меваларнинг эрта баҳорги совуқлар таъсирида зарарланиши кузатилади. Шу сабабли бундай шароитларда навларнинг биологик хусусиятларини ҳисобга олган ҳолда навларни танлаш, кузатилган ва аниқланган маълумотлар асосида агротехник тадбирларни ўз муддатида мақбул вариантларда қўллаш орқали мунтаззам мева етиштиришга эришиш мумкин.

ТАДҚИҚОТ НАТИЖАЛАРИ

Ўрик мевали дарахтларни етиштиришда ҳар бир навнинг биологик талаблари ва хўжалик-технологик хусусиятлари асосан маданийлаштирилаётган ҳудуднинг табиий тупроқ-иқлим шароитларига мос келиши асосий омиллардан бири ҳисобланади. Ўрик навларида йиллик биологик фазаларини ўрганишда тадқиқотлар давомида ташқи муҳит шароитларига боғлиқ ҳолда фенологик кузатувлар усулидан фойдаланилди. Тажрибада ўрганилган маҳаллий ва интродукция қилинган ўрик навлари дарахтларида фенологик фазаларнинг ўтиш муддатларини кузатиш улар ўртасида маълум тафовутни аниқлаш имконини беради.

Ушбу ўрик навларида куртакларнинг бўртиши Субхоны (st) навида 4/III бўлиб, унга нисбатан Моника Бланка нави – 8 кун (24/II), Шалах нави – 5 кун (27/II) ва Исфарак нави – 4 кун (28/II) илгари кузатилган бўлса, аксинча, Калони Кандак нави эса – 1 кун (5/III) кейин куртаклари бўртганлиги қайд қилинди. Қолган ўрик навлари стандарт нави билан бир хил (4/III) санасида куртаклар бўртганлиги аниқланди.

Ўрганилаётган ўрик навларида ғунчалаш фазаси энг эрта Моника Бланка навида (28/II) дан бошланиб, ушбу фаза Субхоны (st) навида 8 кун кеч (8/III) бошланганлиги аниқланди. Субхоны (st) навига нисбатан Исфарак навида – 5 кун (3/III), Шалах ва Юбилейный Навои навларида – 3 кун (6/III), Наджими ва Исфарак Бадамский навларида – 1 кун (7/III) олдин шаклланган бўлса, Калони Кандак навида – 1 кун (9/III) кейин ғунчалаганлиги кузатилди.

Ўрикнинг Субхоны (st) навида гуллашнинг бошланишидан тугашигача бўлган муддат давомийлиги – 11 кун (10/III–21/III) бўлган бўлса, унга нисбатан Моника Бланка навида – 9 кун (4/III–13/III), Шалах ва Юбилейный Навои навларида – 10 кунни (8/III–18/III) ташкил қилди. Аксинча, бошқа навларда ушбу фаза давомийлиги Субхоны (st) навига нисбатан 2-3 кунга кечроқ бўлганлиги аниқланди.

Ўрикнинг Моника Бланка (24/II – 1/IV), Шалах (27/II – 2/IV) ва Исфарак (28/II – 5/IV) навларида куртак бўртишидан то тўлиқ барг чиқаришигача – 34-36 кун ҳамда уларнинг шаклланиши учун юқори фойдали ҳарорат йиғиндисини (+581,3°C) талаб қилган бўлса, аксинча камроқ фойдали ҳарорат йиғиндисида (+499,0°C) Субхоны (st), Субхоны Заря, Субхоны Гигант, Наджими, Исфарак Бадамский, Калони Кандак ва Юбилейный Навои навларида куртак бўртишидан то тўлиқ барг чиқаришигача – 30-32 кунни ташкил қилди.

Ўрик навлари мевасининг Субхоны (st) навига (13/VI) нисбатан эрта

пишиш Наджими навида (25/V) 19 кун бўлиб, қолган навларда эса ушбу фазадаги фарқ 4-11 кунни ташкил қилди. Бунда, гуллашдан то мевани пишишигача фойдали ҳарорат йиғиндиси Наджими навида +1579,7°С ни ташкил қилган бўлса, қолган навларда +1846,0°С фойдали ҳарорат йиғиндисида мевалари пишганлиги аниқланди.

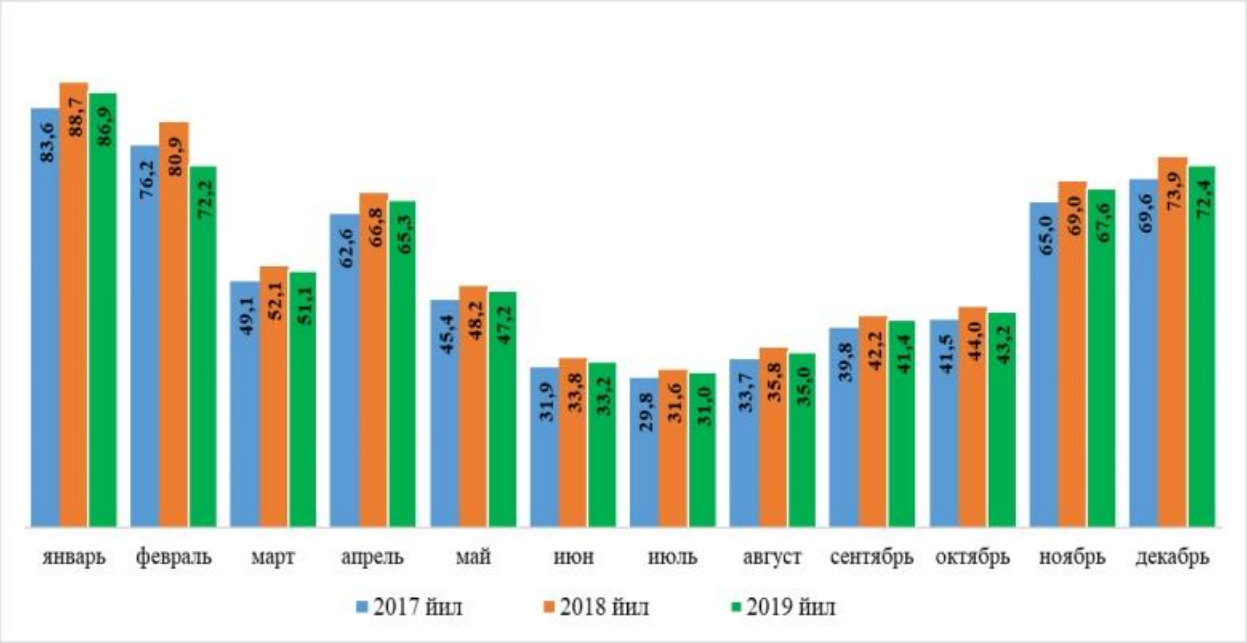
Ўрганилаётган ўрик навларида баргларнинг энг эрта сарғайиши Субхоны (st) навида (24/IX) кузатилиб, стандартга нисбатан Юбилейный Навои нави – 4 кун (28/IX) ҳамда бошқа навларда (1/X – 19/X) эса баргларни сарғайиши 8–26 кунгача кеч бошланганлиги аниқланди.

Ҳазонрезгилик стандарт Субхоны (st) навига (7/X) нисбатан энг эрта (25 %) бошланиши 10-11 кун Моника Бланка ва Шалах навларида (27/IX ва 28/IX) бўлган бўлса, аксинча 7-12 кун кеч ҳазонрезгиликни бошланиши (25 %) Исфарак Бадамский (14/X) ва Субхоны Гигант (19/X) навларда бўлганлиги аниқланди.

Ўрикнинг Субхоны (st) навида (5/IV – 21/XI) тўлиқ барг чиқаришидан то ҳазонрезгиликни тугашигача – 230 кунни ташкил қилган бўлса, унга нисбатан Субхоны Заря (2/IV – 15/XI) нави – 13 кун (227 кун), Юбилейный Навои (4/IV – 17/XI) ва Наджими (5/IV – 17/XI) навларида – 4-5 кун (226 кун) илгари тугаганлиги аниқланди. Аксинча, ҳазонрезгиликни тугаши Субхоны (st) навига нисбатан Моника Бланка (1/IV – 4/XII) навида 13 кунга кеч (243 кун) бўлганлиги аниқланди.

Ўрганилган ўрик навларининг куртак бўртишидан то ҳазонрезгиликни тугашигача бўлган вегетация даври Субхоны (st) навида – 245 кунни ташкил қилди. Калони Кандак навида вегетация даври (241 кун) бўлиб, Субхоны (st) навига нисбатан 4 кунга эрта, аксинча Субхоны Заря ва Наджими навларида – 3 кунга (248 кун), Юбилейный Навои навида – 4 кунга (249 кун), Исфарак навида – 7 кунга (252 кун), Шалах ва Исфарак Бадамский навларида – 9 кунга (254 кун), Субхоны Гигант навида – 10 кунга (255 кун) ҳамда Моника Бланка навида – 17 кунгача (262 кун) вегетация даври узун бўлганлиги аниқланди.

Олиб борилган тадқиқотларда ўрик навларида куртак бўртишидан то ҳазонрезгиликни тугашигача йиллик вегетация даври Субхоны (st), Субхоны Заря, Субхоны Гигант, Наджими ва Юбилейный Навои навларида – 5555,3°С, Исфарак Бадамский ва Калони Кандак навларида – 5619,0°С, Шалах ва Исфарак навларида – 5701,3°С ҳамда Моника Бланка навида – 5761,6°С фойдали ҳарорат йиғиндисида тиним даврига ўтганлиги аниқланди.



1-расм. Ҳавонинг нисбий намлиги %

Демак, март, апрель ва май ойларида ҳаво ҳарорати илиқ бўлиб, апрелда ўртача 16,9°С, майда 24,2°С даражани ташкил этди. Ёғингарчилик мартда 31,0 мм, апрелда 34,9 мм, майда 19,6 мм, жами уч ойда ўртача 77,4 мм ни ташкил этди. Ҳавонинг нисбий намлиги ўртача мартда 50,8 %, апрельда 64,9 %, майда 46,9 % бўлди.Ёзнинг уч ойи иссиқ бўлиб, ёғингарчилик кам бўлди. Май, июн, июль ойларида ҳавонинг нисбий намлиги ўртача 43 % бўлиб, ўртача ҳаво ҳарорати 28,6°С ни ташкил этди. Июл ойида ҳаво ҳарорати юқори бўлиб,12июлдан 20 июлгача ҳаво ҳарорати 41-42,5°С гача тупроқда 41°С даражагача кўтарилди.

Август ойида ҳавонинг ўртача ҳарорати 26,6°С ташкил қилган бўлса, ойнинг биринчи ўн кунлигида максимал даража 41,5°С ни, тупроқда 40,5°С ни ташкил этди. Бу кўп йиллик ҳаво ҳароратининг кўрсатгичидан 4-5°С кам демакдир. Сентябр кузнинг биринчи ойида ҳавонинг нисбий намлиги ўртача 41,1%, ўртача ҳаво ҳарорати 21,1°С, максимал 39°С, минимал 25,5°С ни ташкил қилди. 30 сентябр куни кучли чанг ва тўзон бўлиб, ҳаво ҳарорати +38°С дан +10°С пасайиб кетди.

Бунда қиёсий ток баргларининг 30-40% совуқдан зарарланганга ўхшаб бужмайиб қолди. Ўрик барглари тўқ яшил рангдан оч яшил рангга кира бошлади. Ўрик дарахтининг ўрта ярусининг баргларининг ранги ўзгара бошлаганлиги кузатилди. Коллекцион боғлардаги дарахтларнинг уйғониши учун ҳавонинг ўртача суткалик ҳарорат 16,6°С ни ташкил этди. Энг паст ҳаво ҳарорати ноябр-феврал ойларида бўлиб, ўртача кунлик ҳаво ҳарорати 6,3°С ни ташкил этди. Ўртача суткалик ҳаво ҳарорати март ойининг 3-декадасидан бошлаб кўтарилиб борди. Энг юқори ўртача суткалик ҳаво ҳарорати 29-31°С кузатилди.

Тадқиқотлар давомида олинган кўрсаткичларга кўра, ўрганилган ўрик навларининг 8-10 ёшли Субхоны (st) навида шох-шабба ҳажми – 69,7 $м^3$ ни ташкил қилган бўлса, унга нисбатан 8,1 $м^3$ га кенг шох-шабба ҳажми Исфарак Бадамский (77,8 $м^3$) ҳамда энг кичик шох-шабба ҳажмини Субхоны Заря (12,8 $м^3$), Юбилейный Навои (34,2 $м^3$), Калони Кандак (43,0 $м^3$) ва Наджими (44,6 $м^3$)

навларида намоён бўлганлиги аниқланди. Шунингдек, Субхоны (st) навига нисбатан 15,5-0,8 м^3 кичик Моника Бланка (54,2 м^3), Субхоны Гигант (57,1 м^3), Исфарак (59,0 м^3) ва Шалах (68,9 м^3) навларида аниқланди (1-жадвал).

1-жадвал

Маҳаллий ва интродукция қилинган ўрик навларида шох-шабба ҳажмининг шаклланиши

Навлар номи	Шох-шабба баландлиги, см	Шох-шабба кенглиги, см		Шох-шабба проекцияси, м^2	Шох-шабба ҳажми, м^3
		қаторда	қатор оралиғида		
Субхоны (st)	414,7±8,5	357,0±6,5	459,7±7,7	16,6 ±0,28	69,7 ±1,13
Моника Бланка	431,9±8,0	333,0±6,8	366,7±6,0	12,4 ±0,20	54,2 ±0,97
Шалах	402,9±8,2	403,7±8,2	423,0±7,9	17,0 ±0,26	68,9 ±1,13
Исфарак	449,9±9,2	304,7±6,2	415,7±8,2	12,9 ±0,25	59,0 ±1,18
Субхоны Заря	213,4±4,4	235,0±4,8	249,4±5,1	5,9 ±0,12	12,8 ±0,25
Субхоны Гигант	449,8±9,2	350,3±7,1	353,4±7,0	12,5 ±0,26	57,1 ±0,89
Наджими	365,0±6,7	327,3±6,7	361,7±6,7	12,1 ±0,23	44,6 ±0,81
Исфарак Бадамский	461,6±9,1	318,7±6,5	511,7±10,0	16,6 ±0,32	77,8 ±1,39
Калони Кандак	359,8±6,6	314,0±6,4	368,7±6,1	11,7 ±0,23	43,0 ±0,67
Юбилейный Навои	336,1±6,2	277,7±5,7	341,7±6,2	9,8 ±0,20	34,2 ±0,52

ХУЛОСА

Олиб борилган тадқиқотлар натижасида маҳаллий ва интродукция қилинган ўрик навларининг вегетация давридаги фенологик ривожланиш босқичлари ўртасида сезиларли фарқлар мавжудлиги аниқланди. Навларнинг куртак бўртиши, ғунчалаши, гуллаши, барг ёзиши, мева пишиши, баргларнинг сарғайиши ва хазонрезгилик муддатлари уларнинг биологик хусусиятлари ҳамда ташқи муҳит шароитларига мослашувчанлиги билан боғлиқ эканлиги кузатилди. Фенологик кузатувлар асосида Моника Бланка, Шалах ва Исфарак навларида куртакларнинг бўртиши ва вегетация жараёнининг айрим босқичлари нисбатан эрта бошланганлиги, Наджими навида эса меваларнинг энг эрта, яъни Субхони (st) навига нисбатан 19 кун олдин пишиши аниқланди. Ушбу навда гуллашдан мева пишишгача бўлган давр учун +1579,7°C фойдали ҳарорат йиғиндиси талаб этилган. Тадқиқот натижалари ўрик навларининг вегетация даври давомийлиги ва фойдали ҳароратга бўлган талаби бир-биридан фарқ қилишини кўрсатди. Моника Бланка, Шалах ва Исфарак навларида куртак бўртишидан тўлиқ барг ёзилишигача 34–36 кун давом этиб, +581,3°C фойдали ҳарорат йиғиндиси талаб қилинган бўлса, Субхони (st), Субхони Заря, Субхони Гигант, Наджими, Исфарак Бадамский, Калони Кандак ва Юбилейный Навои навларида ушбу давр 30–32 кунни ташкил этди.

Шунингдек, навлар ўртасида баргларнинг сарғайиши ва хазонрезгилик муддатларида ҳам фарқлар кузатилди. Субхони (st) навига нисбатан Моника

Бланка ва Шалах навларида хазонрезгилик эртароқ бошланган, Исфарак Бадамский ва Субхони Гигант навларида эса кечроқ бошланганлиги қайд этилди. Вегетация даврининг энг узоқ давом этиши Моника Бланка навида 243 кунни ташкил қилди.

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BIOLABORATORIYALARDA ENCARSIA PARTENOPEANI (HYMENOPTERA) KO‘PAYTIRISH, YIG‘IB OLISH VA AGROBIOTSENOZDA ALEYRODIDAE OILASI VAKILLARIGA QARSHI QO‘LLASH

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Annotatsiya. *Tadqiqotlarda 1 m² maydonga 5, 10, 15 va 20 dona imago qo‘llash variantlari sinovdan o‘tkazildi. Eng yuqori biologik samaradorlik (78–85%) 15 dona/m² me’yorda qayd etildi, biroq iqtisodiy jihatdan eng maqbul natija 10 dona/m² me’yorda kuzatildi. Entomofagni bargda 3–5 ta lichinka paydo bo‘lgan davrda va 7–10 kunlik interval bilan qo‘llash oqkanotlilar populyatsiyasini barqaror nazorat qilish imkonini berdi. Issiqxona sharoitida samaradorlik ochiq maydonga nisbatan yuqori bo‘ldi.* ***Encarsia partenopea*** *qo‘llanilganda barglarning zararlanishi kamaydi, xlorofill miqdori va fotosintez faolligi oshdi, pomidor hosildorligi 12–18% ga, bodring hosildorligi esa 10–15% ga ko‘paydi. Hosil yo‘qotishlari 20–25% dan 5–8% gacha kamaydi. Kam zaharli insektitsidlar bilan integratsiyalashgan holda qo‘llash biologik samaradorlikni yanada oshirdi.*

Kalit so‘zlar: *Encarsia partenopea, entomofag, oqqanotli, Bemisia tabaci, Trialeurodes vaporariorum, biologik kurash, parazitoid, integratsiyalashgan himoya, biologik samaradorlik, issiqxona, sabzavot ekinlari, kimyoviy insektitsidlar, zararkunanda populyatsiyasi, hosildorlik, iqtisodiy samaradorlik.*

Аннотация. *В опытах изучались нормы выпуска 5, 10, 15 и 20 имаго на 1 м². Наибольшая биологическая эффективность (78–85%) была достигнута при норме 15 имаго/м², тогда как наиболее экономически выгодной оказалась норма 10 имаго/м². Максимальная эффективность наблюдалась при выпуске энтомофага в фазе появления 3–5 личинок белокрылки на лист и при повторных выпусках с интервалом 7–10 дней. В тепличных условиях эффективность была выше, чем в открытом грунте. Использование Encarsia partenopea способствовало снижению повреждения листьев, увеличению содержания хлорофилла и интенсивности фотосинтеза, а также повышению урожайности томата на 12–18% и огурца на 10–15%. Потери урожая снизились с 20–25% до 5–8%. Совместное применение энтомофага с малотоксичными инсектицидами обеспечило высокую эффективность интегрированной защиты растений.*

Ключевые слова: *Encarsia partenopea, энтомофаг, белокрылка, Bemisia tabaci, Trialeurodes vaporariorum, биологическая борьба, паразитоид, интегрированная защита растений, биологическая эффективность, теплица,*

овощные культуры, химические инсектициды, популяция вредителя, урожайность, экономическая эффективность.

Abstract. *The experiments investigated the release of 5, 10, 15, and 20 adults per m². The highest biological efficiency (78–85%) was achieved at a release rate of 15 adults/m², while the 10 adults/m² treatment provided the best economic return due to lower application costs. Early release, when 3–5 whitefly larvae per leaf were present, resulted in parasitism rates of up to 85%. Releasing the parasitoid every 7–10 days ensured stable suppression of the pest population. Greenhouse conditions provided higher biological efficiency than open-field conditions because of more favorable environmental stability. The use of E. partenopea significantly reduced leaf damage, increased chlorophyll content and photosynthetic activity, and improved crop productivity. Tomato yield increased by 12–18%, cucumber yield by 10–15%, while crop losses caused by whiteflies decreased from 20–25% to 5–8%. Integration of the parasitoid with low-toxicity insecticides further improved pest management efficiency without significantly affecting parasitoid survival.*

Keywords: *Encarsia partenopea, entomophagous parasitoid, whitefly, Bemisia tabaci, Trialeurodes vaporariorum, biological control, parasitoid, integrated pest management (IPM), biological efficacy, greenhouse, vegetable crops, chemical insecticides, pest population, crop yield, economic efficiency.*

KIRISH

Jahonda issiqxona xo‘jaliklari va yopiq yer ekinlarining rivojlanishi bilan birga zararkunandalarga qarshi biologik kurash usullarini takomillastirish muhim ahamiyat kasb etmoqda. Jahon amaliyotida issiqxona ekinlari zararkunandalariga qarshi kurashda entomofaglarni qo‘llash har yili 15-20% ga ortib bormoqda. Aleyrodidae oilasiga mansub oqqanot zararkunandalari issiqxona va yopiq yer sharoitlarida pomidor, bodring, qalampir kabi sabzavot ekinlariga jiddiy iqtisodiy zarar keltirib, hosildorlikni 25-40% gacha kamaytiradi.

O‘zbekiston Respublikasida issiqxona xo‘jaliklarining rivojlanishi va organik mahsulot ishlab chiqarishga bo‘lgan talabning ortishi ekologik xavfsiz usullardan foydalanishni dolzarb qilmoqda. Hozirgi kunda respublikamizda 8 000 gektardan ortiq issiqxonalar mavjud bo‘lib, ularda har yili 850 ming tonnadan ortiq ekologik toza mahsulot yetishtiriladi. Biroq, Aleyrodidae oilasi vakillari - oqqanot zararkunandalarining faollashuvi sababli hosildorlik 30% gacha kamayadi va ekinlarning sifati pasayadi.

Muammoning o‘rganilganlik darajasi. Aleyrodidae Aleyrodidae oilasi vakillari va ularga qarshi biologik kurash usullarini o‘rganish bo‘yicha jahon va milliy miqyosda keng ko‘lamli tadqiqotlar olib borilgan.

Jahon tajribasi. Oqqanot zararkunandalarining bioekologiyasi, zararliligi va ularga qarshi kurashish usullari bo‘yicha M. Byrne, L. Bellows (AQSH, 2018), J.C. van Lenteren (Niderlandiya, 2020), T. Hoddle (Kaliforniya universiteti, 2019) tomonidan fundamental tadqiqotlar amalga oshirilgan. Ularning ishlarida Aleyrodidae oilasi vakillarining 1500 dan ortiq turi o‘rganilgan va ularning issiqxona ekinlariga keltiradigan iqtisodiy zarari 30-45% ekanligi isbotlangan.

Encarsia parazitlarining biologiyasi va samaradorligini o‘rganishda D. Gerling,

R.T. Rosenheim (Izrail, 2017-2021), S. Polaszek (Britaniya tabiat tarixi muzeyi, 2019), E. Urbaneja-Bernat (Ispaniya, 2020) olimlar muhim hissa qo‘shgan. Gerling va hamkasblari Encarsia formoza va E. partenopeani turlarining oqqanot nimfalarini parazitlashtirish mexanizmlarini aniqlagan, parazitlashtirish samaradorligi 75-90% ekanligini isbotlagan.

Entomofaglarni biolaboratoriyalarda ko‘paytirish texnologiyalari bo‘yicha P.A. Stansly, S.E. Naranjo (Florida universiteti, 2018), J.P. Sanderson (Kornell universiteti, 2019-2022), Y. Wang (Xitoy qishloq xo‘jalik fanlar akademiyasi, 2021) olimlar innovatsion usullarni ishlab chiqqan. Stansly in vitro sharoitida enkarziya ko‘paytirish texnologiyasini takomillashtirib, ishlab chiqarish samaradorligini 40% ga oshirishi mumkinligini ko‘rsatgan.

Tadqiqotning maqsadi. Tadqiqotning maqsadi Encarsia partenopeani (Hymenoptera: Aphelinidae) entomofagini biolaboratoriyalarda samarali ko‘paytirish, sifatli yig‘ib olish texnologiyalarini ishlab chiqish hamda agrobiotsenozda Aleyrodidae oilasi vakillariga qarshi optimal qo‘llash usullarini yaratish orqali issiqxona ekinlarini ekologik xavfsiz usulda himoya qilish tizimini takomillashtirishdan iborat. Maqsad enkarziyani ko‘paytirishda mexanik shikastlanishni minimallashtirish, biomahsulotning yashovchanligini 95% dan yuqori darajada ta’minlash, issiqxona sharoitida oqqanot zararkunandalariga qarshi biologik samaradorlikni 90% gacha yetkazish hamda kimyoviy preparatlar sarfini 70-80% ga qisqartirish imkoniyatlarini ilmiy asoslash va amaliyotga joriy etishni o‘z ichiga oladi.

TADQIQOT USULLARI

Biolaboratoriya sharoitida Encarsia parthenopea entomofagini ko‘paytirish texnologiyasini ishlab chiqish, yig‘ib olish va agrobiotsenozda oqqanotlarga (Aleyrodidae) qarshi qo‘llashda K.K.Fasulati, B.P.Adashkevich, T.M.Atamirzayeva hamda J.C. van Lenterenning entomofaglarning sifat ko‘rsatkichlari va ommaviy ko‘paytirish reglamentlari bo‘yicha uslubiy tavsiyalariga asoslanildi.

Zararkunanda oqqanotlarning tur tarkibini aniqlash va ularning agrobiotsenozdagi iqtisodiy ahamiyatini baholashda K.M.Valiyev, A.I.Vanin, A.I.Ilinskiy, I.V.Tropin hamda Encarsia turkumi taksonomiyasi bo‘yicha A. Polaszek tasniflaridan foydalanildi. Oqqanot populyatsiyasining zichligi va rivojlanish dinamikasini hisoblash F.N.Semevskiy uslubiyati bo‘yicha, ularning entomofag bilan o‘zaro munosabatini baholash esa M.S. Hoddle va E. Zchori-Feinlarning funksional reaksiya modellari asosida amalga oshirildi.

TADQIQOT NATIJALARI VA MUXOKAMASI

Tajribalarda entomofagni qo‘llash meyorlari sifatida 1 m² maydonga 5, 10, 15 va 20 dona imago qo‘yish variantlari tanlandi. Nazorat variantida (entomofag qo‘llanilmagan holat) oqqanotlilar soni 15 kun ichida 2,1–2,5 barobarga oshgani kuzatildi. 5 dona/m² meyorda qo‘llanilganda zararkunanda soni 10 kun ichida 42–50% ga kamaygan, ammo 20 kundan so‘ng qayta o‘sish holatlari qayd etilgan. 10 dona/m² meyorda esa 15 kun ichida oqqanotlilar zichligi 65–72% ga kamaygan va populyatsiya barqaror past darajada saqlangan. Eng yuqori samaradorlik 15 dona/m² meyorda qayd etildi. Bu holatda 20 kun davomida zararkunanda soni 78–85% gacha kamaygan va iqtisodiy zarar yetkazish chegarasidan (IZMM) 2–3 barobar past darajaga tushgan. 20

dona/m² meyorda esa biologik samaradorlik 85–90% ni tashkil etgan bo‘lsa-da, iqtisodiy jihatdan samaradorlik pasaygan, ya’ni ortiqcha sarf-xarajatlar kuzatilgan. Shu asosda amaliyot uchun 10–15 dona/m² meyor eng maqbul deb belgilandi.

Entomofagni qo‘llash muddati va davriyligi ham muhim omil sifatida o‘rganildi. Oqqanotlilar populyatsiyasi 1 bargda 3–5 ta lichinka paydo bo‘lgan bosqichda entomofagni birinchi marta qo‘llash eng samarali ekani aniqlandi. Erta bosqichda qo‘llanilganda parazitlash darajasi 80–85% gacha yetgan, kechiktirilganda (10–12 ta/barg) bu ko‘rsatkich 60–65% gacha tushgan.

Takroriy qo‘llash bo‘yicha tajribalarda 7, 10 va 14 kunlik intervallar taqqoslandi. 7 kunlik intervalda oqqanotlilar populyatsiyasi eng barqaror nazorat qilingan va umumiy kamayish 82–88% ni tashkil etgan. 10 kunlik intervalda bu ko‘rsatkich 70–78%, 14 kunlikda esa 60–68% gacha tushgan. Shu bois 7–10 kunlik takroriy qo‘llash optimal deb topildi.

Teplitsa sharoitida olib borilgan tadqiqotlarda entomofag samaradorligi yuqoriroq bo‘lgani qayd etildi. Xususan, yopiq muhitda 10 dona/m² meyorda qo‘llanilganda 15 kun ichida oqqanotlilar soni 72–80% ga kamaygan. Ochiq maydonda esa bu ko‘rsatkich 60–68% ni tashkil etgan. Bu farq tashqi muhit omillari (shamol, harorat o‘zgarishi, yomg‘ir) ta’siri bilan izohlandi.

Qo‘llash usullari ham taqqoslandi. Imagolarni to‘g‘ridan-to‘g‘ri o‘simliklarga qo‘yish va parazitlangan nimfalarni tarqatish usullari o‘rganildi. Imagolarni qo‘llashda parazitlash tez boshlangan va 5–7 kun ichida samara kuzatilgan. Nimfalarni tarqatishda esa ta’sir 8–10 kundan keyin namoyon bo‘lgan, ammo umumiy samaradorlik o‘xshash bo‘lgan (75–82%). Amaliyotda tezkor ta’sir talab etilganda imagolarni qo‘llash afzal deb topildi.

Entomofagni qo‘llashda zararkunanda zichligiga qarab differensial yondashuv ishlab chiqildi. Agar oqqanotlilar soni 1 bargda 5 tagacha bo‘lsa, 5–10 dona/m² yetarli bo‘lgan. 5–10 ta/barg holatida 10–15 dona/m², 10 tadan yuqori bo‘lganda esa 15–20 dona/m² qo‘llash tavsiya etildi. Bu yondashuv orqali biologik samaradorlik 15–20% ga oshirildi.

Tadqiqotlarda entomofag qo‘llanilganda o‘simliklarning fiziologik holati yaxshilangani ham qayd etildi. Xususan, barglardagi zararlanish darajasi 65–80% ga kamaygan, xlorofill miqdori 15–20% ga oshgan. Bu esa fotosintez intensivligining 10–14% ga ortishiga olib kelgan.

Hosildorlik ko‘rsatkichlari ham baholandi. Entomofag qo‘llanilgan variantlarda pomidor hosili 12–18% ga, bodringda esa 10–15% ga oshgan. Nazorat variantida zararkunanda ta’sirida hosil yo‘qotishlari 20–25% ni tashkil etgan bo‘lsa, entomofag qo‘llanilganda bu ko‘rsatkich 5–8% gacha kamaytirildi.

Iqtisodiy samaradorlik tahliliga ko‘ra, 10 dona/m² meyorda qo‘llash eng maqbul natija bergan. Bu holatda sarf-xarajatlar 1 gektarga 18–22% ga kamaygan, sof daromad esa 25–30% ga oshgan. 15 dona/m² meyorda biologik samara yuqori bo‘lsa-da, iqtisodiy samaradorlik biroz past bo‘lgan.

Shuningdek, entomofagni kimyoviy insektitsidlar bilan integratsiyalash imkoniyatlari ham o‘rganildi. Kam zaharli preparatlar bilan birgalikda qo‘llanilganda entomofagning hayotchanligi 85–90% darajada saqlangan va umumiy samaradorlik 90%

gacha oshgan. Biroq yuqori toksik insektitsidlar entomofag populyatsiyasini 40–60% gacha kamaytirgan..

Kimyoviy vositalarga nisbatan afzalliklari asoslandi.

Tajribalar natijasiga ko‘ra, kimyoviy insektitsidlar qo‘llanilganda oqqanotlilar populyatsiyasi 3–5 kun ichida 85–95% gacha kamaygan. Biroq 12–15 kundan so‘ng ularning soni qayta tiklanib, 1,6–2,2 barobarga oshgani kuzatildi. Bu holat zararkunandalarda rezistentlik (chidamlilik) shakllanishi bilan bog‘liq ekani aniqlandi. Encarsia partenopeani qo‘llanilganda esa populyatsiya kamayishi 10–12 kun ichida 70–85% ni tashkil etgan bo‘lsa-da, keyingi davrda qayta ko‘payish holati kuzatilmagan va barqaror past daraja saqlangan.

Kimyoviy vositalarning takroriy qo‘llanilishi ham tahlil qilindi. Insektitsidlar 10 kunlik intervalda 3–4 marta qo‘llanilganda samaradorlik saqlangan, ammo har bir qo‘llashdan so‘ng zararkunanda populyatsiyasida chidamli individlar ulushi 15–20% ga oshgan. 30 kun davomida rezistentlik darajasi 40–60% gacha yetgan. Entomofag qo‘llanilganda esa bunday holat kuzatilmagan, chunki biologik kurash tabiiy tanlanish mexanizmlariga asoslangan.

1-jadval

Entomofagni yig‘ib olish va saqlash samaradorligi

№	O‘zgaruvchi/Shartlar	Laboratoriya	Teplitsa	Ochiq maydon	Izoh
1	Harorat (°C)	25	22	28	Optimal harorat laboratoriyada 25°C
2	Nisbiy namlik (%)	70±5	65±5	75±5	Optimal namlik hayotchanlikni saqlaydi
3	Imago chiqish foizi (%)	88–92	82–88	75–80	Entomofag samaradorligi muhitga bog‘liq
4	Parazitlash darajasi (%)	80–85	72–80	60–68	Lichinka bosqichida yuqori samara
5	Mexanik shikastlanish (%)	5	7	12	Yig‘ish usuliga bog‘liq
6	Yo‘qotishlar saqlash davomida (%)	6–8	8–10	15–18	Uzoq saqlash samaraga ta’sir qiladi

Ekologik xavfsizlik jihatidan olib borilgan tahlillar ko‘rsatdiki, kimyoviy insektitsidlar qo‘llanilganda agrobiotsenozdagi foydali hasharotlar (entomofaglar, changlatuvchilar) nobud bo‘lishi 65–80% ni tashkil etgan.

Ayniqsa, asalari va boshqa changlatuvchilar soni 50–60% ga kamaygan. Encarsia partenopeani qo‘llanilganda esa foydali organizmlarga ta’sir minimal bo‘lib, ularning 90–95% qismi saqlanib qolgan.

2-jadval

№	Ko‘rsatkichlar	22°C	25°C (optimal)	28°C
1	Rivojlanish davri (kun)	21,4 ±0,6	17,5 ±0,4	15,2 ±0,3
2	Imago chiqish foizi (%)	72–78	88–92	62–65
3	Parazitlash darajasi (%)	60–68	80–85	55–60

№	Ko‘rsatkichlar	22°C	25°C (optimal)	28°C
4	Urg‘ochi mahsuldorligi (dona)	45–55	60–75	38–42
5	Yashash davomiyligi (kun)	9,2 ±0,5	12,3 ±0,7	7,8 ±0,4

Entomofagni laboratoriya sharoitida ko‘paytirish texnologiyasi. Tuproq va o‘simliklarda kimyoviy qoldiq moddalar miqdori ham baholandi. Insektitsidlar qo‘llanilgandan keyin 20 kun o‘tgach ham tuproqda ularning 18–25% qoldiqlari saqlangani aniqlandi.

O‘simlik mahsulotlarida esa 10–15% holatda ruxsat etilgan meyordan yuqori qoldiqlar qayd etilgan. Entomofag qo‘llanilganda esa bunday holat umuman kuzatilmagan, mahsulotlar to‘liq ekologik toza bo‘lgan.

Iqtisodiy samaradorlik tahliliga ko‘ra, kimyoviy kurash usulida 1 gektar maydonga sarf-xarajatlar o‘rtacha 1,2–1,5 mln so‘mni tashkil etgan (3–4 marta ishlov berish hisobiga). Entomofag qo‘llanilganda esa bu ko‘rsatkich 0,8–1,0 mln so‘m atrofida bo‘lgan. Ya’ni 20–30% iqtisodiy tejamkorlikka erishilgan. Shu bilan birga, hosildorlik entomofag qo‘llanilganda 10–18% ga yuqori bo‘lgan.

3-jadval

Xo‘jayin hasharot populyatsiyasini barqaror saqlash

№	Ko‘rsatkichlar	Pomidor	Bodring	Baklajan
1	Tuxum qo‘yish (dona/urg‘ochi)	95–120	80–95	70–85
2	Rivojlanish davri (kun)	18–20	20–22	21–24
3	Nimfa yashovchanligi (%)	85–90	78–84	70–75
4	Optimal zichlik (dona/barg)	40–60	35–50	30–45
5	Populyatsiya o‘sish koeffitsiyenti (R_0)	2,1–2,3	1,8–2,0	1,6–1,9

4-jadval

Parazitlash darajasi va biologik samaradorlik

№	Ko‘rsatkichlar	Laboratoriya	Teplitsa	Ochiq maydon
1	Parazitlash darajasi (%)	78–85	72–80	60–68
2	Imago chiqish foizi (%)	86–92	82–88	75–80
3	Bir urg‘ochi mahsuldorligi (dona)	62–74	55–68	48–60
4	Zararkunanda kamayishi (%)	80–85	70–80	60–70
5	Biologik samaradorlik (%)	82–88	75–85	65–75

Mehnat xarajatlari ham taqqoslandi. Kimyoviy ishlov berishda har bir gektarga 6–8 ishchi soat sarflangan bo‘lsa, entomofag qo‘llashda bu ko‘rsatkich 3–4 soatni tashkil etgan. Demak, mehnat unumdorligi 1,8–2,0 barobarga oshgan. Agroekotizim barqarorligi nuqtai nazaridan ham muhim natijalar olindi. Kimyoviy vositalar qo‘llanilganda tabiiy biologik muvozanat buzilib, ikkinchi darajali zararkunanda hasharotlar soni 25–30% ga oshgan. Entomofag qo‘llanilganda esa agrobiotsenozda biologik muvozanat saqlangan va hatto boshqa zararkunanda turlarining soni 10–15% ga kamaygan.

5-jadval

Agrobiotsenozda qo‘llash meyorlari

№	Meyor (dona/m²)	10 kun (%)	15 kun (%)	20 kun (%)	Iqtisodiy baholash
1	5	42–50	55–60	50–55	Past
2	10	65–72	70–75	68–72	Yuqori
3	15	75–82	78–85	80–87	Optimal
4	20	80–85	85–90	88–92	Ortiqcha sarf

Kimyoviy vositalarning inson salomatligiga ta’siri ham baholandi. Insektitsidlar bilan ishlashda xavflilik darajasi yuqori bo‘lib, maxsus himoya vositalari talab etilgan. Tadqiqotlar davomida ishchilarning 12–18% da yengil darajadagi intoksikatsiya belgilari (bosh og‘rig‘i, ko‘ngil aynishi) kuzatilgan. Entomofag qo‘llanilganda esa bunday holatlar qayd etilmagan.

Tadqiqotlarda integratsiyalashgan kurash tizimi (IPM) doirasida entomofagning o‘rni ham aniqlandi. Kam zaharli insektitsidlar bilan birgalikda qo‘llanilganda umumiy samaradorlik 85–90% gacha oshgan.

6-jadval

Iqtisodiy samaradorlik va taqqoslama tahlil

№	Ko‘rsatkichlar	Kimyoviy usul	Biologik usul	Farq (%)
1	Hosildorlik (t/ga)	52,4	58,7	+12,0
2	Mahsulot narxi (so‘m/kg)	2 700	3 200	+18,5
3	Yalpi daromad (so‘m)	141 480 000	187 840 000	+32,7
4	Jami xarajat (so‘m)	1 350 000	950 000	–29,6
5	Sof daromad (so‘m)	140 130 000	186 890 000	+33,4
6	Rentabellik (%)	10 377	19 673	+89,5

Biroq yuqori toksik preparatlar entomofag populyatsiyasini 40–50% gacha kamaytirgani sababli ulardan foydalanish cheklandi. Uzoq muddatli kuzatishlar natijasida kimyoviy kurash usulida har yili preparatlar dozasini 10–15% ga oshirish talab etilgan, chunki zararkunanda chidamliligi ortib borgan. Entomofag qo‘llanilganda esa bunday holat kuzatilmagan va samaradorlik yillar davomida barqaror saqlangan. Encarsia partenopeani entomofagini qo‘llash kimyoviy insektitsidlarga nisbatan quyidagi asosiy afzalliklarga ega ekani ilmiy jihatdan asoslandi: yuqori va barqaror biologik samaradorlik (75–85%), ekologik xavfsizlik (0% qoldiq moddalar), iqtisodiy tejamkorlik (20–30%), foydali organizmlarni saqlash (90–95%) va agrobiotsenoz barqarorligini ta’minlash.

XULOSA

Olib borilgan tadqiqotlar natijalari Encarsia partenopea entomofagini oqqanotlilarga qarshi biologik kurashning samarali vositasi ekanligini tasdiqladi. Tajribalarda entomofagning qo‘llash meyori, muddati, takroriyligi va qo‘llash usullari o‘rganilib, eng maqbul agrotexnik tavsiyalar ishlab chiqildi. Tadqiqotlar shuni ko‘rsatdiki, 10–15 dona/m² meyorda entomofag qo‘llash biologik va iqtisodiy jihatdan eng maqbul hisoblanadi. Xususan, 15 dona/m² meyorda oqqanotlilar soni 20 kun davomida 78–85% ga kamayib, iqtisodiy zarar yetkazish chegarasidan 2–3 barobar

past darajaga tushgan. Biroq iqtisodiy tahlillar 10 dona/m² meyorda sarf-xarajatlar kamroq bo‘lib, sof daromad 25–30% ga oshishini ko‘rsatdi. Shu bois ishlab chiqarish amaliyoti uchun 10–15 dona/m² meyor tavsiya etiladi. Entomofagni zararkunanda populyatsiyasi past bo‘lgan, ya’ni 1 bargda 3–5 ta lichinka aniqlangan bosqichda qo‘llash eng yuqori samara berdi. Takroriy qo‘llashda 7–10 kunlik interval oqqanotlilar populyatsiyasini barqaror nazorat qilish imkonini berib, biologik samaradorlikni 82–88% gacha ta’minladi. Teplitsa sharoitida entomofagning samaradorligi ochiq maydonga nisbatan yuqori bo‘lib, tashqi muhit omillarining cheklanganligi sababli oqqanotlilar populyatsiyasi 72–80% gacha kamaydi. Imagolarni to‘g‘ridan-to‘g‘ri qo‘llash tezkor ta’sir ko‘rsatgan bo‘lsa, parazitlangan nimfalarni tarqatish usuli ham yuqori umumiy samaradorlikka ega ekanligi aniqlandi.

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AMARANT NAVLARI VA NAMUNALARINING MAHSULDORLIK KO‘RSATKICHLARI

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Annotatsiya: *Maqolada Toshkent viloyati sharoitida amarant navlari va namunalarining ayrim mahsuldorlik ko‘rsatkichlari, jumladan, ro‘vakning quruq massasi, bir ro‘vakdagi urug‘ massasi, 1000 dona urug‘ massasi hamda o‘simliklarning yashil biomassasi bo‘yicha olingan natijalar keltirilgan. Tadqiqotlarda genotiplar o‘rtasidagi farqlar va yillar bo‘yicha belgilar o‘zgaruvchanligi baholangan. Shuningdek, amarant genotiplarining fuzarioz bilan kasallanish darajasi aniqlangan. Tajriba natijalariga ko‘ra, RRC-1027, New 41, New 45, New 30 va Check 3 namunalarida ayrim mahsuldorlik ko‘rsatkichlari nisbatan yuqori bo‘lgan. RRC-1027 genotipida ro‘vakning quruq massasi va bir ro‘vakdagi urug‘ massasi yuqori qiymatlarni namoyon qilgan. Olingan natijalar amarant genotiplarini mahalliy agroiqlim sharoitida baholash va istiqbolli boshlang‘ich materiallarni tanlash uchun ilmiy asos bo‘lib xizmat qiladi.*

Kalit so‘zlar: *amarant, Amaranthus spp., genotip, ro‘vak, quruq massa, yashil massa, urug‘ massasi, 1000 dona urug‘ massasi, mahsuldorlik, fuzarioz.*

Аннотация: *В статье представлены результаты исследований некоторых показателей продуктивности сортов и образцов амаранта в условиях Ташкентской области, включая сухую массу метёлки, массу семян с одной метёлки, массу 1000 семян, а также зелёную биомассу растений. В ходе исследований проведена оценка различий между генотипами и изменчивости изучаемых признаков по годам. Кроме того, определена степень поражения генотипов амаранта фузариозом. Согласно результатам эксперимента, у образцов RRC-1027, New 41, New 45, New 30 и Check 3 отмечены относительно высокие значения отдельных показателей продуктивности. Генотип RRC-1027 характеризовался высокими значениями сухой массы метёлки и массы семян с одной метёлки. Полученные результаты служат научной основой для оценки генотипов амаранта в местных агроклиматических условиях и отбора перспективного исходного материала.*

Ключевые слова: *амарант, Amaranthus spp., генотип, метёлка, сухая масса, зелёная масса, масса семян, масса 1000 семян, продуктивность, фузариоз.*

Abstract. *The article presents the results of a study of selected productivity traits of amaranth varieties and accessions under the conditions of the Tashkent Region, including panicle dry mass, seed mass per panicle, 1000-seed mass, and plant green biomass. Differences among genotypes and year-to-year variability of the studied traits were evaluated. The incidence of Fusarium disease in amaranth genotypes was also determined. The experimental results showed relatively high values for some productivity traits in the RRC-1027, New 41, New 45, New 30, and Check 3 accessions. The RRC-1027 genotype demonstrated high values of panicle dry mass and seed mass per panicle. The obtained results provide a scientific basis for evaluating amaranth genotypes under local agroclimatic conditions and selecting promising initial breeding material.*

Keywords: *amaranth, Amaranthus spp., genotype, panicle, dry mass, green biomass, seed mass, 1000-seed mass, productivity, Fusarium disease.*

KIRISH

Amarant (*Amaranthus* spp.) oziq-ovqat va yem-xashak yo‘nalishida foydalaniladigan, yuqori biologik mahsuldorlikka ega ekinlardan biridir. Ayrim amarant turlari qurg‘oqchilik va yuqori harorat sharoitlariga moslashuvchanligi bilan ajralib turadi. So‘nggi tadqiqotlarda amarant genotiplarining o‘sish, biomassani shakllantirish va urug‘ hosildorligi bo‘yicha sezilarli genotipik farqlarga ega ekanligi ko‘rsatilgan [1–3].

Amarant doni oqsil, yog‘, mineral moddalar, oziq tolalari va biologik faol birikmalarning manbai hisoblanadi. Ayniqsa, urug‘ oqsilining aminokislota tarkibida lizin va metionin miqdorining nisbatan yuqoriligi uning oziqaviy qiymatini oshiradi [4].

Amarant donini yorma, un va boshqa oziq-ovqat mahsulotlari ishlab chiqarishda qayta ishlash mumkin. Unidan non, pechenye, pishiriq va boshqa mahsulotlar tayyorlash imkoniyati mavjud. Bunda amarant unini boshqa don ekinlari unlari bilan aralashtirish texnologik xususiyatlarni yaxshilashi mumkin [1, 5].

Amarantning mahsuldorligi genotip, agroiqlim sharoiti, ekish muddati, oziqlanish va namlik bilan ta’minlanganlik kabi omillarga bog‘liq. Shu sababli mahalliy sharoitda turli genotiplarning morfologik va mahsuldorlik belgilarini ko‘p yillik kuzatish asosida baholash muhim hisoblanadi [2, 3].

TADQIQOT MATERIALI VA USULLARI

Tadqiqotlar Toshkent viloyati sharoitida amarantning turli nav va namunalarida olib borildi. Tajribada New 65, New 21, Check 2, New 41, New 13, New 30, Check 7, Check 5, New 45, Check 3, RRC-1027 hamda standart sifatida Marhamat navi o‘rganildi.

Mahsuldorlik belgilarini baholashda ro‘vakning quruq massasi, bir ro‘vakdagi urug‘ massasi, 1000 dona urug‘ massasi va bir tupdagi yashil massa miqdori hisobga olindi. Tajriba yillari bo‘yicha o‘rtacha qiymat va o‘zgaruvchanlik koeffitsiyenti (V, %) aniqlandi.

Fuzarioz bilan kasallanish darajasi kasallik belgilari kuzatilgan o‘simliklar sonining tekshirilgan jami o‘simliklar soniga nisbati asosida hisoblandi:

Kasallanish darajasi (%) = (kasallangan o‘simliklar soni / tekshirilgan o‘simliklar soni) × 100.

Amarantda *Fusarium oxysporum* bilan bog‘liq ildiz chirishi, poya zararlanishi va so‘lish belgilari qayd etilganligi zamonaviy tadqiqotlarda ham ko‘rsatilgan [6, 7].

NATIJALAR VA ULARNING MUHOKAMASI

Ro‘vakning quruq massasi. 2019–2021-yillarda o‘rganilgan genotiplarda ro‘vakning quruq massasi bo‘yicha sezilarli farqlar aniqlandi. Mazkur belgi genotipning mahsuldorlik potensialini baholashda muhim ko‘rsatkichlardan biri bo‘lib, uning qiymati yillar bo‘yicha ham o‘zgarib bordi.

1-jadval. Amarant nav va namunalarida ro‘vakning quruq massasi, g

Nav va namunalar	2019-yil M±m	V, %	2020-yil M±m	V, %	2021-yil M±m	V, %
New 65	140,0±0,78	2,71	142,1±1,29	1,65	162,8±0,75	1,54
New 21	116,5±0,88	2,11	122,5±0,96	2,10	133,0±0,95	1,99
Check 2	146,2±0,58	2,59	152,4±1,13	1,40	158,6±0,67	1,34
New 41	194,8±0,51	1,90	202,4±0,97	1,81	210,0±1,06	0,99
New 13	155,6±1,14	2,27	160,4±1,32	1,99	163,1±1,49	1,48
New 30	159,6±1,23	5,51	164,4±1,27	4,47	166,9±1,40*	3,13
Check 7	160,7±1,61	2,08	162,7±1,27	1,59	165,2±0,92	1,11
Check 5	115,5±0,74	1,01	120,4±0,71	0,93	126,8±1,62	1,05
New 45	187,9±1,43	1,94	194,0±1,19	1,57	198,4±1,79	1,22
Check 3	202,4±1,71	1,81	208,1±0,63	1,27	212,9±0,94	1,27
RRC-1027	204,9±1,13	1,85	213,1±1,02	1,60	216,9±1,57	1,01
Marhamat	141,8±0,39	1,39	143,8±0,99	1,22	149,0±1,10	1,13

Jadval ma’lumotlariga ko‘ra, 2019-yilda ro‘vakning eng yuqori quruq massasi RRC-1027 namunasi — 204,9 g va Check 3 — 202,4 g da qayd etilgan. 2020-yilda ushbu ko‘rsatkich mos ravishda 213,1 va 208,1 g ni, 2021-yilda esa 216,9 va 212,9 g ni tashkil etdi.

Standart Marhamat navida ro‘vakning quruq massasi yillar bo‘yicha 141,8; 143,8 va 149,0 g ni tashkil etgan. RRC-1027 namunasida ushbu ko‘rsatkich standart navga nisbatan barcha kuzatuv yillarida yuqori bo‘lgan.

Genotiplar o‘rtasidagi mahsuldorlik belgilarining farqlanishi boshqa tadqiqotlarda ham qayd etilgan. Xususan, amarant genotiplarini baholashda hosil va hosil elementlarining genotiplar bo‘yicha sezilarli o‘zgarishi aniqlangan [2, 3].

Bir tupdagi yashil massa miqdori ham genotiplar bo‘yicha farq qilgan. Kuzatuvlarda ushbu ko‘rsatkich o‘rtacha 1240 g dan 1720 g gacha bo‘lgan. Eng yuqori qiymat RRC-1027 oq amarant namunasida qayd etilgan, standart Marhamat navida esa 1455 g ni tashkil qilgan.

Olingan natijalar RRC-1027, Check 3 va New 65 kabi genotiplarni mahalliy sharoitda mahsuldorlik belgilarini yaxshilashga qaratilgan seleksiya ishlarida boshlang‘ich material sifatida qo‘shimcha baholash mumkinligini ko‘rsatadi. Biroq bunday xulosa genotiplarning ko‘p yillik hosildorligi, irsiyligi va genotip × muhit o‘zaro ta’siri bo‘yicha qo‘shimcha ma’lumotlar bilan tasdiqlanishi lozim.

Bir ro‘vakdagi urug‘ massasi. Bir ro‘vakdagi urug‘ massasi amarantning urug‘ mahsuldorligini tavsiflovchi muhim ko‘rsatkichlardan biridir. Tadqiqot yillarida ushbu belgi bo‘yicha ham genotiplar o‘rtasida farqlar kuzatildi.

2-jadval. Amarant nav va namunalarida bir ro‘vakdagi urug‘ massasi, g

Nav va namunalar	2019-yil M±m	V, %	2020-yil M±m	V, %	2021-yil M±m	V, %
New 65	10,3±0,23	6,39	11,1±0,33	5,93	12,3±0,32	4,47
New 21	10,6±0,24	6,84	10,7±0,29	5,48	12,1±0,53	4,54
Check 2	11,1±0,09	4,75	11,5±0,45	3,87	12,5±0,46	3,47
New 41	10,8±0,24	4,49	11,2±0,14	2,57	14,0±0,28	2,01
New 13	11,9±0,27	4,52	13,1±0,35	3,42	14,9±0,30	3,07
New 30	11,4±0,35	6,20	13,2±0,24	3,70	15,2±0,29	2,87
Check 7	11,0±0,32	5,82	11,3±0,60	4,37	12,5±0,32	3,69
Check 5	11,5±0,13	4,39	13,4±0,61	3,78	14,3±0,31	2,27
New 45	11,6±0,19	3,37	13,5±0,22	3,24	14,9±0,32	3,02
Check 3	11,2±0,25	4,58	13,1±0,55	4,37	14,5±0,30	3,36
RRC-1027	13,6±0,15	3,53	13,7±0,20	3,05	15,5±0,27	2,24
Marhamat	13,0±0,12	3,46	13,4±0,30	3,25	14,2±0,35	2,23

2019-yilda bir ro‘vakdagi urug‘ massasi 10,3–13,6 g oralig‘ida bo‘lgan. Eng yuqori ko‘rsatkich RRC-1027 namunasida — 13,6 g, standart Marhamat navida esa 13,0 g qayd etilgan.

2020-yilda qiymatlar 10,7–13,7 g oralig‘ida bo‘lib, RRC-1027 namunasida 13,7 g ga yetgan. 2021-yilda esa ushbu belgi 12,1–15,5 g oralig‘ida o‘zgarib, eng yuqori qiymat RRC-1027 — 15,5 g va New 30 — 15,2 g namunalarida qayd etilgan.

RRC-1027 namunasida bir ro‘vakdagi urug‘ massasi 2019–2021-yillarda mos ravishda 13,6; 13,7 va 15,5 g ni tashkil etgan. Shu sababli matnda uchragan **14,7 g** qiymati jadval ma’lumotlariga mos kelmaydi va olib tashlandi.

V qiymatlarining yillar bo‘yicha kamayishi ayrim genotiplarda ushbu belgining tajriba sharoitidagi o‘zgaruvchanligi pasayganini ko‘rsatadi. Biroq bu holatning o‘zi belgining genetik jihatdan barqarorligini isbotlamaydi; bunday xulosa uchun dispersiya tahlili va genotip × muhit o‘zaro ta’siri alohida baholanishi kerak.

1000 dona urug‘ massasi. 1000 dona urug‘ massasi urug‘lik materialining fizik ko‘rsatkichlaridan biri bo‘lib, amarant genotiplarini baholashda qo‘llaniladi. Tadqiqotlarda mazkur ko‘rsatkich bo‘yicha ham genotiplar o‘rtasida farqlar qayd etilgan.

2020-yilda 1000 dona urug‘ massasi New 65 namunasida 2,31 g dan New 41 namunasida 2,84 g gacha bo‘lgan. 2021-yilda yuqori qiymatlar New 45 — 3,14 g, Check 5 — 3,16 g va New 41 — 3,22 g namunalarida qayd etilgan.

1000 dona urug‘ massasining yillar bo‘yicha ortishi urug‘larning shakllanish sharoitlari va genotip xususiyatlari bilan bog‘liq bo‘lishi mumkin. Biroq bu ko‘rsatkichning ortishini bevosita “seleksiya jarayonining samaradorligi” sifatida talqin qilish uchun qo‘shimcha genetik-statistik ma’lumotlar talab etiladi.
Amarant genotiplarida urug‘ va boshqa hosil elementlarining genotiplararo farqlanishi zamonaviy tadqiqotlarda ham qayd etilgan [2, 3].

Amarant navlari va namunalarining fuzarioz bilan kasallanish darajasi. Amarant yetishtirishda *Fusarium* turkumiga mansub zamburug‘lar ildiz, poya va

boshqa organlarning zararlanishi bilan bog‘liq kasalliklarni keltirib chiqarishi mumkin. Amarantda *Fusarium oxysporum* bilan bog‘liq ildiz chirishi va poya zararlanishi qayd etilgan [6, 7]. Shuningdek, amarant fuzarioz kasalliklarida bir nechta *Fusarium* turlari ishtirok etishi mumkinligi ko‘rsatilgan [6].

Tadqiqotlarda Toshkent davlat agrar universitetining o‘quv-ilmiy tajriba maydonida amarant nav va namunalarining fuzarioz bilan kasallanish darajasi aniqlandi.

3-jadval. Amarant nav va namunalarining fuzarioz bilan kasallanish darajasi

Nav va namunalar	Tekshirilgan o‘simliklar soni, dona	Kasallangan o‘simliklar soni, dona	Kasallanish darajasi, %
New 65	44	3	6,8
New 21	43	4	9,3
Check 2	42	4	9,5
New 41	44	3	6,8
New 13	43	3	6,8
New 30	43	4	9,3
New 45	44	4	9,0
Check 7	43	4	9,3
Check 5	44	4	9,0
Check 3	43	3	7,0
RRC-1027	44	3	6,8
Marhamat	43	4	9,3

Jadval ma’lumotlariga ko‘ra, eng past kasallanish darajasi New 65, New 41, New 13 va RRC-1027 namunalarida — 6,8% ni tashkil etdi. Check 3 namunasida kasallanish darajasi 7,0% bo‘lgan.

Standart Marhamat navida kasallanish darajasi 9,3% ni tashkil etdi. RRC-1027, New 65, New 41 va New 13 namunalarida bu ko‘rsatkich standartga nisbatan 2,5 foiz punktga past bo‘lgan.

Shu bilan birga, mazkur natijalar asosida ushbu genotiplarni bevosita “fuzariozga chidamli” deb baholash to‘g‘ri emas. Ilmiy jihatdan **“kasallanish darajasi nisbatan past bo‘lgan genotiplar”** iborasidan foydalanish maqsadga muvofiq. Chidamlilikni tasdiqlash uchun kasallikning rivojlanish darajasi, patogenni identifikatsiya qilish, takroriy tajribalar va statistik tahlil natijalari talab etiladi.

2026-yilda O‘zbekistonning arid va sho‘rlangan sharoitlarida o‘tkazilgan tadqiqotda ham RRC-1027 genotipida *Fusarium* so‘lishi bilan kasallanish darajasi 6,8% bo‘lgani qayd etilgan. Ushbu natija mazkur genotipning turli stress sharoitlaridagi kasallanish ko‘rsatkichlarini qo‘shimcha baholash zarurligini ko‘rsatadi [8].

XULOSA

Toshkent viloyati sharoitida o‘rganilgan amarant nav va namunalarining mahsuldorlik ko‘rsatkichlari genotiplar bo‘yicha sezilarli farqlangan.

Ro‘vakning quruq massasi bo‘yicha RRC-1027 va Check 3 namunalari yuqori natijalarni ko‘rsatdi. 2021-yilda RRC-1027 namunasida ushbu ko‘rsatkich 216,9 g, Check 3 namunasida 212,9 g ni tashkil etdi.

Bir ro‘vakdagi urug‘ massasi bo‘yicha 2021-yilda eng yuqori qiymat RRC-1027 — 15,5 g va New 30 — 15,2 g namunalarida qayd etildi.

1000 dona urug‘ massasining yuqori qiymatlari New 45, Check 5 va New 41 namunalarida kuzatildi. 2021-yilda mos ravishda 3,14; 3,16 va 3,22 g qiymatlar qayd etildi.

Fuzarioz bilan kasallanish darajasi New 65, New 41, New 13 va RRC-1027 namunalarida 6,8% bo‘lib, standart Marhamat navidagi 9,3% ko‘rsatkichdan past bo‘ldi.

RRC-1027 namunasi ro‘vak massasi, bir ro‘vakdagi urug‘ massasi va kasallanish darajasi bo‘yicha kompleks baholash uchun istiqbolli genotip sifatida ajralib turdi. Uni seleksiya uchun boshlang‘ich material sifatida tavsiya etishdan oldin ko‘p yillik va ko‘p muhitli tajribalarda hosildorlik, sifat ko‘rsatkichlari va kasallikka munosabatini qo‘shimcha baholash maqsadga muvofiq.

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TUPROQLARNING HAJM OG‘IRLIGIGA ORGANO-MINERAL KOMPOSTLARNING TA’SIRI

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Annotatsiya. *Ushbu maqolada organo-mineral kompostlarning tuproqning hajm og‘irligiga ta’siri o‘rganilgan. Tadqiqotlar davomida turli tarkib va me’yorlarda qo‘llanilgan organik va mineral komponentlar asosida tayyorlangan kompostlarning tuproqning fizik xususiyatlariga ta’siri baholangan. Organik moddalarga boy kompostlardan foydalanish natijasida tuproqning zichlashish darajasi kamayib, uning hajm og‘irligi me’yorlashganligi aniqlangan. Kompost tarkibidagi organik moddalar tuproq agregatlarini barqarorlashtirib, g‘ovaklikni oshirishi va tuproqning suv-fizik xususiyatlarini yaxshilashi kuzatilgan. Tadqiqot natijalari organo-mineral kompostlardan foydalanish tuproqning fizik holatini yaxshilash, unumdorligini oshirish va qishloq xo‘jaligi ekinlari uchun qulay tuproq muhitini shakllantirishda samarali agrotexnik tadbir ekanligini ko‘rsatadi.*

Kalit so‘zlar: *tuproq, hajm og‘irligi, organo-mineral kompost, tuproq zichligi, g‘ovaklik, organik modda, tuproq unumdorligi, tuproq agregatlari, agrotexnologiya.*

Аннотация. *В статье представлены результаты исследования влияния органо-минеральных компостов на объемную массу почвы. В ходе исследований оценено воздействие компостов, приготовленных на основе органических и минеральных компонентов в различных составах и нормах внесения, на физические свойства почвы. Установлено, что применение компостов, обогащенных органическим веществом, способствует снижению степени уплотнения почвы и улучшению ее объемной массы. Органические компоненты компоста способствуют формированию и стабилизации почвенных агрегатов, увеличению пористости и улучшению водно-физических свойств почвы. Полученные результаты показывают, что применение органо-минеральных компостов является эффективным агротехническим приемом для улучшения*

физического состояния почвы, повышения ее плодородия и формирования благоприятных условий для роста и развития сельскохозяйственных культур.

Ключевые слова: *почва, объемная масса, органо-минеральный компост, плотность почвы, пористость, органическое вещество, плодородие почвы, почвенные агрегаты, агротехнология.*

Abstract. *This article presents the results of a study on the effect of organo-mineral composts on soil bulk density. The study evaluated the influence of composts prepared from organic and mineral components in different compositions and application rates on the physical properties of soil. It was found that the application of organic matter-rich composts reduced soil compaction and improved soil bulk density. The organic components of the compost contributed to the formation and stabilization of soil aggregates, increased soil porosity, and improved its water-physical properties. The results demonstrate that the application of organo-mineral composts is an effective agronomic practice for improving soil physical conditions, enhancing soil fertility, and creating favorable soil conditions for the growth and development of agricultural crops.*

Keywords: *soil, bulk density, organo-mineral compost, soil density, porosity, organic matter, soil fertility, soil aggregates, agricultural technology.*

KIRISH

Tuproqlarning o‘simliklar ildiz tizimi joylashgan qatlami zichlansa ularning o‘sishi hamda rivojlanishi qiyin bo‘lib boradi. Buning natijasida o‘simlikning yer ústki qismi o‘sish va rivojlanishdan ortda qoladi, hosildorlik esa kam bo‘ladi. Shuning uchun tuproqlarning zichlanishini oldini olish maqsadida tuproqda boricha o‘simlik qoldiqlarini ko‘proq qoldirishi, organik va sideratli o‘g‘itlarni qo‘llash, tuproqga ishlov berish tadbirlarini qo‘llashni ko‘rishimiz kerak. Tuproq zichlanishiga sabab bo‘ladigan omillarni, bu sug‘orishlar, qator orasidan traktorlarning qayta-qayta yurishi ham sabab bo‘lishi mumkin.

R.V.Perchenko [1; 38-39-b.] takidlashicha, qishloq xo‘jaligida kompostdan foydalanish organik chiqindilarni minimallashtirish va o‘simlikchilikka qo‘shiladigan o‘g‘itlar va fungitsidlar miqdorini kamaytirish uchun juda samarali. Kompost tuproqning barcha fizik xususiyatlarini yaxshilaydi: massa, zichlik, gidravlik o‘tkazuvchanlik, porozlik va suvni ushlab turish qobiliyati va boshqalar.

S.M.Boltaevning [2; 16-17-b.] tajribalarida olingan ma’lumotlarga ko‘ra, o‘rtacha sho‘rlangan taqirsimon tuproqlar sharoitida noan‘anaviy agrorudalardan Xavdog‘ bentonit loyqasi va go‘ngdan tayyorlangan kompostni tuproqqa berishganda tuproqning meliorativ holatini yaxshilab, tuproqning suv-fizik va agroximyoviy holati yaxshilangan, ya’ni kompost tuproqning hajm og‘irligini kamaytirib nam sig‘imini oshirgan.

A.Ismailova, B.Niyazalievlarning [3; 38-39-b.] ma’lumotlari bo‘yicha, ma’dan o‘g‘itlarni yillik me’yorini 25 foizga kamaytirib, unga qo‘shimcha ravishda glaukonit va glaukofosni 600, 900 va 1200 kg/ga me’yorida amal davrida oziqlantirish uchun qo‘llash va glaukonit va glaukofosni 1200 va 1500 kg/ga me’yorida shudgor ostiga qo‘llanilganda tuproq hajm massasi va tuproq zichlanishi kam bo‘lishi kuzatilgan.

MATERIALLAR VA USLUBLAR

Tajriba dala usuli bo‘yicha olib borildi. Tadqiqotlar 9 variantdan 4 qaytariqtan iborat bo‘lib, variantlar tizimli uslubda joylashtirildi. Tajribada tuproqning agrofizikaviy tahlillarini o‘tkazishda «Методы агрофизических исследований» (Tashkent, 1973) uslubiy qo‘llanmasidan foydalanildi [4].

Tuproq zichlanishini kamaytirish bo‘yicha bir qancha ilmiy-tadqiqot ishlari olib borilgan. Lekin Qoraqalpog‘iston Respublikasi sharoitida har xil tarkibdagi kompostlarni qo‘llash bo‘yicha ilmiy-tadqiqotlar yetarli bo‘lmaganligi sababli biz tajribada kompostlarning qo‘llashning tuproq hajm og‘irligini yaxshilashdagi samaradorligi bo‘yicha dala tajribasini o‘tkazdik. Tajriba davomida bahorda va kuzda tuproqning 0-30 va 30-50 sm qatlamida kompost, organik va mineral o‘g‘itlarning tuproq hajm salmog‘iga tasirini aniqlash maqsadida tuproq namunalarini oldik va laboratoriya sharoitida aniqladik.

NATIJALAR

Olingan malumotlarga ko‘ra, 2021 yil vegetatsiya davri boshida tuproqning 0-30 sm qatlamida tuproq hajm salmog‘i variantlar bo‘yicha o‘rtacha 1,31-1,36 g/sm^3 gacha bo‘ldi.

Tajribalarda vegetatsiya davri boshida nazorat (NPK) variantida tuproqning hajm og‘irligi 0-30 va 30-50 sm qatlamlarda 1,36 va 1,45 g/sm^3 tashkil qilgan bo‘lsa, g‘o‘zaning vegetatsiya davri oxirida tuproqning 0-30 va 30-50 sm qatlamlarda hajm og‘irligi 1,41 va 1,51 g/sm^3 bo‘lib, bahordagi ko‘rsatkichlarga nisbatan ortganligi aniqalandi.

Mineral o‘g‘itlar bilan organik o‘g‘itlar 10, 20 va 30 t/ga miqdorda qo‘llanilgan 2-4 variantlarda vegetatsiya davri boshida tuproqning 0-30 va 30-50 sm qatlamlarda hajm og‘irligi 1,32-1,33-1,34 g/sm^3 va 1,43-1,44-1,44 g/sm^3 ni, g‘o‘zaning vegetatsiya davri oxirida tuproqning yuqoridagi qatlamlarida mos holda hajm og‘irligi 1,37-1,38-1,39 g/sm^3 va 1,47-1,49-1,50 g/sm^3 tashkil qilib, 1-nazorat variantiga nisbatan 0,02-0,03-0,04 ва 0,01-0,02-0,04 g/sm^3 kamroq bo‘lganligi aniqlandi.

Mineral o‘g‘itlarga qo‘shimcha kompost-1 12 t/ga va kompost-2 14 t/ga miqdorlarda qo‘llanilgan 5 va 6 variantlarda vegetatsiya davri boshida tuproqning 0-30 va 30-50 sm qatlamlarda hajm og‘irligi 1,33-1,33 va 1,43-1,44 g/sm^3 tashkil qilgan holda, nazorat variantiga nisbatan 0,03-0,03 ва 0,02-0,03 g/sm^3 kamroq bo‘ldi. Vegetatsiya davri oxiriga kelib bu ayirmachiliklar 1-variantiga nisbatan kamroq bo‘ldi.

Gektariga 20 t/ga miqdorda kompost-3 qo‘llanilgan 7 variantda vegetatsiya davri boshida tuproqning 0-30 va 30-50 sm qatlamlarda hajm og‘irligi mos ravishda 1,32 va 1,43 g/sm^3 tashkil qilib, g‘o‘zaning vegetatsiya davri oxirida tuproqning yuqoridagi qatlamlarida mos holda hajm og‘irligi 1,36 va 1,47 g/sm^3 tashkil qildi hamda nazorat variantiga nisbatan mutonasib 0,05 ва 0,04 g/sm^3 kamroq bo‘lganligi aniqlandi.

Tajribada kompost-4 gektariga 22 tonna qo‘llanilgan 8-variantda esa variantda vegetatsiya davri boshida tuproqning 0-30 va 30-50 sm qatlamlarda hajm og‘irligi mos holda 1,31 va 1,42 g/sm^3 tashkil qilib, nazorat variantiga nisbatan mutonasib 0,05 ва 0,03 g/sm^3, go‘ng me’yorlariga nisbatan 0,03-0,02-0,01 ва 0,02-0,02-0,01 g/sm^3 kamaygan. Vegetatsiya davri oxirida yuqoridagi tuproq qatlamlarida mos ravishda hajm og‘irligi 1,35 va 1,46 g/sm^3 ni tashkil qildi va 1-nazorat variantiga nisbatan 0,06

va 0,05 g/sm^3 ga va go‘ng me’yorlariga solishtirganda 0,04-0,03-0,02 ва 0,04-0,03-0,02 g/sm^3 ga kamroq bo‘lganligi aniqlandi.

Kompost-5 24 t/ga qo‘llanilgan 9-variantda variantda vegetatsiya davri boshida tuproqning 0-30 va 30-50 sm qatlamlarda hajm og‘irligi mos 1,33 va 1,42 g/sm^3 bo‘lib, bu nazorat variantiga nisbatan 0,03 g/sm^3 va 0,03 g/sm^3 ga kamayganligi aniqlandi. Vegetatsiya davri oxiriga kelib bu ayirmachiliklar 1-variantiga nisbatan kamroq bo‘ldi.

XULOSA

Tadqiqot natijalariga ko‘ra, gektariga 22 tonna qo‘llanilgan 8-variantda esa variantda vegetatsiya davri boshida tuproqning 0-30 va 30-50 sm qatlamlarda hajm og‘irligi mos holda 1,31 va 1,42 g/sm^3 tashkil qilib, nazorat variantiga nisbatan mutonasib 0,05 ва 0,03 g/sm^3 kamaygan. Vegetatsiya davri oxirida yuqoridagi tuproq qatlamlarida mos ravishda hajm og‘irligi 1,35 va 1,46 g/sm^3 ni tashkil qilib, bu nazorat variantiga nisbatan 0,06 va 0,05 g/sm^3 ga kamroq bo‘lganligi aniqlandi.

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TOSHKENT VILOYATI SHAROITIDA INTRODUKSIYA QILINGAN AMARANT GENOTIPLARINING MORFOLOGIK XUSUSIYATLARI VA FUZARIOZ BILAN KASALLANISH DARAJASINI BAHOLASH

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Annotatsiya. *Mazkur tadqiqot Toshkent viloyatining tuproq-iqlim sharoitida xorijdan introduksiya qilingan amarant (*Amaranthus *spp.) genotiplarining morfologik xususiyatlarini tavsiflash, ularning fenotipik xilma-xilligini aniqlash hamda tabiiy infeksiya fonida fuzarioz bilan kasallanish darajasini baholashga bag‘ishlangan. Tadqiqotlar 2019–2022-yillarda olib borilib, Sho‘rlangan yerlarda biodehqonchilik xalqaro markazi (ICBA) orqali introduksiya qilingan New 65, New 21, Check 2, New 41, New 13, New 30, New 45, Check 7, Check 5, Check 3 va RRC-1027 genotiplari hamda andoza sifatida Marhamat navi o‘rganildi. Morfologik baholash jarayonida asosiy poyaning rangi va shakli, urug‘ qobig‘ining rangi, fiziologik pishgan ro‘vakning rangi va zichligi, barg shakli hamda barg cheti kabi belgilar hisobga olindi. Tadqiqot natijalariga ko‘ra, barcha genotiplarda poya shakli, barg shakli, barg cheti va ro‘vak zichligi bo‘yicha nisbatan bir xillik kuzatildi, biroq poya, urug‘ qobig‘i va fiziologik pishgan ro‘vak ranglarida yaqqol fenotipik farqlanish aniqlandi. Urug‘ qobig‘i rangining sariq, yashil, oq va qizil shakllarda namoyon bo‘lishi kolleksiya materiallarining morfologik xilma-xilligini ko‘rsatdi. Tabiiy infeksiya sharoitida fuzarioz bilan kasallanish darajasi genotiplar bo‘yicha 6,8–9,5% oralig‘ida bo‘ldi. Eng past kasallanish New 65, New 41 va RRC-1027 genotiplarida qayd etildi. Dala kuzatuvlarini urug‘larning laboratoriya sharoitidagi fitopatologik tahlili bilan birgalikda olib borish genotiplarning fitopatologik holatini kompleks baholash imkonini berdi. Olingan natijalar amarant genofondini mahalliy agroekologik sharoitda baholash, morfologik jihatdan farqlanuvchi va tabiiy infeksiya fonida nisbatan kam kasallangan genotiplarni ajratish hamda keyingi seleksiya va fitopatologik tadqiqotlar uchun istiqbolli boshlang‘ich materiallarni tanlashda ilmiy asos bo‘lib xizmat qiladi.*

Kalit so‘zlar: *Amaranthus, amarant, introduksiya, genotip, morfologik belgilar, fenotipik xilma-xillik, fuzarioz, Fusarium, kasallanish darajasi, urug‘ sog‘lomligi, seleksiya.*

Аннотация. *Настоящее исследование посвящено изучению морфологических особенностей интродуцированных генотипов амаранта*

*(*Amaranthus *spp.), оценке их фенотипического разнообразия и определению степени поражения растений фузариозом в почвенно-климатических условиях Ташкентской области. Исследования проводились в 2019–2022 годах. В качестве объектов изучения были использованы генотипы New 65, New 21, Check 2, New 41, New 13, New 30, New 45, Check 7, Check 5, Check 3 и RRC-1027, интродуцированные через Международный центр биоземледелия на засоленных землях (ICBA), а сорт Мархамат использовался в качестве стандарта. При морфологической оценке учитывались цвет и форма главного стебля, цвет семенной оболочки, цвет и плотность метёлки в фазе физиологической спелости, форма листа и край листовой пластинки. Установлено, что по форме стебля, форме листьев, краю листа и плотности метёлки изученные генотипы характеризовались относительным сходством. Вместе с тем выраженные фенотипические различия выявлены по окраске стебля, семенной оболочки и физиологически зрелой метёлки. Цвет семенной оболочки варьировал от жёлтого и зелёного до белого и красного, что свидетельствует о морфологическом разнообразии изученной коллекции. В условиях естественного инфекционного фона степень поражения фузариозом варьировала от 6,8 до 9,5%. Наиболее низкий уровень поражения отмечен у генотипов New 65, New 41 и RRC-1027. Комплексная оценка полевых наблюдений и лабораторного исследования фитопатологического состояния семян позволила более полно охарактеризовать изучаемые генотипы. Полученные результаты могут быть использованы при оценке амарантового генофонда в местных агроэкологических условиях, отборе перспективного исходного материала для селекции и проведении последующих фитопатологических исследований.*

Ключевые слова: *Amaranthus, амарант, интродукция, генотип, морфологические признаки, фенотипическая изменчивость, фузариоз, степень поражения, здоровье семян, генофонд, селекция.*

Abstract. *This study was aimed at characterizing the morphological traits of introduced amaranth (*Amaranthus *spp.) genotypes, assessing their phenotypic diversity, and determining the degree of Fusarium disease incidence under the soil and climatic conditions of the Tashkent Region. The research was conducted during 2019–2022. The study included the genotypes New 65, New 21, Check 2, New 41, New 13, New 30, New 45, Check 7, Check 5, Check 3, and RRC-1027, introduced through the International Center for Biosaline Agriculture (ICBA), while the Marhamat cultivar was used as a standard. Morphological evaluation included the color and shape of the main stem, seed coat color, color and density of the panicle at physiological maturity, leaf shape, and leaf margin. The results showed relative uniformity among the studied genotypes in stem shape, leaf shape, leaf margin, and panicle density. However, clear phenotypic differences were observed in stem color, seed coat color, and the color of physiologically mature panicles. Seed coat color varied among yellow, green, white, and red phenotypes, indicating considerable morphological diversity within the studied collection. Under natural infection conditions, Fusarium disease incidence ranged from 6.8 to 9.5% among the genotypes. The lowest incidence was recorded in New 65, New 41, and RRC-1027. The combined assessment of field observations and*

laboratory analysis of the phytopathological condition of seeds provided a more comprehensive characterization of the introduced genotypes. The obtained results provide a scientific basis for evaluating amaranth germplasm under local agroecological conditions, identifying promising genotypes as initial breeding material, and conducting further controlled inoculation and phytopathological studies.

Keywords: *Amaranthus, amaranth, introduction, genotype, morphological traits, phenotypic variation, Fusarium disease, disease incidence, seed health, germplasm, breeding.*

KIRISH

Amarant (*Amaranthus*) oziq-ovqat, ozuqa va qayta ishlash sanoatida ko‘p yo‘nalishli foydalanish imkoniyatiga ega ekinlardan biri hisoblanadi. Amarant urug‘lari oqsil, lipidlar va boshqa oziqaviy komponentlarning manbai bo‘lib, uning vegetativ biomassasidan ozuqa maqsadlarida foydalanish mumkin [2, 3]. Amarant moyining biologik qiymati tarkibidagi skvalen va boshqa lipid komponentlari bilan ham bog‘liq [2, 3].

Amaranthus genofondi morfologik belgilarning keng xilma-xilligi bilan tavsiflanadi. Poya va to‘pgul pigmentatsiyasi, barg morfologiyasi, to‘pgul tuzilishi hamda urug‘ rangi amarant kolleksiya materiallarini tavsiflash va differensiatsiyalashda qo‘llaniladigan muhim fenotipik deskriptorlardir [1]. Morfologik tavsiflash genofondni dastlabki baholash imkonini bersa-da, seleksiya uchun qimmatli boshlang‘ich materiallarni aniqlashda biologik va fitopatologik xususiyatlarni ham hisobga olish zarur.

Amarant C4 fotosintez tipiga mansub bo‘lib, ushbu fiziologik xususiyat yuqori harorat sharoitida fotosintetik jarayonlarning samaradorligi va suvdan foydalanish xususiyatlari bilan bog‘liq. Shu sababli turli geografik hududlardan introduksiya qilingan amarant genotiplarini muayyan tuproq-iqlim sharoitida o‘rganish ularning fenotipik xususiyatlarini aniqlash hamda mahalliy seleksiya dasturlari uchun boshlang‘ich materiallarni ajratishda muhimdir.

Introduksiya qilingan genotiplarni baholashda kasalliklarga munosabati alohida ahamiyat kasb etadi. *Fusarium* turkumiga mansub zamburug‘lar tuproq, o‘simlik qoldiqlari va urug‘ materialida uchrab, ko‘plab qishloq xo‘jaligi ekinlarida kasalliklarni keltirib chiqarishi mumkin [5, 7, 8]. *Fusarium oxysporum* tur kompleksi biologik va genetik jihatdan murakkab bo‘lib, uning tarkibida patogen va patogen bo‘lmagan shtammlar mavjud [6–8]. Shu sababli dala sharoitidagi kasallanish ko‘rsatkichlarini urug‘ sog‘lomligining laboratoriya tahlili bilan birgalikda o‘rganish genotiplarning fitopatologik holatini to‘liqroq tavsiflash imkonini beradi.

Tadqiqotning maqsadi: Toshkent viloyati tuproq-iqlim sharoitida xorijdan introduksiya qilingan amarant genotiplarining asosiy morfologik belgilarini tavsiflash, tabiiy infeksiya fonida fuzarioz bilan kasallanish darajasini aniqlash va keyingi seleksion hamda fitopatologik tadqiqotlar uchun istiqbolli boshlang‘ich materiallarni ajratish.

TADQIQOT MATERIALLARI VA USULLARI

Tadqiqotlar 2019–2022-yillarda Toshkent viloyati tuproq-iqlim sharoitida olib borildi. Tadqiqot obyekti sifatida Sho‘rlangan yerlarda biodehqonchilik xalqaro

markazi (ICBA) orqali xorijdan introduksiya qilingan New 65, New 21, Check 2, New 41, New 13, New 30, New 45, Check 7, Check 5, Check 3 va RRC-1027 (Oq amarant) genotiplari o‘rganildi. Marhamat navi andoza sifatida tajribaga kiritildi.

Dala tajribalarida fenologik kuzatuvlar va morfologik tavsiflash ishlari olib borildi. Morfologik baholashda asosiy poyaning rangi va shakli, urug‘ qobig‘i rangi, fiziologik pishgan ro‘vakning rangi va zichligi, barg shakli hamda barg cheti hisobga olindi.

Fuzarioz bilan tabiiy kasallanish dala sharoitida genotiplar kesimida kasallik belgilari qayd etilgan o‘simliklar sonini hisoblash asosida baholandi. Kasallangan o‘simliklar ulushi quyidagi formula asosida aniqlandi:

$$P = (n / N) \times 100,$$

bunda:

P-kasallangan o‘simliklar ulushi, %;

n-kasallangan o‘simliklar soni, dona;

N-hisobga olingan jami o‘simliklar soni, dona.

Urug‘ sog‘lomligini baholash laboratoriya sharoitida amalga oshirildi. Urug‘ yuzasi bilan bog‘liq zamburug‘larni aniqlash uchun steril suvda tayyorlangan suspenziya mikroskopik tekshirildi va oziqa muhitiga ekildi. Urug‘ning ichki to‘qimalari bilan bog‘liq zamburug‘larni aniqlash uchun yuzaki sterilizatsiya qilingan urug‘lar oziqa muhitiga joylashtirildi. Ekilgan namunalar 23–26 °C haroratda inkubatsiya qilinib, rivojlangan zamburug‘ koloniyalari makro- va mikromorfologik belgilariga ko‘ra baholandi.

Urug‘larning zamburug‘ bilan zararlanish ulushi quyidagi formula asosida hisoblandi:

$$X = (n_1 / M) \times 100,$$

bunda:

X-zararlangan urug‘lar ulushi, %;

n_1-zamburug‘ rivojlanishi aniqlangan urug‘lar soni, dona;

M-tahlil qilingan jami urug‘lar soni, dona.

NATIJALAR VA ULARNING MUHOKAMASI

Introduksiya qilingan amarant genotiplarining morfologik xususiyatlari.

Toshkent viloyati sharoitida introduksiya qilingan amarant genotiplarini morfologik baholash natijasida ayrim belgilar bo‘yicha umumiylik, ayrim belgilar bo‘yicha esa fenotipik farqlanish mavjudligi aniqlandi (1-jadval).

Toshkent viloyati tuproq-iqlim sharoitida introduksiya qilingan amarant genotiplarining morfologik belgilari (2019–2022-yy.) 1-jadval.

№	Genotip	Poya rangi	Poya shakli	Urug‘ qobig‘i rangi	Fiziologik pishgan ro‘vak rangi	Ro‘vak zichligi	Barg shakli	Barg cheti
1	New 65	Qizil	Oval	Sariq	Oq	Zich	Tuxumsimon	Arrasimon
2	New 21	Yashil	Oval	Yashil	Oq	Zich	Tuxumsimon	Arrasimon
3	Check 2	Qizil	Oval	Oq	Qizil	Zich	Tuxumsimon	Arrasimon
4	New 41	Yashil	Oval	Oq	Qizil	Zich	Tuxumsimon	Arrasimon

№	Genotip	Poya rangi	Poya shakli	Urug‘ qobig‘i rangi	Fiziologik pishgan ro‘vak rangi	Ro‘vak zichligi	Barg shakli	Barg cheti
5	New 13	Yashil	Oval	Qizil	Qizil	Zich	Tuxumsimon	Arrasimon
6	New 30	Yashil	Oval	Yashil	Qizil	Zich	Tuxumsimon	Arrasimon
7	New 45	Yashil	Oval	Sariq	Oq	Zich	Tuxumsimon	Arrasimon
8	Check 7	Yashil	Oval	Yashil	Oq	Zich	Tuxumsimon	Arrasimon
9	Check 5	Yashil	Oval	Sariq	Qizil	Zich	Tuxumsimon	Arrasimon
10	Check 3	Yashil	Oval	Yashil	Oq	Zich	Tuxumsimon	Arrasimon
11	RRC-1027 (Oq amarant)	Yashil	Oval	Sariq	Oq	Zich	Tuxumsimon	Arrasimon
12	Marhamat (andoza)	Yashil	Oval	Oq	Qizil	Zich	Tuxumsimon	Arrasimon

Barcha genotiplarda asosiy poya shakli oval, barg shakli tuxumsimon, barg cheti arrasimon va fiziologik pishgan ro‘vak zich bo‘ldi. Mazkur belgilar o‘rganilgan kolleksiya doirasida genotiplarni differensiatsiyalash imkonini bermadi.

Poya rangida esa aniq fenotipik farqlanish kuzatildi. New 65 va Check 2 namunalarida asosiy poya qizil, qolgan 10 ta genotipda yashil bo‘ldi. Shunga ko‘ra, kolleksiyaning 16,7% ida qizil, 83,3% ida yashil poya fenotipi qayd etildi.

Fiziologik pishgan ro‘vak rangiga ko‘ra genotiplar ikki guruhga ajraldi. New 65, New 21, New 45, Check 7, Check 3 va RRC-1027 namunalarida oq, Check 2, New 41, New 13, New 30, Check 5 hamda andoza Marhamat navida qizil ro‘vak qayd etildi. Oq va qizil ro‘vakli genotiplar o‘rganilgan materiallarning mos ravishda 50,0 va 50,0% ini tashkil etdi.

Amarant ekini 1-rasm

Nisbatan keng fenotipik xilma-xillik urug‘ qobig‘i rangida kuzatildi. New 65, New 45, Check 5 va RRC-1027 namunalarida sariq; New 21, New 30, Check 7 va Check 3 da yashil; Check 2, New 41 va Marhamat navida oq; New 13 namunasida qizil urug‘ qobig‘i qayd etildi. Sariq va yashil urug‘ qobig‘iga ega genotiplarning ulushi 33,3% dan, oq urug‘lilar 25,0%, qizil urug‘li genotip esa 8,3% ni tashkil etdi.

Natijalar poya rangi, urug‘ qobig‘i rangi va fiziologik pishgan ro‘vak rangining o‘rganilgan kolleksiyani morfologik tavsiflashda differensial belgilar ekanligini

ko‘rsatdi. Amarant germplazmasini o‘rganishga bag‘ishlangan tadqiqotlarda ham poya, to‘pgul va urug‘ pigmentatsiyasi genotiplarni morfologik differensiatsiyalashda informativ belgilar sifatida qayd etilgan [1].

Fuzarioz bilan kasallanish darajasi: Dala kuzatuvlari davomida introduksiya qilingan amarant genotiplarining tabiiy infeksiya fonida fuzarioz bilan kasallanishi baholandi. Kasallangan o‘simliklar ulushi genotiplar bo‘yicha 6,8–9,5% oralig‘ida o‘zgardi (2-jadval).

Introduksiya qilingan amarant genotiplarining dala sharoitida fuzarioz bilan kasallanish darajasi **2-jadval.**

№	Genotip	Hisobga olingan o‘simliklar, dona	Kasallangan o‘simliklar, dona	Kasallanish, %
1	New 65	44	3	6,8
2	New 21	43	4	9,3
3	Check 2	42	4	9,5
4	New 41	44	3	6,8
5	New 13	43	3	7,0
6	New 30	43	4	9,3
7	New 45	44	4	9,1
8	Check 7	43	4	9,3
9	Check 5	44	4	9,1
10	Check 3	43	3	7,0
11	RRC-1027 (Oq amarant)	44	3	6,8
12	Marhamat (andoza)	43	4	9,3

Andoza Marhamat navida 43 ta hisobga olingan o‘simlikdan 4 tasida kasallik belgilari qayd etilib, kasallanish 9,3% ni tashkil etdi. New 21, New 30 va Check 7 namunalarida ham kasallanish 9,3% bo‘lib, andoza bilan bir xil ko‘rsatkich qayd etildi. Check 2 namunasida 9,5% bilan tajribadagi eng yuqori ko‘rsatkich kuzatildi. New 45 va Check 5 namunalarida kasallangan o‘simliklar ulushi 9,1% ni tashkil etdi.

Eng past kasallanish New 65, New 41 va RRC-1027 namunalarida qayd etilib, 6,8% ni tashkil etdi. Bu andoza Marhamat navidan 2,5 foiz punktga past. New 13 va Check 3 namunalarida 7,0% kasallanish kuzatilib, andozaga nisbatan farq 2,3 foiz punktni tashkil etdi.

Shunday qilib, tabiiy infeksiya fonida New 65, New 41, New 13, Check 3 va RRC-1027 genotiplarida fuzarioz bilan kasallangan o‘simliklar ulushi andoza Marhamat naviga nisbatan past bo‘ldi. Biroq mavjud tajribada genotiplararo farqlarning statistik ishonchliligi va sun’iy inokulyatsiya sharoitidagi reaksiyasi aniqlanmaganligi sababli ushbu namunalarni “fuzariozga chidamli” deb qat’iy tasniflash ilmiy jihatdan yetarli asosga ega emas. Ularni tabiiy infeksiya fonida fuzarioz bilan nisbatan kam kasallangan genotiplar sifatida tavsiflash maqsadga muvofiq.

Mazkur natija seleksiya nuqtayi nazaridan ahamiyatli bo‘lib, nisbatan past kasallanish ko‘rsatkichiga ega genotiplarni nazorat qilinadigan infeksiya fonida takroriy baholash uchun ajratish imkonini beradi.

Amarant urug‘larining sog‘lomligini laboratoriya sharoitida baholash

Dala kuzatuvlarini to‘ldirish maqsadida amarant genotiplarining urug‘ sog‘lomligi laboratoriya sharoitida o‘rganildi. Urug‘ yuzasi va ichki to‘qimalari bilan bog‘liq zamburug‘larni differensial aniqlashga alohida e’tibor qaratildi.

Urug‘ yuzasidagi mikobiotani tekshirishda urug‘lardan steril suv yordamida tayyorlangan suspenziya mikroskopik kuzatildi va oziqa muhitiga ekildi. Urug‘ning ichki to‘qimalari bilan bog‘liq zamburug‘larni aniqlash uchun urug‘lar yuzaki sterilizatsiya qilinib, oziqa muhitiga joylashtirildi. Inkubatsiyadan keyin rivojlangan koloniyalar makroskopik va mikroskopik belgilariga ko‘ra baholandi.

Urug‘ bilan bog‘liq zamburug‘larni aniqlashda mikroskopik tekshiruv va oziqa muhitida inkubatsiya qilish klassik fitopatologik yondashuvlardan hisoblanadi [5, 9, 10]. Ushbu usullar urug‘ materialida zamburug‘larning mavjudligini aniqlash va izolyatlarni dastlabki tavsiflash imkonini beradi.

Shu bilan birga, *F. oxysporum* tur kompleksining genetik va biologik jihatdan murakkabligi hisobga olinishi zarur. Mazkur kompleks tarkibida patogen va patogen bo‘lmagan shtammlarning mavjudligi qayd etilgan [6–8]. Shuning uchun morfologik va mikroskopik belgilarga asoslangan identifikatsiya natijalarini tur va patogenlik darajasida yakuniy tasdiqlash uchun patogenlik sinovlari hamda molekulyar diagnostika usullaridan foydalanish ilmiy jihatdan maqsadga muvofiq.

Dala fitopatologik bahosi bilan urug‘ sog‘lomligining laboratoriya tahlilini birgalikda olib borish introduksiya qilingan amarant genotiplarining fitopatologik holatini kompleks tavsiflash imkonini beradi.

XULOSA

1. Toshkent viloyati tuproq-iqlim sharoitida o‘rganilgan introduksiya qilingan amarant genotiplari morfologik belgilar va tabiiy infeksiya fonida fuzarioz bilan kasallanish ko‘rsatkichlari bo‘yicha differensiatsiyalandi.

2. O‘rganilgan 12 ta genotipda poya shakli, barg shakli, barg cheti va ro‘vak zichligi bo‘yicha bir xillik kuzatilgan bo‘lsa, poya rangi, urug‘ qobig‘i rangi va fiziologik pishgan ro‘vak rangi fenotipik xilma-xillikni ifodalovchi belgilar sifatida ajralib turdi. Ayniqsa, urug‘ qobig‘i rangida sariq, yashil, oq va qizil fenotiplarning mavjudligi kolleksiya materiallarining morfologik xilma-xilligini ko‘rsatdi.

3. Tabiiy infeksiya fonida fuzarioz bilan kasallangan o‘simliklar ulushi 6,8–9,5% oralig‘ida bo‘ldi. Eng past kasallanish New 65, New 41 va RRC-1027 namunalarida 6,8%, New 13 va Check 3 namunalarida 7,0% qayd etildi. Andoza Marhamat navida ushbu ko‘rsatkich 9,3% ni tashkil etdi. New 65, New 41 va RRC-1027 da kasallanish andozaga nisbatan 2,5 foiz punktga past bo‘ldi.

4. Dala va laboratoriya kuzatuvlarini kompleks baholash New 65, New 41, New 13, Check 3 va RRC-1027 genotiplarini tabiiy infeksiya fonida fuzarioz bilan nisbatan kam kasallangan boshlang‘ich materiallar sifatida ajratish imkonini berdi. Ushbu genotiplarning fuzariozga reaksiyasini nazorat qilinadigan inokulyatsiya sharoitida takroriy baholash va ajratilgan *Fusarium* izolyatlarini molekulyar usullar bilan identifikatsiya qilish keyingi tadqiqotlarning muhim yo‘nalishi hisoblanadi.

5. Olingan natijalar introduksiya qilingan amarant genofondini morfologik va fitopatologik belgilar bo‘yicha kompleks baholash seleksiya uchun istiqbolli boshlang‘ich materiallarni ilmiy asosda ajratish imkonini berishini ko‘rsatadi.

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DYNAMICS OF LEAF NUMBER IN INTRODUCED QUINOA (*CHENOPODIUM QUINOA* WILLD.) VARIETY SAMPLES UNDER IRRIGATED CONDITIONS

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Abstract. *The study was conducted to evaluate the dynamics of leaf formation in introduced quinoa (Chenopodium quinoa Willd.) variety samples under irrigated conditions. Six quinoa materials, including Check1 (Ames-654), New 14 (Ames-13761), New 21 (BO-16), New 42 (CHEN-298), New 170 (PI433232), and New 141 (D-12229), were evaluated during the 2025 and 2026 growing seasons. Leaf number was determined at three successive developmental stages, and the mean value, standard deviation, and coefficient of variation were used to characterize the variability of the trait. In 2025, the mean number of leaves increased from 4.6–6.3 leaves at the first developmental stage to 20.9–28.8 leaves at the second stage and 38.1–49.8 leaves at the third stage. New 21 showed the highest leaf number at the first stage, while New 141 and New 42 demonstrated the highest values at the second and third stages, respectively. In 2026, the same general tendency of increasing leaf number was observed throughout plant development. New 21 maintained a high level of early leaf formation, whereas New 42 and New 141 demonstrated superior leaf formation during later developmental stages. The coefficient of variation was generally low at the second and third stages, indicating comparatively stable expression of the trait. The results demonstrate considerable differences among introduced quinoa materials in the dynamics of leaf formation and indicate that leaf number at different developmental*

stages can be used as an informative biometric characteristic in the comparative evaluation and selection of quinoa materials.

Keywords: *Chenopodium quinoa Willd., quinoa, leaf number, leaf formation, developmental stages, introduced variety samples, biometric traits, irrigated conditions.*

Annotatsiya. *Tadqiqot sug‘oriladigan sharoitda introduksiya qilingan quinoa (Chenopodium quinoa Willd.) nav namunalarida barglarning shakllanish dinamikasini baholash maqsadida olib borildi. 2025 va 2026-yillardagi vegetatsiya mavsumlarida oltita quinoa materiali, jumladan Check1 (Ames-654), New 14 (Ames-13761), New 21 (BO-16), New 42 (CHEN-298), New 170 (PI433232) va New 141 (D-12229) o‘rganildi. Barglar soni o‘simlik rivojlanishining ketma-ket uchta bosqichida aniqlandi hamda belgining o‘zgaruvchanligini tavsiflash uchun o‘rtacha qiymat, standart og‘ish va variatsiya koeffitsientidan foydalanildi. 2025-yilda barglarning o‘rtacha soni birinchi rivojlanish bosqichida 4,6–6,3 donadan ikkinchi bosqichda 20,9–28,8 donagacha, uchinchi bosqichda esa 38,1–49,8 donagacha oshdi. Birinchi bosqichda New 21 eng yuqori barg sonini ko‘rsatgan bo‘lsa, ikkinchi va uchinchi bosqichlarda mos ravishda New 141 va New 42 namunalarida eng yuqori qiymatlar qayd etildi. 2026-yilda ham o‘simlik rivojlanishi davomida barglar sonining ortib borish tendensiyasi kuzatildi. New 21 dastlabki barg hosil bo‘lishida yuqori ko‘rsatkichni saqlab qolgan bo‘lsa, keyingi rivojlanish bosqichlarida New 42 va New 141 namunalari yuqori barg hosil qilish ko‘rsatkichlarini namoyon etdi. Variatsiya koeffitsienti, odatda, ikkinchi va uchinchi bosqichlarda past bo‘lib, ushbu belgining nisbatan barqaror ifodalanishini ko‘rsatdi. Olingan natijalar introduksiya qilingan quinoa materiallari o‘rtasida barg hosil bo‘lish dinamikasi bo‘yicha sezilarli farqlar mavjudligini ko‘rsatadi hamda turli rivojlanish bosqichlaridagi barglar sonidan quinoa namunalarini qiyosiy baholash va tanlashda informativ biometrik belgi sifatida foydalanish mumkinligini ko‘rsatadi.*

Kalit so‘zlar: *Chenopodium quinoa Willd., quinoa, barglar soni, barg hosil bo‘lishi, rivojlanish bosqichlari, introduksiya qilingan nav namunalari, biometrik belgilar, sug‘oriladigan sharoit.*

Аннотация. *Исследование проведено с целью оценки динамики формирования листьев у интродуцированных образцов сортов киноа (Chenopodium quinoa Willd.) в условиях орошения. В течение вегетационных сезонов 2025 и 2026 годов были изучены шесть образцов киноа, включая Check1 (Ames-654), New 14 (Ames-13761), New 21 (BO-16), New 42 (CHEN-298), New 170 (PI433232) и New 141 (D-12229). Количество листьев определяли на трёх последовательных этапах развития растений, а для характеристики вариабельности признака использовали среднее значение, стандартное отклонение и коэффициент вариации. В 2025 году среднее количество листьев увеличивалось с 4,6–6,3 листа на первом этапе развития до 20,9–28,8 листа на втором этапе и 38,1–49,8 листа на третьем этапе. На первом этапе наибольшее количество листьев отмечено у образца New 21, тогда как на втором и третьем этапах наиболее высокие значения зарегистрированы соответственно у New 141 и New 42. В 2026 году также наблюдалась общая*

тенденция увеличения количества листьев по мере развития растений. Образец New 21 сохранял высокий уровень раннего формирования листьев, тогда как на последующих этапах развития New 42 и New 141 характеризовались более высокими показателями формирования листьев. Коэффициент вариации, как правило, был низким на втором и третьем этапах, что свидетельствует о сравнительно стабильном проявлении данного признака. Полученные результаты демонстрируют наличие значительных различий между интродуцированными образцами киноа по динамике формирования листьев и показывают, что количество листьев на различных этапах развития может использоваться в качестве информативного биометрического признака при сравнительной оценке и отборе образцов киноа.

Ключевые слова: *Chenopodium quinoa Willd., киноа, количество листьев, формирование листьев, этапы развития, интродуцированные образцы сортов, биометрические признаки, условия орошения.*

INTRODUCTION

Quinoa (*Chenopodium quinoa* Willd.) is an important annual crop characterized by substantial diversity in morphological, physiological and agronomic traits. The introduction and evaluation of diverse quinoa materials under new environmental conditions are important steps in identifying plant materials with valuable characteristics for agricultural production and breeding.

Leaves are the principal organs responsible for photosynthetic activity, and the number of leaves formed during plant development reflects the intensity of vegetative growth. Consequently, quantitative assessment of leaf number can provide useful information when comparing varieties and introduced samples. The expression of morphological traits is not constant throughout plant development. The number of leaves increases progressively as plants pass through successive developmental stages, while the rate of leaf formation can differ among genetic materials. Therefore, observations conducted at several stages may provide a more complete characterization of vegetative development than measurements taken at a single stage.

The evaluation of quinoa materials under irrigated conditions is particularly relevant for regions where irrigation plays an important role in crop production. Differences in leaf formation among introduced materials may reflect their biological characteristics and their response to local growing conditions. The present study focused on six introduced quinoa variety samples and examined the dynamics of leaf number during three developmental stages over two growing seasons. The main objective was to determine differences in leaf formation among the studied materials and to identify samples characterized by a comparatively high and stable number of leaves during plant development.

MATERIALS AND METHODS.

The research was conducted under irrigated conditions using six introduced quinoa variety samples. The studied materials were:

Code	Variety/sample
Check1	Ames-654
New 14	Ames-13761
New 21	BO-16

Code	Variety/sample
New 42	CHEN-298
New 170	PI433232
New 141	D-12229

The experimental design consisted of six materials with three replications. The experimental plot was established under irrigated conditions, and sowing in the first experimental year was carried out on 1 April 2025. Observations were conducted during the growing season in order to characterize the formation of vegetative organs at successive stages of plant development.

Determination of leaf number. Leaf number was recorded at three developmental stages. At each stage, leaves were counted on the plants included in the observations, and the obtained values were used to determine the mean number of leaves for each variety/sample.

The following statistical parameters were calculated:

- **M±m** — arithmetic mean and its error;
- **σ** — standard deviation;
- **V%** — coefficient of variation.

The coefficient of variation was calculated according to the equation:

$$V = (\sigma / M) \times 100$$

where M represents the arithmetic mean and σ represents the standard deviation. The obtained values were compared among the studied materials and between developmental stages in order to determine the dynamics of leaf formation.

RESULTS AND DISCUSSION

3.1. Leaf number at the first developmental stage. The first developmental stage was characterized by relatively low leaf numbers in all studied quinoa materials. However, considerable differences among the samples were observed.

In 2025, the mean number of leaves ranged from 4.6 ± 0.34 in Check1 to 6.3 ± 0.41 in New 21. The highest value was recorded in New 21, followed by New 170 with 5.9 ± 0.36 leaves and New 42 with 5.8 ± 0.39 leaves. New 14 had 5.7 ± 0.33 leaves, while Check1 and New 141 recorded 4.6 ± 0.34 and 4.7 ± 0.33 leaves, respectively.

The coefficient of variation ranged from 11.80% to 15.20%. The lowest variability was observed in New 14, whereas Check1 showed the highest variation.

In 2026, the mean number of leaves ranged from 4.8 ± 0.32 in Check1 to 6.5 ± 0.39 in New 21. New 21 again demonstrated the highest value. New 170 recorded 6.1 ± 0.34 leaves, while New 42 had 6.0 ± 0.37 leaves. The lowest value after Check1 was observed in New 141. The first-stage results therefore demonstrate a relatively consistent pattern across the two years. New 21 was distinguished by a comparatively high number of leaves during the initial phase of development.

Table 1. Leaf number at the first developmental stage in introduced quinoa variety samples in 2025–2026

Variety/sample	2025 M±m	σ	V, %	2026 M±m	σ	V, %
Check1	4.6±0.34	0.69	15.20	4.8±0.32	0.64	13.33
New 14	5.7±0.33	0.67	11.80	5.9±0.31	0.62	10.51
New 21	6.3±0.41	0.82	13.06	6.5±0.39	0.78	12.00

Variety/sample	2025 M±m	σ	V, %	2026 M±m	σ	V, %
New 42	5.8±0.39	0.78	13.60	6.0±0.37	0.74	12.33
New 170	5.9±0.36	0.73	12.50	6.1±0.34	0.69	11.31
New 141	4.7±0.33	0.67	14.36	4.9±0.31	0.62	12.65

3.2. Leaf number at the second developmental stage. The second developmental stage was associated with a pronounced increase in leaf number. In 2025, the mean values ranged from 20.9 ± 0.55 leaves in Check1 to 28.8 ± 0.39 leaves in New 141.

New 141 showed the highest value, followed by New 42 with 27.2 ± 0.45 leaves. New 170 and New 21 recorded 25.7 ± 0.41 and 25.2 ± 0.39 leaves, respectively. New 14 had 22.4 ± 0.53 leaves, while Check1 had the lowest value.

The coefficient of variation ranged from 2.73% to 5.26%. Such relatively low values indicate that the expression of leaf number was comparatively uniform within the studied materials at this developmental stage. In 2026, a similar increase in leaf number was observed. Check1 reached 21.8 leaves, while New 14, New 21, New 42, New 170 and New 141 reached 23.2, 26.0, 28.0, 26.4 and 29.5 leaves, respectively. New 141 remained the material with the highest leaf number at the second developmental stage, followed by New 42. This consistency indicates a relatively strong capacity for leaf formation during the intermediate period of vegetative development.

Table 2. Leaf number at the second developmental stage in 2025–2026

Variety/sample	2025 M±m	σ	V, %	2026 M±m	σ	V, %
Check1	20.9±0.55	1.10	5.26	21.8±0.52	1.04	4.77
New 14	22.4±0.53	1.04	4.79	23.2±0.50	1.00	4.31
New 21	25.2±0.39	0.78	3.13	26.0±0.38	0.76	2.92
New 42	27.2±0.45	0.91	3.37	28.0±0.44	0.88	3.14
New 170	25.7±0.41	0.82	3.20	26.4±0.40	0.80	3.03
New 141	28.8±0.39	0.78	2.73	29.5±0.38	0.76	2.58

3.3. Leaf number at the third developmental stage. The third developmental stage was characterized by the highest leaf numbers in all studied materials.

In 2025, New 42 showed the highest mean value, reaching 49.8 ± 0.56 leaves. New 141 followed closely with 49.2 ± 0.84 leaves. New 170 recorded 45.1 ± 0.89 leaves, while New 14 and New 21 had 41.6 ± 0.82 and 40.0 ± 0.74 leaves, respectively. The lowest value was observed in Check1, at 38.1 ± 1.11 leaves.

The coefficient of variation ranged from 2.27% in New 42 to 5.86% in Check1. The combination of a high mean value and low coefficient of variation in New 42 is particularly noteworthy, indicating a relatively stable expression of high leaf number at the later developmental stage. In 2026, the number of leaves increased further in all studied materials. New 42 recorded the highest value of 51.0 leaves, followed by New 141 with 50.3 leaves. New 170 reached 46.2 leaves, whereas New 14 and New 21 recorded 43.0 and 41.2 leaves, respectively. Check1 had the lowest value of 39.5 leaves. The results indicate that New 42 and New 141 were characterized by the greatest accumulation of leaves during the later stage of plant development.

Table 3. Leaf number at the third developmental stage in 2025–2026

Variety/sample	2025 M±m	σ	V, %	2026 M±m	σ	V, %
Check1	38.1±1.11	2.23	5.86	39.5±1.04	2.08	5.27
New 14	41.6±0.82	1.64	3.95	43.0±0.80	1.60	3.72
New 21	40.0±0.74	1.49	3.72	41.2±0.72	1.44	3.50
New 42	49.8±0.56	1.13	2.27	51.0±0.55	1.10	2.16
New 170	45.1±0.89	1.79	3.97	46.2±0.86	1.72	3.72
New 141	49.2±0.84	1.68	3.42	50.3±0.81	1.62	3.22

3.4. Dynamics of leaf formation across developmental stages. The three-stage observations clearly demonstrate progressive leaf formation in all six quinoa materials. In 2025, Check1 increased from 4.6 leaves at the first stage to 20.9 leaves at the second stage and 38.1 leaves at the third stage. New 14 increased from 5.7 to 22.4 and subsequently to 41.6 leaves. New 21 increased from 6.3 to 25.2 and then to 40.0 leaves. New 42 increased from 5.8 leaves at the first stage to 27.2 at the second and 49.8 at the third stage. New 170 increased from 5.9 to 25.7 and subsequently to 45.1 leaves. New 141 showed an increase from 4.7 leaves at the first stage to 28.8 at the second and 49.2 leaves at the third stage.

A similar developmental pattern was observed in 2026. The number of leaves increased from the first stage to the second and third stages in all studied materials. New 42 reached the highest value at the third stage, while New 141 remained close to it.

Table 4. Dynamics of leaf number according to developmental stage in 2025–2026

Variety/sample	2025 Stage I	2025 Stage II	2025 Stage III	2026 Stage I	2026 Stage II	2026 Stage III
Check1	4.6	20.9	38.1	4.8	21.8	39.5
New 14	5.7	22.4	41.6	5.9	23.2	43.0
New 21	6.3	25.2	40.0	6.5	26.0	41.2
New 42	5.8	27.2	49.8	6.0	28.0	51.0
New 170	5.9	25.7	45.1	6.1	26.4	46.2
New 141	4.7	28.8	49.2	4.9	29.5	50.3

The dynamics indicate that the ranking of the studied materials changed during ontogenetic development. New 21 demonstrated the highest number of leaves at the initial stage, whereas New 141 became the leading material at the second stage. At the third stage, New 42 demonstrated the highest leaf number. This pattern suggests that early leaf formation and subsequent leaf accumulation represent related but not identical characteristics. Some materials may initiate leaf development more actively at the beginning of growth, while others may demonstrate stronger leaf accumulation during subsequent vegetative development.

The relatively high values observed in New 42 and New 141 during the later stages indicate a strong development of the leaf apparatus. This characteristic may be of interest in further comparative studies of vegetative productivity and plant architecture.

3.5. Interannual comparison. Comparison between the two growing seasons showed a generally similar pattern of leaf formation. The mean leaf number in 2026 was slightly higher than in 2025 for all six studied materials.

At the first stage, the increase ranged from 0.2 leaves in all materials. At the second stage, the increase ranged from 0.7 leaves in New 14 to 0.9 leaves in Check1 and New 141. At the third stage, differences between years ranged from 1.2 leaves in New 21 to 1.4 leaves in New 42 and New 170. The general consistency of the ranking of materials across years indicates that differences in leaf formation were not entirely random. New 21 maintained a high position during the first stage, while New 42 and New 141 showed superior performance during later stages.

From a breeding perspective, the stability of a morphological characteristic across developmental stages and growing seasons is an important consideration. Materials that combine a high mean value with comparatively low variability may be useful candidates for further evaluation.

CONCLUSION

The investigation of six introduced quinoa variety samples under irrigated conditions demonstrated clear differences in the dynamics of leaf formation during three developmental stages.

In the first developmental stage, New 21 recorded the highest mean leaf number in both years, with 6.3 leaves in 2025 and 6.5 leaves in 2026. At the second developmental stage, New 141 demonstrated the highest values, reaching 28.8 leaves in 2025 and 29.5 leaves in 2026. At the third developmental stage, New 42 had the highest leaf number, with 49.8 leaves in 2025 and 51.0 leaves in 2026. New 141 was also characterized by a high leaf number, reaching 49.2 and 50.3 leaves, respectively. The coefficient of variation was relatively low at the second and third developmental stages, particularly in New 42 and New 141. This indicates comparatively stable expression of leaf number during the later phases of plant development. The study demonstrates that assessment of leaf number at several developmental stages provides more informative characterization of quinoa vegetative development than a single measurement. The differences observed among the introduced materials indicate the presence of distinct patterns of leaf formation. New 42 and New 141 can be considered particularly noteworthy materials with regard to high leaf number during later developmental stages, while New 21 demonstrated comparatively strong early leaf formation.

Leaf number and its developmental dynamics may therefore be used as supplementary biometric characteristics in the comparative evaluation of introduced quinoa materials and in the identification of promising materials for further breeding studies.

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MARJUMAKNI POYA BALANDLIGIGA EKISH MUDDATI, ME’YORI VA USULLARINING TA’SIRI

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Annotatsiya. *Ushbu maqolada marjumak (Fagopyrum esculentum Moench.) o‘simligining asosiy poya balandligiga ekish muddati, ekish me’yori va ekish usullarining ta’siri bo‘yicha olib borilgan tadqiqot natijalari keltirilgan. Tadqiqotlar Toshkent davlat agrar universitetining eksperimental ilmiy-tadqiqot va o‘quv tajriba xo‘jaligida qadimdan sug‘oriladigan tipik bo‘z tuproqlar sharoitida olib borildi. Tajribada marjumakning “Iliyshevskaya” navi takroriy ekin sifatida uch xil ekish muddatida (20-iyun, 1-iyul, 10-iyul), uch xil ekish me’yorida (1,0; 2,0; 3,0 mln. dona urug‘/ga) hamda uch xil ekish usulida (yakka, qo‘sh va uch qatorli) ekib o‘rganildi.*

Tadqiqot natijalariga ko‘ra, marjumak o‘simligining poya balandligi bo‘yicha eng yuqori ko‘rsatkich boshqa muddatlarga nisbatan erta muddatda 20-iyunda 3,0 mln. dona urug‘/ga me’yorda uch qatorli usulda ekilgan variantda kuzatilib, meva hosil bo‘lish davrida 88-105 sm ga yetganligi aniqlandi. Mazkur variant 1,0 mln. dona urug‘/ga yakka qatorli va 2,0 mln. dona urug‘/ga qo‘sh qatorli ekilgan variantlarga nisbatan solishtirilganda mos ravishda 17 sm va 11 sm yuqori bo‘lganligi qayd etildi. Ekish muddatining kechikishi va ekish me’yorining oshishi poya balandligining o‘zgarishiga sezilarli ta’sir ko‘rsatganligi, bu esa o‘z navbatida o‘simlikning yotib qolishga chidamliligi va hosil shakllanishiga bevosita bog‘liq ekanligi ilmiy asoslandi.

Kalit so‘zlar: *marjumak, poya balandligi, ekish muddati, ekish me’yori, ekish usullari, takroriy ekin, hosildorlik.*

Аннотация. *В данной статье представлены результаты исследований по изучению влияния сроков посева, норм высева и способов посева на высоту стебля гречихи (Fagopyrum esculentum Moench.). Исследования проводились в экспериментальном научно-исследовательском и учебно-опытном хозяйстве Ташкентского государственного аграрного университета в условиях типичных орошаемых серозёмов. В опыте сорт гречихи «Илишевская» изучался в качестве повторной культуры при трёх сроках посева (20 июня, 1 июля, 10 июля), трёх нормах высева (1,0; 2,0; 3,0 млн шт. всхожих семян/га) и трёх способах посева (однострочный, двустрочный и трёхстрочный).*

По результатам исследований установлено, что наивысший показатель высоты стебля гречихи отмечен при раннем сроке посева 20 июня с нормой высева 3,0 млн шт./га трёхстрочным способом, достигая в фазу плодообразования 88-105 см. Данный вариант превосходил варианты с однострочным посевом при норме 1,0 млн шт./га и двустрочным посевом при норме 2,0 млн шт./га соответственно на 17 см и 11 см. Установлено, что

задержка сроков посева и увеличение нормы высева оказывают существенное влияние на изменение высоты стебля, что, в свою очередь, непосредственно связано с устойчивостью растений к полеганию и формированием урожая. Полученные результаты имеют важное практическое значение для определения оптимальных агротехнических параметров возделывания гречихи в качестве повторной культуры.

Ключевые слова: *гречиха, высота стебля, срок посева, норма высева, способы посева, повторная культура, урожайность.*

Abstract. *This article presents the results of studies on the effect of sowing dates, seeding rates and planting methods on the stem height of buckwheat (Fagopyrum esculentum Moench.). The research was conducted at the experimental research and training farm of Tashkent State Agrarian University under the conditions of typical irrigated sierozem soils. In the experiment, the buckwheat variety "Ilishevskaya" was studied as a second crop with three sowing dates (June 20, July 1, July 10), three seeding rates (1.0; 2.0; 3.0 million germinating seeds/ha) and three planting methods (single-row, double-row and three-row).*

According to the research results, the highest stem height of buckwheat was observed at the early sowing date June 20 with a seeding rate of 3.0 million seeds/ha using the three-row method, reaching 88-105 cm at the fruit formation stage. This variant exceeded the variants with single-row sowing at 1.0 million seeds/ha and double-row sowing at 2.0 million seeds/ha by 17 cm and 11 cm, respectively. It was established that delayed sowing dates and increased seeding rates significantly affect stem height, which in turn is directly related to plant lodging resistance and yield formation. The obtained results are of great practical importance for determining the optimal agrotechnical parameters for cultivating buckwheat as a second crop.

Keywords: *buckwheat, stem height, sowing date, seeding rate, planting methods, second crop, yield.*

KIRISH

Marjumak (*Fagopyrum esculentum Moench.*) qimmatli yorma don, yem-xashak ekini bo‘lib, uning doni yuqori ozuqaviylik qiymatiga, rutin, flavonoidlar, muhim aminokislotalar va minerallarga boyligi bilan ajralib turadi. Unidan konditerlik sanoatida foydalaniladi. Somoni hayvonlarni oziqlantirish uchun ishlatiladi. 100 kg somonda 30 ozuqa birligi mavjud[1, 6, 7, 11].

Jahon miqyosida marjumak yetishtirishda hosildorlik va don sifatining barqarorligi ko‘p jihatdan ekish muddati, me’yori, usuli hamda o‘simliklarning poya balandligi va yotib qolishga (lodging) chidamliligiga bog‘liq [5, 17].

Poya balandligi bu marjumakning muhim morfologik ko‘rsatkichlaridan biri bo‘lib, u o‘simlikning yotib qolishga chidamliligini, yorug‘likdan foydalanish samaradorligini va hosil shakllanishini belgilaydi [15, 18]. Tadqiqotlar shuni ko‘rsatadiki, poya balandligi mahalliy sharoitga mos ekish muddati, maqbul ko‘chat qalinligi va o‘simliklarning bir tekis joylashishini ta’minlovchi ekish usullari hisobiga maqbullashtiriladi; aksincha, haddan tashqari ko‘chat qalinligi va noo‘rin ekish muddati poyalarni uzun, ingichka va yotib qolishga moyil qiladi [8, 9, 12, 13, 14, 15, 19].

Xususan, Lee va boshqalar Koreyada o‘tkazilgan tadqiqotda ekish kechiktirilganda o‘simlik bo‘yi, poya diametri va quruq modda massasi kamayganligini aniqlagan [12]. Xiang va boshqalar Xitoyda iyulda ekilgan tartariq marjumakda past harorat stressi va quyosh radiatsiyasining kamayishi hisobiga hosildorlik va o‘sish ko‘rsatkichlari sezilarli pasayganligini qayd etgan [20].

Rossiyada “Devyatka” navi uchun 3,0 mln. dona/ga me’yorida keng qatorli ekish eng samarali bo‘lgan [16]. Braziliyada 110 kg/ga ekish me’yori yuqori hosil olishni ta’minlagan [8]. Xitoyda 45 kg/ga azot va 90 tup/m² ko‘chat qalinilikda eng yuqori hosil (1339,44 kg/ga) olingan [10].

Dala ekinlari hayotining faollik darajasini ko‘rsatuvchi eng muhim jarayonlardan biri bu o‘sishdir. Bu jarayonda o‘simlik tanasida barcha fiziologik va biokimyoviy reaksiyalar sodir bo‘lib, natijada yangi hujayralar hamda organlarning hosil bo‘lishi bilan ularning umumiy quruq massasini ortib borishi kuzatiladi [4, 10]. Shu bilan birgalikda o‘simliklarning o‘sishiga tashqi sharoitning ko‘plab omillari o‘z ta’sirini ko‘rsatadi [12, 20].

Marjumak o‘simligi nisbatan tezpishar o‘simliklardan biri bo‘lib, bu o‘simlikda barcha rivojlanish fazalar boshqa o‘simliklarga nisbatan tez va qisqa muddatlarda kechadi [11, 12].

Marjumakda o‘sish va rivojlanish jarayonining kechishi ma’lum darajada asosiy poya balandligida yaqqol namoyon bo‘ladi [19]. O‘simlikda fiziologik jarayonlar qanchalik jadal kechsa, o‘sish va rivojlanish jarayonlari shunchalik faol kechadi [10, 20].

MATERIAL VA TADQIQOT USLUBLARI.

Tadqiqot ishlari Toshkent davlat agrar universitetining eksperimental ilmiy-tadqiqot va o‘quv tajriba xo‘jaligida 2015-2017-yillar davomida olib borildi. Tajriba maydoni Toshkent viloyati Qibray tumanida joylashgan bo‘lib, qadimdan sug‘oriladigan tipik bo‘z tuproqlar bilan xarakterlanadi.

Tajriba ob’ekti sifatida marjumakning “Iliyshevskaya” navi tanlab olindi. Ushbu nav takroriy ekin sifatida uch xil ekish muddatida (20-iyun, 1-iyul, 10-iyul), uch xil ekish me’yorida (1,0; 2,0 va 3,0 mln. dona/ga) hamda uch xil ekish usulida (yakka, qo‘sh va uch qatorli) ekib o‘rganildi. Variantlarning bunday kombinatsiyasi ekish omillarining marjumak o‘sishi, rivojlanishi va hosil shakllanishiga ta’sirini har tomonlama baholash imkonini berdi.

Dala tajribalarida fenologik kuzatishlar va biometrik o‘lchovlar bir qator ilmiy-uslubiy qo‘llanmalar asosida olib borildi. Xususan, “Методика Государственного сортоиспытания сельскохозяйственных культур”, “Дала тажрибаларини ўтказиш услублари”, “O‘simlikshunoslikda ilmiy tadqiqot ishlari” kabi manbalardan keng foydalanildi[2]. O‘simliklarning fotosintetik faolligini aniqlashda A.A.Nichiporovich uslubiyoti qo‘llanildi. Iqtisodiy samaradorlik V.N.Polozhiy usuli bo‘yicha baholandi. Olingan raqamli ma’lumotlarga statistik ishlov berishda B.A.Dospexovning “Методика полевого опыта” qo‘llanmasi asosidagi dispersiyaviy tahlil usuli qo‘llanilgan bo‘lib, hisoblashlar Microsoft Excel dasturida bajarildi[3].

NATIJALAR VA ULARNING MUHOKAMASI.

O‘simlikning asosiy poya balandligi o‘simlikda o‘sish jarayonining qay darajada

kechishini o‘zida aks ettiradi. O‘simlik sog‘lom o‘ssa, undagi barcha jarayonlar, shu jumladan fiziologik va biokimyoviy jarayonlar jadal kechsa o‘simlikning asosiy poya balandligi ham yuqori bo‘ladi. Biroq, o‘simlikning asosiy poya balandligi ham me’yor darajasida bo‘lishi lozim. Poya balandligi juda past bo‘lsa, o‘simlik nimjon o‘sadi va unda yetarlicha hosil elementlari shakllanmaydi. Aksincha poya balandligi me’yordan yuqori bo‘lsa o‘simlikning o‘suv va hosil elementlari nisbatida o‘suv organlarining salmog‘i ortib ketadi, o‘simlik yotib qolishga moyil bo‘ladi. Natijada hosildorlik sezilarli kamayishi kuzatiladi. Shu tafayli har bir ekinning eng maqbul ko‘chat qalinligini o‘rganish muhim ilmiy va amaliy ahamiyatga ega.

Poya balandligi turli omillarga, shu jumladan o‘simlikning biologik xususiyatlariga, nav xususiyatiga, tuproq iqlim sharoitiga, olib borilgan agrotexnik tadbirlarga, o‘simlikning oziqlanish maydoni va ko‘chat qalinligiga bog‘liq.

Har bir o‘simlikning biologik xususiyati va nav xarakteristikasidan kelib chiqqan holda optimal ko‘chat qalinligi turlicha bo‘ladi. Shu tufayli tajribada ekish me’yori, muddati va usullarini marjumakning asosiy poya balandligiga ta’sirini o‘rganishni o‘z oldimizga maqsad qilib oldik.

Ekish muddati, me’yori va usullarini marjumak o‘simligining o‘sish jarayonlariga, shuningdek asosiy poya balandliga ma’lum darajada ta’sir etishi rivojlanishning dastlabki davridan boshlab namoyon bo‘ldi.

Tadqiqot natijalarini tahlil qilish shuni ko‘rsatdiki, marjumakning asosiy poya balandligi ekish muddati, ekish me’yori va ekish usulining o‘zaro kombinatsiyasiga bevosita bog‘liq bo‘lib, bu qonuniyat barcha fenologik rivojlanish fazalarida izchil namoyon bo‘ldi (1-jadval).

1-jadval

Marjumakni poya balandligiga ekish muddati, me’yori va usullarining ta’siri (2015-2017 yy.)

№	Ekish muddati	Ekish me’yori, mln. dona/ga	Ekish usuli	Asosiy poya balandligi, sm			
				Shoxlanish	Shonalash	Gullash	Meva hosil bo‘lish
1.	20 iyun	1,0	Yakka qatorli	21	54	66	88
2.		2,0	Qo‘sh qatorli	23	57	71	94
3.		3,0	Uch qatorli	25	62	76	105
4.	1 iyul	1,0	Yakka qatorli	19	49	61	85
5.		2,0	Qo‘sh qatorli	21	53	67	89
6.		3,0	Uch qatorli	22	58	72	91
7.	10 iyul	1,0	Yakka qatorli	17	47	59	79
8.		2,0	Qo‘sh qatorli	19	50	64	82
9.		3,0	Uch qatorli	21	55	67	84

Eng yuqori poya balandligi 20-iyunda ekilgan, ekish me’yori 3,0 mln. dona urug‘/ga bo‘lgan uch qatorli usul variantida (3-variant) kuzatildi. Ushbu variantda poya balandligi shoxlanish fazasida 25 sm, shonalash fazasida 62 sm, gullash fazasida 76 sm va meva hosil bo‘lish fazasida 105 sm ni tashkil etdi. Bu ko‘rsatkichlar tajribadagi barcha boshqa variantlarga nisbatan yuqori bo‘lib, o‘simlikning vegetativ va generativ organlarini to‘liq shakllantirish uchun eng qulay agrotexnik sharoit aynan mazkur kombinatsiyada yaratilganligidan dalolat beradi.

1-rasm

Ayni shu ekish muddatida (20-iyun) ekish usuli va me'yorining differensial ta'siri yaqqol namoyon bo‘ldi. Yakka qatorli usulda 1,0 mln. dona urug‘/ga ekilgan variantda (1-variant) meva hosil bo‘lish fazasida poya balandligi 88 sm ni tashkil etgan bo‘lsa, qo‘sh qatorli usulda 2,0 mln. dona urug‘/ga ekilgan variantda (2-variant) bu ko‘rsatkich 94 sm ga yetdi. Demak, uch qatorli usulda 3,0 mln. dona urug‘/ga ekilgan variantga (3-variant, 105 sm) nisbatan yakka qatorli variant 17 sm ga, qo‘sh qatorli variant esa 11 sm ga past bo‘lgan. Bu farq o‘simliklar orasidagi ozuqa maydoni, yorug‘lik rejimi va raqobat munosabatlarining ekish sxemasiga qarab tubdan o‘zgarishini ko‘rsatgan.

Mazkur qonuniyat keyingi ekish muddatlarida 1-iyul va 10-iyulda ham to‘liq saqlanib qoldi, bu esa aniqlangan tendensiyaning tasodifiy emas, balki qonuniy xarakterga ega ekanligini tasdiqlaydi. Xususan, 1-iyulda ekilgan variantlar ichida 3,0 mln. dona urug‘/ga uch qatorli usulda ekilgan variantda (6-variant) meva hosil bo‘lish fazasida poya balandligi 91 sm bo‘lib, yakka qatorli variantga (4-variant, 85 sm) nisbatan 6 sm, qo‘sh qatorli variantga (5-variant, 89 sm) nisbatan esa 2 sm yuqori bo‘ldi. 10-iyulda ekilgan variantlar ichida ham shunga o‘xshash holat kuzatilib, uch qatorli usulda 3,0 mln. dona urug‘/ga ekilgan variantda (9-variant) poya balandligi 84 sm ni tashkil etib, yakka qatorli variantdan (7-variant, 79 sm) 5 sm, qo‘sh qatorli variantdan (8-variant, 82 sm) 2 sm yuqori bo‘lgan.

XULOSA

Tajriba natijalariga ko‘ra marjumak o‘simligining poya balandliligi bo‘yicha eng yuqori ko‘rsatkich boshqa muddatlarga nisbatan erta muddatda 3,0 mln. dona urug‘/ga uch qatorli usulda ekilgan variantda kuzatilgan bo‘lib, 88-105 smga yetkanligi kuzatildi. Bu variant 1,0 mln. dona urug‘/ga yakka qatorli va 2,0 mln. dona urug‘/ga qo‘sh qatorli ekilgan variantlarga nisbatan solishtirilganda 17 sm va 11 sm yuqori bo‘lganligi kuzatilgan.

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OLIY TA'LIM TIZIMIDA INNOVATSION XIZMATLAR SAMARADORLIGINI OSHIRISHNING IQTISODIY ASOSLARI

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Annotatsiya. *Mazkur maqolada oliy ta'lim tizimida innovatsion xizmatlar samaradorligini oshirishning iqtisodiy asoslari tadqiq etilgan. Unda oliy ta'lim xizmatlarining iqtisodiy mazmuni, innovatsion yondashuvlarning ta'lim sifati, inson kapitali va mehnat bozori bilan bog'liqligi ilmiy jihatdan tahlil qilingan. Shuningdek, raqamli platformalar, elektron ta'lim, akademik boshqaruv, sifat monitoringi va universitetlarning ish beruvchilar bilan hamkorligi innovatsion xizmatlar samaradorligini oshirishning muhim omillari sifatida ko'rib chiqilgan. Tadqiqot natijasida oliy ta'limda innovatsion xizmatlarni rivojlantirish resurslardan oqilona foydalanish, ta'lim sifatini oshirish va raqobatbardosh kadrlar tayyorlashning muhim iqtisodiy sharti ekanligi asoslab berilgan.*

Kalit so'zlar: *oliy ta'lim, innovatsion xizmatlar, ta'lim xizmatlari, iqtisodiy samaradorlik, inson kapitali, raqamli iqtisodiyot, universitet boshqaruvi, mehnat bozori, ta'lim sifati, raqamli transformatsiya.*

Аннотация. *В статье исследуются экономические основы повышения эффективности инновационных услуг в системе высшего образования. Рассмотрены экономическое содержание образовательных услуг, влияние инновационных подходов на качество образования, человеческий капитал и потребности рынка труда. Особое внимание уделено цифровым платформам, электронному обучению, академическому управлению, мониторингу качества и сотрудничеству университетов с работодателями. В результате исследования обосновано, что развитие инновационных услуг в высшем образовании является важным условием рационального использования ресурсов, повышения качества образования и подготовки конкурентоспособных кадров.*

Ключевые слова: *высшее образование, инновационные услуги, образовательные услуги, экономическая эффективность, человеческий капитал, цифровая экономика, управление университетом, рынок труда, качество образования, цифровая трансформация.*

Abstract. *This article examines the economic foundations for improving the efficiency of innovative services in the higher education system. The study analyzes the economic nature of higher education services and the impact of innovative approaches on education quality, human capital and labour market needs. Particular attention is paid to digital platforms, e-learning, academic management, quality monitoring and cooperation between universities and employers. The research substantiates that the*

development of innovative services in higher education is an important condition for rational use of resources, improvement of education quality and training of competitive specialists.

Keywords: *higher education, innovative services, educational services, economic efficiency, human capital, digital economy, university management, labour market, education quality, digital transformation.*

KIRISH

Bugungi kunda oliy ta’lim tizimi iqtisodiy taraqqiyotning oddiy ijtimoiy sohasi emas, balki inson kapitalini shakllantiruvchi va innovatsion iqtisodiyotga malakali kadrlar yetkazib beruvchi muhim institut sifatida namoyon bo‘lmoqda. Raqamli iqtisodiyot sharoitida universitetlardan faqat nazariy bilim berish emas, balki amaliy ko‘nikma, innovatsion fikrlash, tadbirkorlik madaniyati va raqamli kompetensiyalarni shakllantirish talab qilinadi. Bu esa oliy ta’lim xizmatlari mazmunini ham, ularni tashkil etish mexanizmlarini ham yangilashni zarur qiladi.

Oliy ta’lim tizimida innovatsion xizmatlar deganda elektron ta’lim platformalari, masofaviy ta’lim, virtual laboratoriyalar, raqamli kutubxonalar, individual ta’lim trayektoriyalari, startap loyihalar, ilmiy-amaliy inkubatorlar, universitet va ishlab chiqarish o‘rtasidagi hamkorlikka asoslangan xizmatlar tushuniladi. Bunday xizmatlar oliy ta’lim muassasalarining iqtisodiy samaradorligini oshirish, mavjud resurslardan oqilona foydalanish va ta’lim oluvchilarning mehnat bozoridagi raqobatbardoshligini kuchaytirishga xizmat qiladi.

O‘zbekiston Respublikasida ta’lim tizimini modernizatsiya qilish, raqamli texnologiyalarni joriy etish va innovatsion rivojlanishni jadallashtirish bo‘yicha keng ko‘lamli islohotlar amalga oshirilmoqda. “Raqamli O‘zbekiston – 2030” strategiyasida raqamli infratuzilmani rivojlantirish, raqamli ko‘nikmalarga ega kadrlar tayyorlash va zamonaviy axborot texnologiyalarini keng qo‘llash muhim vazifa sifatida belgilangan. “2022–2026-yillarga mo‘ljallangan Yangi O‘zbekistonning taraqqiyot strategiyasi”da esa ta’lim sifatini oshirish, yoshlarning intellektual salohiyatini rivojlantirish hamda innovatsion yondashuvlarni amaliyotga joriy etish masalalari alohida o‘rin tutadi.

Shu jihatdan oliy ta’lim tizimida innovatsion xizmatlar samaradorligini oshirishning iqtisodiy asoslarini tadqiq etish dolzarb ilmiy-amaliy ahamiyatga ega. Maqolaning maqsadi oliy ta’limda innovatsion xizmatlar samaradorligini oshirishga ta’sir etuvchi iqtisodiy omillarni aniqlash, mavjud muammolarni tahlil qilish va ularni takomillashtirish bo‘yicha ilmiy takliflar ishlab chiqishdan iborat. Tadqiqot obyekti sifatida oliy ta’lim tizimida innovatsion xizmatlarni rivojlantirish jarayoni, predmeti sifatida esa ushbu xizmatlarning iqtisodiy samaradorlikka ta’sir etuvchi tashkiliy, moliyaviy va raqamli omillari tanlangan.

MAVZUGA OID ADABIYOTLAR SHARHI

Oliy ta’lim tizimida innovatsion xizmatlar samaradorligi masalasi raqamli iqtisodiyot, inson kapitali, ta’lim xizmatlari bozori va universitet boshqaruvi bilan bevosita bog‘liq. A. Abdullayev raqamli iqtisodiyot sharoitida zamonaviy ta’lim texnologiyalarining iqtisodiy mazmunini izohlab, ta’lim xizmatlarini raqamlashtirish xarajatlarni optimallashtirish va bilim olish imkoniyatlarini kengaytirishga xizmat qilishini ta’kidlaydi [3]. Bu yondashuv oliy ta’limdagi innovatsion xizmatlarni alohida

texnik vosita emas, balki iqtisodiy samaradorlikni oshiruvchi boshqaruv mexanizmi sifatida baholash imkonini beradi.

D. Bell postindustrial jamiyat nazariyasida bilim, axborot va ilmiy salohiyat iqtisodiy rivojlanishning asosiy omiliga aylanishini asoslaydi [4]. M. Kastels esa axborotlashgan jamiyatda tarmoqlashgan iqtisodiyot, kommunikatsion texnologiyalar va bilim almashinuvi iqtisodiy o‘sishning muhim sharti ekanligini ko‘rsatadi [5]. Ushbu nazariy qarashlar oliy ta’lim tizimida innovatsion xizmatlarni rivojlantirishning kengroq ijtimoiy-iqtisodiy mohiyatini ochib beradi.

Isxakova S. A. va Amriyeva Sh. Sh. oliy ta’lim tizimi samaradorligini oshirish masalasini o‘rganib, ta’lim sifati, boshqaruv yondashuvlari va innovatsion mexanizmlar o‘rtasidagi bog‘liqlikka alohida e’tibor qaratadi [6]. Amriyeva Sh. Sh. oliy ta’lim muassasalarida ta’lim xizmatlari sifatini yaxshilash yo‘llarini tahlil qilib, xizmat ko‘rsatish sifati, talabalar ehtiyojlari, raqamli monitoring va ta’lim jarayonining moslashuvchanligi samaradorlikni oshirishda muhim ahamiyatga ega ekanligini asoslaydi [7].

Sh. I. Artikova va K. D. Rajabova o‘quv jarayonini innovatsion yondashuv asosida tashkil etish masalalarini tadqiq etib, interaktiv pedagogik texnologiyalar va zamonaviy metodlarning ta’lim natijalariga ta’sirini ko‘rsatadi [8]. Amriyeva Sh. Sh., Akobirova M. A. va Normukhammadova A. Sh. raqamli iqtisodiyotda oliy ta’lim xizmatlari tizimining rivojlanish yo‘nalishlarini tahlil qilib, universitet xizmatlari sifati mehnat bozori talablari, raqamli infratuzilma va institutsional boshqaruv bilan chambarchas bog‘liq ekanligini qayd etadi [9].

Shuningdek, Yo‘ldashev Sh. ta’lim tizimida innovatsion rivojlanish va raqamli transformatsiya jarayonlarini o‘rganib, raqamli texnologiyalar ta’lim tizimida faqat texnik yangilanish emas, balki o‘quv jarayoni, baholash, boshqaruv va kadrlar tayyorlash tizimining sifat jihatdan o‘zgarishini bildiradi, degan fikrni ilgari suradi [10]. Xorijiy manbalarda esa oliy ta’lim xizmatlari samaradorligi ko‘proq inson kapitali, universitetlarning innovatsion ekotizimdagi roli va mehnat bozori bilan integratsiyasi orqali izohlanadi.

TADQIQOT METODOLOGIYASI

Maqolani tayyorlashda tizimli yondashuv, qiyosiy tahlil, iqtisodiy tahlil, mantiqiy umumlashtirish, induksiya va deduksiya usullaridan foydalanildi. Tizimli yondashuv asosida oliy ta’limdagi innovatsion xizmatlar universitet boshqaruvi, moliyaviy resurslar, raqamli infratuzilma, pedagogik jarayon va mehnat bozori bilan bog‘liq yaxlit tizim sifatida o‘rganildi.

Qiyosiy tahlil usuli an’anaviy ta’lim xizmatlari va innovatsion ta’lim xizmatlarining iqtisodiy samaradorlikka ta’sirini solishtirishda qo‘llanildi. Bunda xarajatlar, ta’lim qamrovi, xizmat sifati, talabalar faolligi, raqamli monitoring imkoniyatlari va bitiruvchilarning mehnat bozoriga moslashuvi kabi ko‘rsatkichlar e’tiborga olindi.

Iqtisodiy tahlil orqali innovatsion xizmatlarning resurslardan foydalanish samaradorligi, vaqt va moliyaviy xarajatlarni qisqartirish, akademik jarayonlarni avtomatlashtirish hamda oliy ta’lim muassasalarining raqobatbardoshligini

oshirishdagi roli baholandi. Normativ-huquqiy hujjatlar va ilmiy adabiyotlar tahlili esa mavzuning nazariy va amaliy asoslarini aniqlashtirishga yordam berdi.

TAHLIL VA NATIJALAR

Oliy ta’lim tizimida innovatsion xizmatlar samaradorligi, avvalo, ta’lim xizmatlarining mazmuni va ularni tashkil etish usullarining yangilanishi bilan bog‘liq. An’anaviy ta’limda asosiy e’tibor auditoriya mashg‘ulotlari, ma’ruza va seminarlar, bosma o‘quv adabiyotlari va standart baholash shakllariga qaratilgan bo‘lsa, innovatsion ta’lim xizmatlarida elektron platformalar, raqamli kontent, masofaviy ta’lim, individual yondashuv va amaliy loyihalar muhim o‘rin egallaydi.

Innovatsion xizmatlarning iqtisodiy samaradorligi bir necha yo‘nalishda ko‘rinadi. Birinchi yo‘nalish xarajatlarni optimallashtirishdir. Raqamli ta’lim platformalari va elektron resurslar bosma materiallar, ortiqcha ma’muriy jarayonlar va ayrim tashkiliy xarajatlarni kamaytiradi. Albatta, dastlab raqamli infratuzilma uchun mablag‘ talab etiladi, lekin uzoq muddatda bu investitsiyalar ta’lim jarayonining tejamkorligi va moslashuvchanligini oshiradi.

Ikkinchi yo‘nalish ta’lim xizmatlari qamrovining kengayishidir. Masofaviy ta’lim, onlayn kurslar va elektron kutubxonalar hududiy cheklovlarni kamaytiradi. Bu ayniqsa ishlayotgan talabalar, chekka hududlarda yashovchi yoshlar va qayta tayyorlash kurslarida qatnashuvchi mutaxassislar uchun muhimdir. Ta’lim xizmatlaridan foydalanish imkoniyati kengaygan sari inson kapitaliga kiritilayotgan investitsiyalarning ijtimoiy-iqtisodiy qaytimi ham ortadi.

Uchinchi yo‘nalish sifat monitoringining kuchayishidir. Raqamli platformalar talabalar faolligi, topshiriqlar bajarilishi, o‘zlashtirish ko‘rsatkichlari va pedagogik faoliyat natijalarini kuzatish imkonini beradi. Bu boshqaruv qarorlarini taxmin yoki umumiy kuzatuvlarga emas, aniq ma’lumotlarga tayangan holda qabul qilishga yordam beradi. Natijada universitet boshqaruvida ma’lumotlarga asoslangan yondashuv shakllanadi.

To‘rtinchi yo‘nalish mehnat bozori bilan integratsiyadir. Innovatsion xizmatlar tarkibiga amaliy loyihalar, startap inkubatorlar, ish beruvchilar bilan hamkorlikda ishlab chiqilgan o‘quv kurslari, professional sertifikatlash va amaliyot dasturlari kirganda, bitiruvchilarning ishga joylashish imkoniyati ortadi. Bu oliy ta’lim xizmatlari samaradorligini faqat ta’lim jarayonidagi natijalar bilan emas, balki keyingi iqtisodiy natijalar bilan ham baholash zarurligini ko‘rsatadi.

1-jadval

Oliy ta’lim tizimida innovatsion xizmatlarning iqtisodiy samaradorlikka ta’siri

Innovatsion xizmat turi	Iqtisodiy mazmuni	Samaradorlikka ta’siri	Kutiladigan natija
Elektron ta’lim platformalari	O‘quv jarayonini raqamli muhitda tashkil etish	Bosma materiallar va tashkiliy xarajatlar kamayadi	Ta’lim jarayoni tejamkor va tezkor bo‘ladi
Masofaviy ta’lim xizmatlari	Hududiy cheklovlarsiz bilim olish imkoniyati	Ta’lim qamrovi kengayadi	Ko‘proq talabalar oliy ta’lim xizmatlaridan foydalanadi

Innovatsion xizmat turi	Iqtisodiy mazmuni	Samaradorlikka ta’siri	Kutiladigan natija
Raqamli monitoring tizimi	Talabalar o‘zlashtirishi va faolligini kuzatish	Boshqaruv qarorlari aniqligi ortadi	Ta’lim sifati ustidan nazorat kuchayadi
Virtual laboratoriyalar	Amaliy ko‘nikmalarni raqamli muhitda shakllantirish	Laboratoriya xarajatlari qisman optimallashadi	Amaliy ta’lim imkoniyatlari kengayadi
Virtual laboratoriyalar	Amaliy ko‘nikmalarni raqamli muhitda shakllantirish	Laboratoriya xarajatlari qisman optimallashadi	Amaliy ta’lim imkoniyatlari kengayadi
Startap va inkubatsiya xizmatlari	Talabalar innovatsion loyihalarini qo‘llab-quvvatlash	Universitetning innovatsion faolligi ortadi	Tadbirkorlik ko‘nikmalari rivojlanadi
Ish beruvchilar bilan hamkorlik	O‘quv dasturlarini mehnat bozori talablariga moslashtirish	Bitiruvchilar bandligi oshadi	Raqobatbardosh kadrlar tayyorlanadi

Manba: *mualliflar tomonidan ilmiy adabiyotlar va oliy ta’lim tizimidagi amaliy jarayonlar tahlili asosida tuzilgan.*

Jadvaldan ko‘rinadiki, innovatsion xizmatlar oliy ta’lim tizimida bir vaqtning o‘zida bir nechta iqtisodiy vazifani bajaradi. Ular xarajatlarni qisqartiradi, ta’lim qamrovini kengaytiradi, boshqaruv jarayonlarini tezlashtiradi va talabalar uchun amaliy natijani kuchaytiradi. Shu bilan birga, bu xizmatlarning samaradorligi ularni oddiy texnik vosita sifatida joriy etishga emas, balki universitetning umumiy rivojlanish strategiyasiga bog‘lashga bog‘liq.

Innovatsion xizmatlarni rivojlantirishda oliy ta’lim muassasalarining moliyaviy barqarorligi ham muhim omil hisoblanadi. Zamonaviy platformalar, laboratoriyalar, raqamli kutubxonalar va startap markazlarini tashkil etish ma’lum xarajatlarni talab qiladi. Shu bois davlat moliyalashtirishidan tashqari grantlar, ilmiy loyihalar, xususiy sektor bilan hamkorlik, xalqaro dasturlar va pullik qo‘shimcha ta’lim xizmatlaridan oqilona foydalanish zarur. Mablag‘ manbalari diversifikatsiya qilinmasa, innovatsion xizmatlar barqaror rivojlanishi qiyinlashadi.

Yana bir muhim jihat pedagog kadrlarning innovatsion kompetensiyasidir. Raqamli platforma, elektron kutubxona yoki virtual laboratoriya mavjud bo‘lishi o‘z-o‘zidan ta’lim sifatini oshirmaydi. Bu vositalardan qanday foydalanish, ularni o‘quv jarayoniga qanday integratsiya qilish va talabani faol ishtirokchi sifatida jalb etish o‘qituvchining kasbiy tayyorgarligiga bog‘liq. Shuning uchun innovatsion xizmatlar samaradorligini oshirishda pedagoglarning raqamli va metodik kompetensiyasini rivojlantirish alohida ahamiyat kasb etadi.

Oliy ta’lim tizimida innovatsion xizmatlar samaradorligini oshirishga to‘sqinlik qilayotgan ayrim muammolar ham mavjud. Ular qatoriga raqamli infratuzilmaning barcha ta’lim muassasalarida bir xil rivojlanmaganligi, o‘quv kontentining sifati, elektron resurslarning yetarli emasligi, professor-o‘qituvchilarning raqamli ko‘nikmalari turlicha ekani, ish beruvchilar bilan hamkorlikning ayrim hollarda formal tusda qolishi kiradi. Bu muammolar hal etilmasa, innovatsion xizmatlarning iqtisodiy samarasi to‘liq namoyon bo‘lmaydi.

Shu sababli oliy ta’limdagi innovatsion xizmatlar samaradorligini baholashda faqat texnik jihozlanish darajasiga qarash yetarli emas. Baholash mezonlari ta’lim sifati, talabalar qoniqishi, bitiruvchilar bandligi, o‘quv jarayonining tejamkorligi, ilmiy-innovatsion faollik va raqamli boshqaruv samaradorligini ham qamrab olishi kerak. Ana shunda innovatsion xizmatlar universitet faoliyatining haqiqiy iqtisodiy natijalariga bog‘lanadi.

XULOSA VA TAKLIFLAR

Oliy ta’lim tizimida innovatsion xizmatlar samaradorligini oshirish zamonaviy iqtisodiy rivojlanishning muhim shartlaridan biridir. Raqamli iqtisodiyot sharoitida universitetlar faqat bilim beruvchi muassasa sifatida emas, balki inson kapitalini rivojlantiruvchi, innovatsion g‘oyalarni shakllantiruvchi va mehnat bozori uchun raqobatbardosh kadrlar tayyorlovchi markaz sifatida faoliyat yuritishi zarur.

Tahlil natijalari shuni ko‘rsatadiki, innovatsion xizmatlar oliy ta’limda xarajatlarni optimallashtirish, ta’lim qamrovini kengaytirish, sifat monitoringini takomillashtirish, boshqaruv qarorlarini tezlashtirish va bitiruvchilarning amaliy tayyorgarligini oshirishga xizmat qiladi. Biroq bu natijalarga erishish uchun innovatsion xizmatlar universitet boshqaruvi, moliyalashtirish tizimi, pedagogik metodika va mehnat bozori bilan uzviy bog‘langan bo‘lishi kerak.

Mazkur yo‘nalishda quyidagi takliflarni ilgari surish mumkin: birinchidan, oliy ta’lim muassasalarida innovatsion xizmatlarni rivojlantirish bo‘yicha alohida strategik dasturlar ishlab chiqish; ikkinchidan, raqamli platformalar va elektron resurslar sifatini baholash mezonlarini joriy etish; uchinchidan, professor-o‘qituvchilarning raqamli va innovatsion kompetensiyasini muntazam oshirish; to‘rtinchidan, ish beruvchilar bilan hamkorlikni amaliy loyihalar, stajirovka va qo‘shma o‘quv dasturlari orqali kuchaytirish; beshinchidan, innovatsion xizmatlarni moliyalashtirishda grantlar, davlat-xususiy sheriklik va xalqaro dasturlardan foydalanishni kengaytirish maqsadga muvofiq.

Shuningdek, oliy ta’lim xizmatlari samaradorligini baholashda talabalar qoniqishi, bitiruvchilar bandligi, ta’lim jarayonining raqamlashtirilganlik darajasi, ilmiy loyihalar soni va universitetning mehnat bozori bilan aloqalari kabi ko‘rsatkichlardan foydalanish lozim. Bu yondashuv innovatsion xizmatlarning real iqtisodiy natijasini aniqroq ko‘rsatadi.

Umuman olganda, oliy ta’lim tizimida innovatsion xizmatlarni rivojlantirish iqtisodiy resurslardan oqilona foydalanish, ta’lim sifatini oshirish va inson kapitalini mustahkamlashning samarali yo‘nalishidir. Bu jarayon izchil davom ettirilsa, universitetlarning raqobatbardoshligi ortadi, iqtisodiyot uchun zamonaviy kadrlar tayyorlash imkoniyati kengayadi va innovatsion rivojlanish uchun barqaror ilmiy-amaliy muhit shakllanadi.

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O‘ZBEKISTON RESPUBLIKASI DAVLAT QARZINING TARKIBIY TUZILISHI: TASHQI VA ICHKI QARZ NISBATI TAHLILI

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Annotatsiya. *Maqolada O‘zbekiston Respublikasi davlat qarzining tarkibiy tuzilishi - tashqi va ichki qarz nisbati, valyuta va kreditorlar tarkibi, foiz stavkalari tuzilmasi hamda jalb qilingan mablag’larning tarmoqlar bo‘yicha taqsimoti tahlil qilingan. Iqtisodiyot va moliya vazirligi hamda Markaziy bankning 2017-2025-yillardagi rasmiy ma'lumotlari asosida qarz portfelidagi tarkibiy siljishlar aniqlangan: ichki qarz ulushining bosqichma-bosqich oshib borishi, xalqaro moliya institutlari hissasining yuqoriligi va qarz portfelining dollarlashuvi bilan bog’liq risklar ochib berilgan. Tahlil natijalari asosida ichki qarz bozorini rivojlantirish va valyuta tarkibini diversifikatsiya qilish bo‘yicha takliflar ishlab chiqilgan.*

Kalit so‘zlar: *davlat qarzi, tashqi qarz, ichki qarz, qarz portfeli, valyuta tarkibi, davlat qimmatli qog’ozlari, xalqaro moliya institutlari, fiskal barqarorlik.*

Аннотация. *В статье проанализирована структура государственного долга Республики Узбекистан - соотношение внешнего и внутреннего долга, валютная структура и структура кредиторов, структура процентных ставок, а также отраслевое распределение привлечённых средств. На основе официальных данных Министерства экономики и финансов и Центрального банка за 2017-2025 годы выявлены структурные сдвиги в долговом портфеле: постепенный рост доли внутреннего долга, высокая доля международных финансовых институтов и риски, связанные с долларизацией долгового портфеля. По результатам анализа разработаны предложения по развитию внутреннего долгового рынка и диверсификации валютной структуры.*

Ключевые слова: *государственный долг, внешний долг, внутренний долг, долговой портфель, валютная структура, государственные ценные бумаги, международные финансовые институты, фискальная устойчивость.*

Abstract. *The article analyzes the structure of the public debt of the Republic of Uzbekistan - the ratio of external and domestic debt, the currency and creditor composition, the interest rate structure, and the sect oral distribution of borrowed funds. Based on official data of the Ministry of Economy and Finance and the Central Bank for 2017-2025, structural shifts in the debt portfolio are identified: a gradual increase in the share of domestic debt, a high share of international financial*

institutions, and risks associated with the dollarization of the debt portfolio. Based on the results of the analysis, proposals have been developed for the development of the domestic debt market and diversification of the currency structure.

Keywords: *public debt, external debt, domestic debt, debt portfolio, currency composition, government securities, international financial institutions, fiscal sustainability.*

KIRISH

So‘nggi yillarda O‘zbekistonda amalga oshirilayotgan keng ko‘lamli iqtisodiy islohotlar, infratuzilma va ijtimoiy soha loyihalarini moliyalashtirish ehtiyoji davlat qarzining jadal o‘sishiga olib keldi. Iqtisodiyot va moliya vazirligi ma’lumotlariga ko‘ra, davlat qarzi qoldig’i 2017-yilda 11,6 mlrd dollarni tashkil etgan bo‘lsa, 2026-yilning 1-yanvar holatiga 46,8 mlrd dollarga yetdi, ya’ni sakkiz yil davomida to‘rt baravardan ziyodga oshdi [9]. Bunday sharoitda qarzning umumiy hajmi va uning yalpi ichki mahsulotga nisbati bilan bir qatorda, qarz portfelining ichki tuzilishi - tashqi va ichki qarz nisbati, valyuta tarkibi, kreditorlar tuzilmasi hamda foiz stavkalari tarkibi masalalari alohida ilmiy va amaliy ahamiyat kasb etadi.

Qarz portfelining tarkibiy tuzilishi mamlakatning valyuta, foiz va qayta moliyalashtirish risklariga qay darajada ta'sirchanligini belgilaydi. Tashqi qarz ulushi yuqori bo‘lgan portfel milliy valyuta kursining o‘zgarishiga sezgir bo‘lib, so‘m qadrsizlanganda qarz yuki va unga xizmat ko‘rsatish xarajatlari avtomatik ravishda ortadi. Shu bois 2023-yil 29-aprelda qabul qilingan “Davlat qarzi to‘g’risida”gi Qonunda davlat qarzini valyutalar va manbalar bo‘yicha diversifikatsiya qilish hamda milliy valyutada mablag’ jalb qilish amaliyotini kengaytirish qarz boshqaruvining ustuvor yo‘nalishlari sifatida belgilangan [1].

“O‘zbekiston - 2030” strategiyasida iqtisodiyotni barqaror yuqori sur'atlarda o‘stirish va makroiqtisodiy barqarorlikni ta'minlash vazifalari qo‘yilgan bo‘lib [3], ularning ijrosi qarz siyosatining oqilona yuritilishi bilan bevosita bog’liq. Mazkur maqolaning maqsadi - rasmiy statistik ma'lumotlar asosida O‘zbekiston davlat qarzining tarkibiy tuzilishini kompleks tahlil qilish, undagi tarkibiy siljishlarni aniqlash va portfel tuzilmasini takomillashtirish bo‘yicha takliflar ishlab chiqishdan iborat.

MAVZUGA OID ADABIYOTLARNING TAHLILI

Davlat qarzi muammolari jahon iqtisodiyot fanida keng o‘rganilgan. B.Eyxengrin va hammualliflar davlat qarzining tarixiy evolyutsiyasini tadqiq etib, qarz mablag’lari davlatlarga inqirozlarga qarshi turish, urushlar va pandemiyalar oqibatlarini yumshatish hamda rivojlanish loyihalarini moliyalashtirish imkonini berganini asoslaydi va qarzning o‘zi emas, balki uni boshqarish sifati hal qiluvchi omil ekanini ta’kidlaydi [4]. Ushbu mualliflar jamoasining Xalqaro valyuta jamg’armasi doirasidagi tadqiqotida esa yuqori qarz darajasidan chiqishning tarixiy yo‘llari - iqtisodiy o‘sish, fiskal konsolidatsiya va moliyaviy repressiya mexanizmlari qiyosiy tahlil qilingan [6].

O.Blanshar foiz stavkasi iqtisodiy o‘sish sur’atidan past bo‘lgan sharoitda qarzning fiskal xarajati pasayishini ko‘rsatib, qarz siyosatiga qat’iy miqdoriy chegaralar emas, balki mamlakatning o‘ziga xos sharoitlaridan kelib chiqqan holda yondashish zarurligini asoslaydi [5]. Bu xulosa rivojlanayotgan mamlakatlar, jumladan

O‘zbekiston uchun ham muhim: nominal YAIM o‘sishi qarz o‘sishidan yuqori bo‘lgan davrlarda qarz yuki barqarorlashadi.

O‘zbekiston davlat qarzi xalqaro moliya institutlarining mamlakat bo‘yicha hisobotlarida ham baholab boriladi. Xalqaro valyuta jamg’armasining IV modda bo‘yicha maslahatlashuvlar hisobotida O‘zbekiston davlat qarzi darajasi o‘rtacha muddatli istiqbolda barqaror deb topilgan, biroq davlat ishtirokidagi korxonalarning kafolatlanmagan qarzlari bilan bog’liq shartli majburiyatlar fiskal risk manbai sifatida qayd etilgan [7]. Jahon banki tomonidan tayyorlangan davlat xarajatlari sharhida esa qarz hisobidan moliyalashtiriladigan xarajatlar samaradorligini oshirish va fiskal risklar monitoringini kuchaytirish tavsiya etilgan [8]. Osiyo taraqqiyot banki mintaqaviy sharhlarida O‘zbekistonda investitsiya faolligining yuqoriligi tashqi moliyalashtirishga bo‘lgan ehtiyojni saqlab qolayotgani ko‘rsatilgan [12].

Shu bilan birga, mavjud tadqiqotlarning aksariyati davlat qarzining umumiy hajmi va YAIMga nisbati dinamikasiga qaratilgan bo‘lib, qarz portfelining ichki tarkibiy tuzilishi - tashqi va ichki qarz nisbati, valyuta, kreditor va stavkalar tarkibi kesimidagi kompleks tahlillar yetarli darajada yoritilmagan. Mazkur maqola ana shu bo‘shliqni to‘ldirishga qaratilgan.

TADQIQOT METODOLOGIYASI

Tadqiqotda statistik guruhlash, dinamik qatorlar tahlili, tarkibiy (strukturaviy) tahlil, qiyosiy tahlil hamda ilmiy abstraksiya usullaridan foydalanildi. Axborot bazasini O‘zbekiston Respublikasi Iqtisodiyot va moliya vazirligining davlat qarzi holati va dinamikasi bo‘yicha sharhlari [9], Markaziy bankning to‘lov balansi, xalqaro investitsiya mavqei va tashqi qarz sharhlari [10], Milliy statistika qo‘mitasining rasmiy ma’lumotlari [11] hamda xalqaro moliya institutlarining hisobotlari tashkil etdi. Tahlil 2017-2025-yillarni qamrab oladi. Qarz portfelining tarkibiy tuzilishi to‘rt kesimda o‘rganildi: manbalar (tashqi/ichki), valyutalar, kreditorlar va foiz stavkalari tarkibi hamda jalb qilingan mablag’larning tarmoqlar bo‘yicha taqsimoti.

TAHLIL VA NATIJALAR

Davlat qarzining umumiy dinamikasi tahlili uning jadal, biroq boshqariladigan sur’atlarda o‘sib borayotganini ko‘rsatadi. Davlat qarzi qoldig’i 2017-yildagi 11,6 mlrd dollardan 2019-yil yakuniga 17,8 mlrd, 2020-yil yakuniga 23,4 mlrd, 2021-yil yakuniga 26,3 mlrd dollarga yetdi [9]. Pandemiya davrida byudjet taqchilligini moliyalashtirish ehtiyoji qarz o‘sishini tezlashtirdi: qarzning YAIMga nisbati 2017-yildagi 16,1 foizdan 2020-yilda 33,4 foizgacha, 2021-yil boshiga esa 39 foizgacha ko‘tarildi [9]. Keyingi yillarda nominal YAIMning tez o‘sishi hisobiga bu ko‘rsatkich pasayish tendensiyasiga o‘tdi: 2023-yil boshiga 36,4 foiz, 2025-yil yakuniga esa 31,9 foizni tashkil etdi. 2025-yilda nominal YAIM o‘sish sur'ati (21,1 foiz) davlat qarzi o‘sish sur’atidan (16,7 foiz) yuqori bo‘lgani qarz yukining 2022-yildan buyon ilk bor qisqarishini ta’minladi [9]. Bu ko‘rsatkich “Davlat qarzi to‘g’risida”gi Qonunda belgilangan chegaraviy darajadan (YAIMning 60 foizi) va tuzatuvchi choralar ko‘rila boshlanadigan darajadan (50 foiz) ancha past [1]

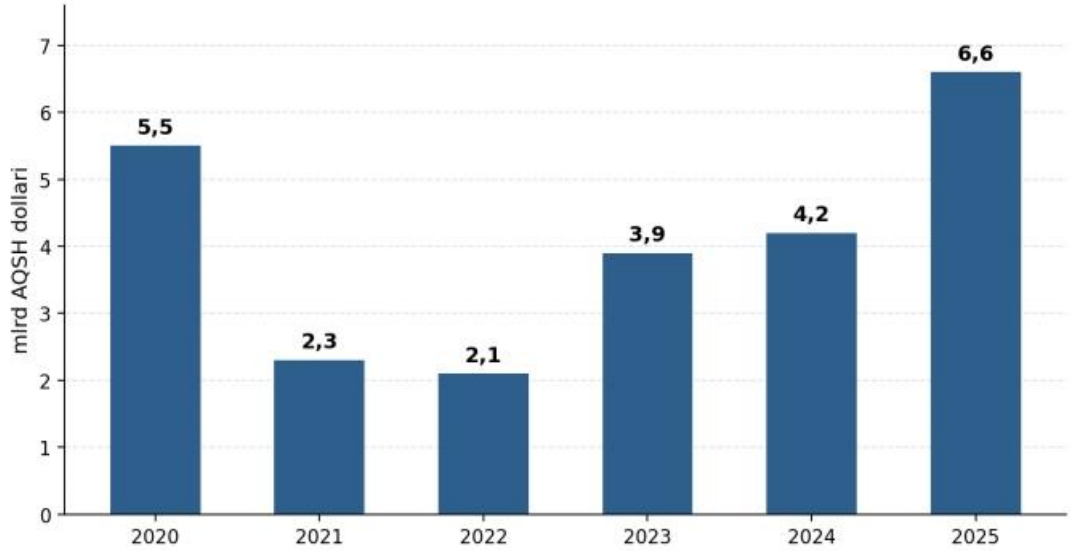
1-jadval

O‘zbekiston davlat qarzining hajmi va tarkibiy tuzilishi dinamikasi

Sana	Jami davlat qarzi, mlrd doll.	Tashqi qarz, mlrd doll.	Ichki qarz, mlrd doll.	Ichki qarz ulushi, %	YAIMga nisbati, %
01.01.2022	26,3	23,6	2,7	10,3	38,0
01.01.2023	29,2	25,9	3,3	11,3	36,4
01.10.2025	44,0	36,7	7,2	16,4	32,3
01.01.2026	46,8	39,8	7,0	15,0	31,9

1-jadval ma’lumotlaridan ko‘rinib turibdiki, qarz portfelida tashqi qarz mutlaq ustunlikka ega bo‘lib qolmoqda: 2026-yilning 1-yanvar holatiga uning ulushi 85 foizni tashkil etdi. Shu bilan birga, ichki qarzning ham mutlaq hajmi, ham ulushi izchil oshib bormoqda: ichki qarz qoldig’i 2022-yil boshidagi 2,7 mlrd dollardan 2026-yil boshiga 7,0 mlrd dollarga yetib, 2,6 baravar ko‘paydi, uning umumiy qarzdagi ulushi esa 10,3 foizdan 15 foizgacha kengaydi [9]. Bu davlat g’aznachilik obligatsiyalari emissiyasining faollashuvi va ichki moliya bozorining bosqichma-bosqich rivojlanishi natijasidir. Biroq xalqaro amaliyot bilan taqqoslaganda ichki qarz ulushi hali ham past bo‘lib, qarz portfelining valyuta riskiga ta'sirchanligini saqlab qolmoqda.

Davlat tashqi qarzining yillik o‘sish sur'atlari tahlili qonunchilik asosidagi tartibga solish mexanizmlarining samarasini ko‘rsatadi. Markaziy bank ma'lumotlariga ko‘ra, davlat tashqi qarzining yillik o‘sishi 2020-yilda 5,5 mlrd dollarni tashkil etgan bo‘lsa, 2021-2022-yillarda 2,1-2,3 mlrd dollargacha pasaydi, 2023-2025-yillarda esa yirik infratuzilma loyihalari va byudjetni qo‘llab-quvvatlash ehtiyoji hisobiga yana o‘sish kuzatildi (1-rasm) [10].



1-rasm. Davlat tashqi qarzining yillik o‘sishi, mlrd AQSH dollari

Kreditorlar tarkibi tahlili davlat tashqi qarzining asosan imtiyozli va uzoq muddatli manbalardan shakllanganini ko‘rsatadi. 2025-yil yakuni holatiga tashqi qarzning 22,3 mlrd dollari yoki 56 foizi xalqaro moliya institutlari hissasiga to‘g’ri keladi, eng yirik kreditorlar Jahon banki va Osiyo taraqqiyot banki hisoblanadi [9]. Taqqoslash uchun, 2022-yilda xalqaro moliya institutlarining ulushi 48,7 foizni tashkil

etgan edi, ya'ni portfelda imtiyozli resurslar ulushi oshgan. Tashqi qarz mablag'larining 84 foizi bir yildan ortiq muddatda so'ndiriladigan uzoq muddatli qarzlardan iborat bo'lib, bu qayta moliyalashtirish riskini pasaytiradi [9]. Shu bilan birga, tashqi qarzning 45 foizi qat'iy belgilangan, 40 foizi esa o'zgaruvchan foiz stavkalarida jalb qilingan [9]. O'zgaruvchan stavkali qarzlarning salmoqli ulushi jahon moliya bozorlarida stavkalar ko'tarilgan davrlarda qarz xizmati xarajatlarining ortishiga olib kelishi mumkin.

2-jadval

Davlat qarzining valyutalar bo'yicha tarkibi (2025-yil 1-oktabr holatiga)

Valyuta turi	Davlat qarzidagi ulushi, %
AQSH dollari	63
O'zbekiston so'mi	12
Yevro	8
Boshqa valyutalar	17

2-jadvaldan ko'rinadiki, davlat qarzining 63 foizi AQSH dollarida, 12 foizi milliy valyutada, 8 foizi yevroda ifodalangan [9]. Portfelning yuqori darajada dollarlashuvi valyuta riskining asosiy manbai hisoblanadi: so'm kursining pasayishi qarzning so'mdagi ekvivalentini va byudjetdan qarz xizmatiga yo'naltiriladigan xarajatlarni avtomatik oshiradi. Qarz xizmatining ko'lami sezilarli: 2022-yilda davlat qarziga xizmat ko'rsatishning jami xarajatlari 2,49 mlrd dollarni tashkil etgan bo'lib, shundan 1,2 mlrd dollari bevosita davlat byudjetidan to'langan [9].

Jalb qilingan mablag'larning yo'nalishlar bo'yicha taqsimoti tahlili shuni ko'rsatadiki, 2025-yil yakuniga tashqi qarzning qariyb yarmi davlat byudjeti taqchilligini moliyalashtirishga yo'naltirilgan [9]. Tarmoqlar kesimida 5,6 mlrd dollar yoki 14 foiz yonilg'i-energetika sanoatiga (shundan 4,1 mlrd dollari elektroenergetikaga), 3,5 mlrd dollar yoki 9 foiz sog'liqni saqlash, ta'lim hamda axborot-kommunikatsiya texnologiyalari sohalariga to'g'ri keladi; transport infratuzilmasi, qishloq va suv xo'jaligi hamda uy-joy kommunal xo'jaligi yo'nalishlarining har biriga 3 mlrd dollardan ortiq mablag' yo'naltirilgan [9]. Byudjet taqchilligini moliyalashtirish ulushining yuqoriligi qarz mablag'laridan foydalanish samaradorligi masalasini kun tartibiga qo'yadi: investitsiya xarakteridagi qarzlar kelgusida daromad oqimini yaratsa, joriy xarajatlarni qoplashga yo'naltirilgan qarzlar bunday manbaga ega emas.

Davlat qarzi tarkibini kengroq makroiqtisodiy kontekstda baholash ham muhim. Markaziy bank ma'lumotlariga ko'ra, 2026-yilning 1-yanvar holatiga mamlakatning umumiy tashqi qarzi 82,2 mlrd dollarga yetdi, bunda korporativ tashqi qarz (41,7 mlrd dollar) ilk bor davlat tashqi qarzidan (40,5 mlrd dollar) oshib ketdi [10]. Korporativ qarz tarkibida davlat ishtirokidagi korxonalarning kafolatsiz qarzlari salmoqli o'rin tutadi. Xalqaro moliya institutlari bunday qarzlarni shartli majburiyat sifatida baholab, ular ayrim loyihalar samarasiz chiqqan taqdirda hukumat balansiga o'tish xavfini fiskal risk manbai sifatida qayd etadi [7]. Bu davlat qarzi statistikasi bilan qamrab olinmaydigan, biroq fiskal barqarorlikka bevosita daxldor bo'lgan segmentni doimiy monitoring qilish zaruratini keltirib chiqaradi.

XULOSA VA TAKLIFLAR

O‘tkazilgan tahlil quyidagi xulosalarga kelish imkonini beradi. Birinchidan, O‘zbekiston davlat qarzi hajmi jihatidan jadal o‘sayotgan bo‘lsa-da, uning YAIMga nisbati (2025-yil yakuniga 31,9 foiz) qonun bilan belgilangan chegaraviy darajalardan sezilarli past bo‘lib, qarz yuki boshqariladigan darajada saqlanmoqda. Ikkinchidan, qarz portfelining tarkibiy tuzilishida ijobiy siljishlar kuzatilmoqda: ichki qarz ulushi 10,3 foizdan 15 foizgacha kengaydi, xalqaro moliya institutlarining imtiyozli resurslari ulushi 56 foizga yetdi, portfelning 84 foizi uzoq muddatli majburiyatlardan iborat. Uchinchidan, portfelda jiddiy tarkibiy risklar saqlanib qolmoqda: qarzning 63 foizi AQSH dollarida ifodalangani valyuta riskini, 40 foizining o‘zgaruvchan stavkalarda jalb qilingani foiz riskini, korporativ tashqi qarzning jadal o‘sishi esa shartli fiskal majburiyatlar riskini yuzaga keltiradi.

Tahlil natijalari asosida quyidagi takliflar ishlab chiqildi. Birinchidan, davlat g’aznachilik obligatsiyalari bozorini rivojlantirish hisobiga ichki qarz ulushini bosqichma-bosqich oshirib borish maqsadga muvofiq. Buning uchun obligatsiyalar muddatlar shkalasini kengaytirish, ikkilamchi bozor likvidligini oshirish hamda pensiya jamg’armalari, sug’urta kompaniyalari va investitsiya fondlari kabi institutsional investorlarning ishtirokini rag’batlantirish talab etiladi. Ikkinchidan, “Davlat qarzi to‘g’risida”gi Qonunda belgilangan milliy valyutada mablag’ jalb qilishni kengaytirish tamoyilini izchil amalga oshirish, jumladan xalqaro moliya institutlari bilan so‘mda kreditlash imkoniyatlarini kengaytirish bo‘yicha muzokaralar olib borish lozim. Uchinchidan, o‘zgaruvchan stavkali qarzlar ulushini kamaytirish va foiz riskini boshqarishning bozor vositalarini joriy etish zarur. To‘rtinchidan, davlat ishtirokidagi korxonalarning kafolatsiz tashqi qarzlari bo‘yicha yagona monitoring tizimini kuchaytirish va shartli majburiyatlarni fiskal risklar tahliliga to‘liq qamrab olish maqsadga muvofiq. Beshinchidan, byudjet taqchilligini moliyalashtirishga yo‘naltirilayotgan qarz ulushini kamaytirib, qarz mablag’larini o‘zini qoplaydigan investitsiya loyihalariga yo‘naltirish ustuvorligini ta'minlash lozim.

Mazkur yo‘nalishlardagi chora-tadbirlarning amalga oshirilishi davlat qarzi portfelining valyuta va foiz risklariga chidamliligini oshirish, ichki moliya bozorini chuqurlashtirish hamda uzoq muddatli fiskal barqarorlikni mustahkamlash imkonini beradi.

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FINANCIAL MANAGEMENT PRACTICES AND THE ECONOMIC SUSTAINABILITY OF SMALL AND MEDIUM ENTERPRISES

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Abstract. *Small and medium enterprises (SMEs) represent a crucial element of today's economy, significantly contributing to employment creation, wealth creation, innovation, and local economic development. Nevertheless, the sustainable economic performance of such firms is often hindered by poor financial management, lack of proper cash flow management, ineffective working capital management, poor financial information, and limited availability of external financing. This paper explores the relationship between financial management and the economic sustainability of SMEs using an organized review of the existing literature on the subject matter. Special focus is placed on financial planning and budgeting, cash flow management, working capital management, financial information systems, capital structure, financial risk management, and investment appraisal. The analysis emphasizes that financial management should be considered not only as an accounting tool but as a strategic skill of the organization, which defines its ability to ensure its liquidity, profitability, funding of growth activities, coping with economic crises, and sustainable performance. Research demonstrates that better financial management positively affects the decision making process and performance. Recent studies also suggest that the link between the investment in working capital and profitability might be nonlinear, implying that SMEs have to aim for optimal liquidity. The study recommends an integrated model where financial planning, working capital effectiveness, information quality, financing, investment appraisal, and risk management together determine the economic sustainability of SMEs.*

Keywords. *Financial management practices; small and medium enterprises; SME sustainability; working capital; financial planning; cash-flow management; financial performance; financial resilience.*

Annotatsiya. *Kichik va o‘rta korxonalar (KO‘K) zamonaviy iqtisodiyotning muhim elementi bo‘lib, ular ish o‘rinlarini yaratish, boylik hosil qilish, innovatsiyalar va mahalliy iqtisodiy rivojlanishga katta hissa qo‘shadilar. Shunga qaramay, bunday firmalarning barqaror iqtisodiy samaradorligi ko‘pincha moliyaviy boshqaruvning*

sustligi, pul oqimlarini to‘g‘ri boshqarmaslik, aylanma mablag‘larni samarasiz boshqarish, moliyaviy axborot sifati pastligi va tashqi moliyalashtirish manbalarining cheklanganligi tufayli to‘sqinlik qiladi. Ushbu maqolada moliyaviy boshqaruv va KO‘Kning iqtisodiy barqarorligi o‘rtasidagi bog‘liqlik mavjud adabiyotlarni tizimli sharhlash asosida o‘rganiladi. Asosiy e’tibor moliyaviy rejalashtirish va byudjetlashtirish, pul oqimlarini boshqarish, aylanma mablag‘larni boshqarish, moliyaviy axborot tizimlari, kapital tarkibi, moliyaviy risklarni boshqarish va investitsiyalarni baholashga qaratilgan. Tahlil shuni ko‘rsatadiki, moliyaviy boshqaruv faqat buxgalteriya vositasi sifatida emas, balki tashkilotning strategik mahorati sifatida qaralishi kerak, chunki u likvidlikni, rentabellikni, o‘sish faoliyatini moliyalashtirishni, iqtisodiy inqirozlarni yengishni va barqaror natijadorlikni ta’minlash qobiliyatini belgilaydi. Tadqiqotlar shuni ko‘rsatadiki, moliyaviy boshqaruvning yaxshilanishi qaror qabul qilish jarayoniga va natijadorlikka ijobiy ta’sir ko‘rsatadi. So‘nggi tadqiqotlar, shuningdek, aylanma mablag‘larga investitsiya va rentabellik o‘rtasidagi bog‘liqlik chiziqli bo‘lmasligi mumkinligini ta’kidlaydi, bu KO‘Klarning optimal likvidlikka erishishga intilishi kerakligini bildiradi. Tadqiqot moliyaviy rejalashtirish, aylanma mablag‘lar samaradorligi, axborot sifati, moliyalashtirish, investitsiyalarni baholash va risklarni boshqarish birgalikda KO‘Klarning iqtisodiy barqarorligini belgilaydigan integratsiyalashgan modelni tavsiya qiladi.

Kalit so‘zlar: *moliyaviy boshqaruv amaliyotlari; kichik va o‘rta korxonalar; KO‘K barqarorligi; aylanma mablag‘lar; moliyaviy rejalashtirish; pul oqimlarini boshqarish; moliyaviy natijadorlik; moliyaviy chidamlilik.*

Аннотация. *Малые и средние предприятия (МСП) представляют собой важнейший элемент современной экономики, внося значительный вклад в создание рабочих мест, прирост благосостояния, инновации и местное экономическое развитие. Тем не менее, устойчивая экономическая эффективность таких фирм часто сдерживается неудовлетворительным финансовым менеджментом, отсутствием надлежащего управления денежными потоками, неэффективным управлением оборотным капиталом, низким качеством финансовой информации и ограниченной доступностью внешнего финансирования. В данной статье исследуется взаимосвязь между финансовым менеджментом и экономической устойчивостью МСП на основе систематизированного обзора существующей литературы по данной теме. Особое внимание уделяется финансовому планированию и бюджетированию, управлению денежными потоками, управлению оборотным капиталом, системам финансовой информации, структуре капитала, управлению финансовыми рисками и оценке инвестиций. Анализ подчеркивает, что финансовый менеджмент следует рассматривать не только как учетный инструмент, но и как стратегический навык организации, определяющий ее способность обеспечивать ликвидность, рентабельность, финансирование деятельности по росту, преодоление экономических кризисов и устойчивую результативность. Исследования показывают, что улучшение финансового менеджмента положительно влияет на процесс принятия решений и*

результативность. Недавние исследования также указывают на то, что связь между инвестициями в оборотный капитал и рентабельностью может быть нелинейной, что предполагает необходимость для МСП стремиться к оптимальной ликвидности. В исследовании рекомендуется комплексная модель, в которой финансовое планирование, эффективность использования оборотного капитала, качество информации, финансирование, оценка инвестиций и управление рисками совместно определяют экономическую устойчивость МСП.

Ключевые слова: *практики финансового менеджмента; малые и средние предприятия; устойчивость МСП; оборотный капитал; финансовое планирование; управление денежными потоками; финансовая результативность; финансовая устойчивость.*

INTRODUCTION

Small and medium enterprises (SMEs) are one of the most critical aspects of today's economic systems. They contribute to wealth creation at the household level, creation of jobs, competition, innovation, entrepreneurship, and development of economies. According to the World Bank, SMEs represent a huge source of employment and economic activity on a global scale. Due to their importance, managers and policymakers have serious worries regarding the financial viability of SMEs.

Despite their importance to the economy, SMEs are faced with serious financial difficulties. Small enterprises have fewer financial resources, have less negotiation power with their suppliers and banks, have a less diversified revenue stream and, therefore, are more prone to fluctuations in their operating costs and demand in comparison with large enterprises. This way, financial management has a special meaning for the stability and viability of the companies.

Financial sustainability does not merely rely on the volume of business resources available. Instead, it relies on the effectiveness of the business's planning, management, and controlling of business resources. The business may access loans and investment, yet it is still vulnerable to financial difficulties. This situation may occur in the event of having poor budgeting practices, unnecessary stockpiling of inventory, poor collection of payments, inadequate cash-flow predictions, and unsuitable debt structure. In addition to that, the significance of the above-mentioned problems cannot be underestimated in the face of inflation, higher prices for borrowing money, supply-chain problems, advances in technology, and overall uncertainty. According to the information provided by OECD, the rising inflation and stricter rules for lending increase the problems that SMEs might be facing when it comes to financing, therefore incurring higher costs of borrowing money (OECD, 2024).

Working-capital management proves to be extremely vital since SMEs rely heavily on the internally generated funds and short-term loans that support day-to-day operations. Late payments from the clients, excess stocks, and poorly managed terms from suppliers can create immediate liquidity challenges even if the company has shown an accounting profit.

The aim of this paper is to explore the effects of financial management techniques on the economic sustainability of SMEs. The paper highlights the importance of financial planning, cash-flow management, working-capital management, accounting information, capital structure, investment evaluation, and risk management. Additionally, it proposes an integrated framework that connects these techniques with liquidity, profitability, efficiency, resilience, and long-term growth.

LITERATURE REVIEW

Financial management refers to the planning, acquisition, allocation, application, and supervision of financial assets in a company. In SMEs, financial decisions are often closely associated with owner-managers because they may run the business without having special finance departments. Thus, the practical implementation of financial management skills is vital.

Musah, Gakpetor, and Pomaa (2018) examined financial management through working-capital management, capital-structure management, accounting information and reporting, and capital budgeting and fixed-asset management. Their empirical study of SMEs in Accra reported relationships between these financial-management practices and profitability and growth. Similar evidence from Sri Lanka indicates significant associations between financial management practices and SME performance, particularly fixed-asset management, working-capital management, and accounting information systems.

Financial planning and budgeting provide a foundation for resource allocation. A budget enables managers to estimate revenues, costs, cash requirements, financing needs, and investment requirements. Cash budgets are especially important because accounting profitability does not necessarily correspond to cash availability. A business can be profitable and still experience cash flow problems due to customers not paying their bills.

The management of working capital includes cash, receivables, payables, and inventories. García-Teruel and Martínez-Solano (2007) conducted a study on Spanish small and medium-sized enterprises and illustrated how reducing inventories, receivables, and the cash conversion cycle can increase profitability. However, recent research indicates that it is necessary to keep working capital investments at an optimal level and that an excessive reduction might also be detrimental. It should be emphasized that the goal of managing working capital should not be just to minimize it.

Accounting information is of vital importance as well. Financial statements contain information regarding profitability, liquidity, cash flows, and assets and liabilities, which will be useful for small and medium-sized enterprises not only when it comes to tax and reporting issues but also planning, monitoring their performance, and making financial decisions.

Capital structure also affects sustainability. Debt can finance growth, but excessive debt creates fixed repayment obligations and increases financial risk. SMEs therefore need to evaluate interest rates, repayment schedules, collateral requirements, debt-service capacity, maturity structure, and currency exposure.

Finally, investment appraisal and financial-risk management help protect scarce SME resources. Investment decisions should consider expected cash flows, costs, risks, and alternative uses of capital, while risk management should address liquidity, credit, interest-rate, foreign-exchange, and market risks.

RESEARCH METHODOLOGY

This article follows the literature-review qualitative analysis approach. The study did not seek to obtain any primary data through survey research but instead, aims to process and synthesize existing theoretical and empirical knowledge regarding financial management practices and SME economic sustainability. The reviewed literature was grouped into six thematic areas: planning and budgeting, cash-flow management, financing, financial and accounting information, capital structure and funding decisions, and investment and financial-risk management.

Economic sustainability refers to the ability of an SME to perform its activities, achieve reasonable profitability, fulfil its financial obligations, withstanding various economic shocks and business development. The analysis is based on the premise that financial management practices affect economic sustainability through the quality of financial decisions concerning liquidity, profitability, effectiveness and financial stability. Thus, the mechanism can be represented through the following path: Financial Management Practices → Quality of Financial Decisions → Liquidity, Profitability, Effectiveness and Financial Resilience → Economic Sustainability.

The study is founded on articles published in scholarly and reputable worldwide publications such as OECD and the World Bank. No primary survey results are reported, which is why no fictitious regression coefficients, statistics or other empirical results are provided in the paper.

RESULTS AND DISCUSSION

Financial planning is said to provide the ground for the rest of the practices in finance management. Businesses that don't have a system for making plans will rely on their reactions to circumstances rather than will have the business resources used effectively in accordance with long-term targets. Financial planning is essential for optimizing the allocation of resources, readiness for crises, and strategic decisions connected with growth.

Management of cash flow is one of the most straightforward ways of linking financial management to sustainability. It is important for a small or medium enterprise to make cash flow forecasts regularly, keep track of profit and losses, study the turnover of inventories, find out the seasonal needs of customers, ensure a certain amount of cash balance, and compare it to the actual cash flows. Rapid growth may create liquidity problems since sometimes the business needs to pay for inventory, manpower, and fixed assets before customers pay the invoices.

Managing working capital efficiently is directly related to successful operation of a company. Poor management of receivables results in greater time needed to receive cash after the sale, while overaccumulating the inventory prevents the company from using the acquired funds efficiently. At the same time, overly aggressive reductions in inventory or credit availability may negatively affect sales. García-Teruel and Martínez-Solano (2007) found that shorter cash-conversion cycles were associated

with higher SME profitability. Recent evidence also supports an optimal rather than unlimited level of working-capital investment.

Access to finance is important, but finance alone does not guarantee sustainability. SMEs with weak accounting records, poor cash-flow forecasting, or inadequate investment appraisal may use borrowed funds inefficiently. Strong internal financial capability can also improve an enterprise's ability to demonstrate creditworthiness to financial institutions.

Capital-structure decisions should balance the benefits of external financing against repayment obligations and financial risk. Borrowing to purchase productive equipment that generates additional cash flow can be economically justified, while borrowing to cover persistent operating losses without restructuring the business model may increase vulnerability.

Investment appraisal converts financial resources into productive capacity. SMEs should evaluate proposed investments using techniques such as payback period, accounting rate of return, net present value, internal rate of return, and profitability index. Even simplified investment appraisal can prevent scarce capital from being committed to low-return assets.

Financial risk management is also essential because SMEs generally have fewer reserves and less capacity to diversify risk than large firms. Managers should identify major risks, estimate their effects, determine acceptable exposure levels, implement mitigation measures, and monitor risks continuously.

Integrated Framework for SME Economic Sustainability. The integrated approach to the management of financial matters for SMEs is confirmed by the observations made. Firstly, financial planning and budget-making lead to better distribution of resources; secondly, cash-flow management lends assurance of liquidity; thirdly, effective working-capital management permits the company to function efficiently; fourthly, accounting information contributes to quality decision-making; fifthly, capital structure management minimizes financial risks; sixthly, investment appraisal guarantees positive growth; seventhly, risk management enhances the resilience of the company.

Economic sustainability should be estimated considering such indicators as profitability, liquidity, operational efficiency, solvency, growth, resilience, and investment capacity. It is easy to understand that a company that is profitable can be considered unsustainable if it suffers from a shortage of cash repeatedly. On the other hand, a company can be liquid, but, at the same time, it can be unsustainable as well due to the lack of profitability rendered by assets.

The integral approach can be represented in the following way: Financial Planning + Cash Flow Management + Working Capital Management + Accounting Information + Capital Structure + Investment Appraisal + Risk Management → Higher Quality of Financial Decisions → Improved Profitability and Liquidity.

Managerial and Policy Implications. SME executives must implement basic financial management systems regardless of the size of their business. Every small and medium-sized enterprise (SME) must keep accurate financial records and make regular cash flow forecasts. Debtors must be probed constantly through clear payment rules

and customer credit policies. Inventory must be controlled based on demand and turnover. Borrowing must be assessed based on the repaying capacity and the purpose of spending. Investment decisions must be made based on the expected profits and risks, and backup plans must be created to deal with declining sales, growing input prices, increasing interest rates as well as disruptions in supply chains.

Policies are equally relevant. SME development schemes must connect financing with literacy schemes, accounting, digital financial solutions as well as managerial training. Evidence presented by OECD suggests the importance of diversity in finance sources as well as policies aimed at ensuring resilience among SMEs in the environment of changing financial conditions (OECD, 2024). Financial institutions can offer consultancy solutions, digital accounting tools, and cash flow monitoring services along with lending.

These steps are especially needed in developing nations where SMEs contribute to significant business volume and jobs while facing significant financial restrictions.

CONCLUSION

This article focuses on the given subject of the link between the financial management practices and the economic sustainability of SMEs. The process shows that financial management is a multifaceted organizational ability that involves financial planning, budgeting, cash-flow management, management of working capital, accounting data, financing choices, investment assessment, and managing financial risk.

The ultimate conclusion is that having access to financial resources alone is not a guarantee of SME sustainability. Financial resources need to be converted into economic results through proper managerial actions. Working capital management is integral because it affects liquidity, efficiency, and profitability.

Research on SMEs gives evidence that effective management of inventory and accounts receivable together with managing cash conversion cycle positively influences profitability, whilst the latest studies prove that it is a need to have optimal working capital rather than excessive one.

Financial planning and budgeting are crucial processes to achieve this objective, as they allow SMEs to forecast financial needs and plan the spending and allocation of resources in the right way. Accounting information makes these processes more effective and improves managerial decisions.

For policymakers, the findings suggest that SME-development strategies should integrate access to finance with financial-literacy programs, accounting support, digital financial tools, and managerial training. Future empirical research could test the proposed framework using firm-level panel data, particularly in emerging economies, and examine whether financial-management capabilities moderate the relationship between access to finance and SME survival, profitability, employment growth, and resilience.

Overall, the economic sustainability of SMEs depends not simply on how much financial capital they possess, but on how effectively they plan, allocate, monitor, and protect that capital.

Table 1. Financial Management Practices and Their Contribution to SME Sustainability

Practice	Primary objective	Sustainability effect
Financial planning	Forecast revenues, costs and financing needs	Improves preparedness and resource allocation
Budgeting	Control planned expenditure	Reduces unnecessary costs
Cash-flow management	Maintain adequate liquidity	Reduces insolvency risk
Receivables management	Accelerate cash collection	Improves liquidity
Inventory management	Avoid excessive stock	Releases tied-up capital
Payables management	Optimize supplier payments	Supports liquidity
Accounting information	Improve financial visibility	Strengthens decision-making
Capital structure	Balance debt and equity	Controls financial risk
Investment appraisal	Select productive investments	Supports long-term growth
Risk management	Reduce exposure to shocks	Improves resilience

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SOIL EROSION AND CONSERVATION STRATEGIES ACROSS CLIMATES WITH A FOCUS ON UZBEKISTAN

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Abstract. *Soil erosion is one of the most challenging threats to agricultural productivity. This study presents a comprehensive literature review focusing on soil erosion types, their driving factors, conservation strategies, and soil productivity restoration. The review analyzes different forms of soil erosion, including water erosion, wind erosion, gully erosion, and human-accelerated erosion, together with the effects of climate change, land-use change, and deforestation. Conservation methods identified in the literature include contour plowing, reforestation, crop rotation, minimum tillage, organic matter management. The findings confirm that restoration of degraded soils is possible but requires integrated and long-term management practices. Although many conservation strategies have proven effective under specific environmental conditions, their successful implementation depends on local soil, climate, and land-use characteristics. Therefore, further researches have to be done to better understand soil erosion and its conservation methods.*

Keywords: *Land degradation, soil erosion, soil conservation, Uzbekistan, agricultural productivity, conservation strategies, contour plowing, soil restoration.*

Annotatsiya. *Tuproq eroziyasi qishloq xo‘jaligi unumdorligi uchun eng qiyin tahdidlardan biridir. Ushbu tadqiqot tuproq eroziyasi turlari, ularning harakatlantiruvchi omillari, tabiatni muhofaza qilish strategiyalari va tuproq unumdorligini tiklashga qaratilgan keng qamrovli adabiyotlar sharhini taqdim etadi. Sharhda suv eroziyasi, shamol eroziyasi, jar eroziyasi va inson tomonidan tezlashtirilgan eroziya kabi tuproq eroziyasining turli shakllari, shuningdek, iqlim o‘zgarishi, yerlardan foydalanish o‘zgarishi va o'rmonlarning kesilishi ta’siri tahlil qilinadi. Adabiyotda aniqlangan tabiatni muhofaza qilish usullari konturli shudgorlash, o‘rmonlarni qayta tiklash, almashlab ekish, minimal ishlov berish, organik moddalarni boshqarishni o‘z ichiga oladi. Topilmalar degradatsiyaga uchragan tuproqlarni tiklash mumkinligini tasdiqlaydi, ammo integratsiyalashgan va uzoq muddatli boshqaruv amaliyotlarini talab qiladi. Ko‘pgina tabiatni muhofaza qilish strategiyalari ma’lum atrof-muhit sharoitlarida samarali ekanligi isbotlangan bo‘lsada, ularni muvaffaqiyatli amalga oshirish mahalliy tuproq, iqlim va yerlardan foydalanish xususiyatlariga bog‘liq. Shuning uchun, tuproq eroziyasi va uni muhofaza qilish usullarini yaxshiroq tushunish uchun qo‘shimcha tadqiqot, izlanishlarni o‘tkazish kerak.*

Kalit so‘zlar: *Yerlarning degradatsiyasi, tuproq eroziyasi, tuproqni muhofaza qilish, O‘zbekiston, qishloq xo‘jaligi unumdorligi, tabiatni muhofaza qilish strategiyalari, konturli shudgorlash, tuproqni tiklash.*

Аннотация. *Эрозия почв представляет собой одну из наиболее серьезных угроз для продуктивности сельского хозяйства. В данном исследовании представлен всесторонний обзор литературы, посвященный видам эрозии почв, факторам, способствующим их развитию, стратегиям охраны почв и восстановлению их продуктивности. В обзоре анализируются различные формы эрозии, включая водную, ветровую и овражную эрозию, а также эрозию, ускоренную антропогенным воздействием, и рассматривается влияние изменения климата, изменений в землепользовании и обезлесения. К числу методов охраны почв, описанных в литературе, относятся контурная вспашка, лесовосстановление, севооборот, минимальная обработка почвы и управление содержанием органического вещества. Результаты исследования подтверждают, что восстановление деградированных почв возможно, однако оно требует применения комплексных и долгосрочных мер управления. Хотя многие стратегии охраны почв доказали свою эффективность в определенных природных условиях, их успешная реализация зависит от местных почвенных и климатических характеристик, а также от особенностей землепользования. В связи с этим необходимы дальнейшие исследования для углубленного понимания процессов эрозии почв и методов их предотвращения.*

Ключевые слова: *деградация земель, эрозия почв, охрана почв, Узбекистан, продуктивность сельского хозяйства, стратегии охраны почв, контурная вспашка, восстановление почв.*

INTRODUCTION

Soil is a fundamental resource for agricultural production, yet the recovery of degraded soil requires a long period of time (Juliev et al., 2024). Agriculture plays a significant role in Uzbekistan's economy, accounting for 17.3% of GDP and 30.9% of the gross value added of small businesses in 2025 (National Statistics Committee of the Republic of Uzbekistan). These figures highlight the importance of sustainable soil management for ensuring agricultural productivity and food security.

Previous studies have examined soil erosion and conservation practices in different regions. Research in Africa described major erosion types and assessment methods (Eric Roose et al., 2008), while studies in South Africa focused on water erosion in duplex soils and conservation measures such as reforestation and drainage (Parwada & Van Tol, 2016). Other studies proposed improved tillage systems for controlling wind and water erosion (Mirzaev et al., 2019), highlighted the effectiveness of plant cover in reducing soil erosion and runoff (Zuazo & Pleguezuelo, 2008), and examined the relationship between soil degradation, climate change, and food security on a global scale (Lal, 2014).

This thesis reviews the major causes of soil erosion and evaluates widely used soil conservation strategies. Based on international research and practical case studies, it discusses approaches such as terracing, contour plowing, cover cropping, crop rotation, agroforestry, windbreaks, vegetation restoration, nutrient and water

management, and no-till farming, emphasizing their potential application for improving soil conservation practices in Uzbekistan.

MYTHOLOGY AND LITERATURE REVIEW

This study adopts a qualitative analytical approach based on secondary data. Scientific articles, books, and statistical reports were systematically reviewed and analyzed to examine soil degradation, soil erosion, and soil conservation strategies under different climatic and environmental conditions. The research is focused on Uzbekistan; however, studies and experiences from other continents and countries were also reviewed to provide a broader understanding of the causes, impacts, and management of soil degradation.

2.1. Studies on soil degradation and erosion

Early studies of erosion (in scope of our research) discuss soil erosion rates and productivity loss for two areas of the United States, the types of erosion including water erosion, wind erosion (H.E. Dregne, 1987). As author states water erosion is more serious problem than wind erosion in both arid and humid regions. In some areas water erosion has reduced soil productivity for over 50 years.

Eric Roose et al. (2008) in his 50 years of research of Africa, examined main problems of soil erosion, and conservation strategies to be done in places. Erosion is highly associated with loss of nutrient loss and carbon sequestration. Restoration of soil: as authors state water and soils are non-renewable resources, if the thin topsoil over a hard calcareous or granitic rock is eroded, it will not be possible to restore the soil in a single lifetime because it takes 1000 to 3000 years to create 10 cm of soil.

It is possible to restore soil productivity, by following these steps:

1. Since eroded soils produce high runoff, the first step is to manage water flow using measures such as stone bunds, vegetative hedges, and basins.
2. Because degraded soils are compact and unstable, they should be deeply plowed and improved with organic matter or calcium carbonate to increase stability.
3. As deeper soil layers have lower biological activity than the humus layer, compost or manure rich in microbes and mycorrhiza should be added to improve nutrient availability.
4. Since degraded soils are nutrient-poor and cannot retain nutrients well, fertilizers should be applied directly to plants when needed rather than relying on the soil to store them.
5. If soil pH is too low (below 5), it should be raised above 5 to reduce aluminium toxicity. (Eric Roose et al., 2008)

2.2 Uzbekistan

The total land area of Uzbekistan is 44.7 hectares with natural pastures - 46.8%, forest lands 8%, and urban and infrastructure areas 34.5%. Arable land constitutes only 4.3 million hectares of which 3.3 million ha. directed to irrigated agriculture. A large area of land in Uzbekistan is affected by degradation and desertification, including strong soil compaction and crust formation (more than 50% of irrigated land), wind erosion (56% of all lands), irrigation erosion (covering 7,603 sq. km of land), soil salinization (47% of the irrigated area), and low organic matter in soils. (Umarov et al., 2025, cited as Eshmatov, 2024).

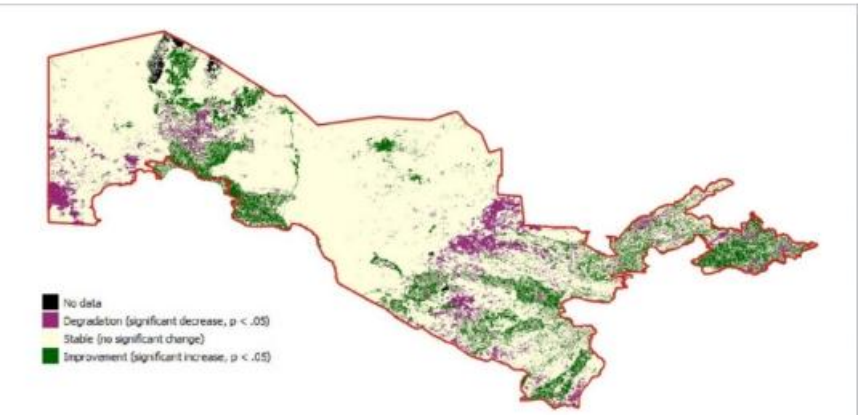

Figure 1. Land degradation trends in Uzbekistan for the period 2010–2020 prepared using the Trends. Earth tool. Source of data: Soil and Agrochemical Research Institute, Tashkent, Uzbekistan. (Umarov et al., 2025)

Mitigation actions in Uzbekistan. Uzbekistan and Kazakhstan together account for around 6 million hectares of the dried bed of the Aral Sea. Of this, about 3.2 million hectares are located in Uzbekistan, with approximately 2.5 million hectares designated for forest plantations. A national program to rehabilitate the Aral Sea region was launched in 2017. By the end of 2024, more than 1.7 million hectares had already been afforested. Plants such as "saxaul" and "tamarisk", which are resistant to salinity, play an important role in reducing the spread of harmful dust and salts into the atmosphere. They also help absorb excess salt from the soil, gradually improving land conditions for agricultural use. In addition, the Forestry Agency of Uzbekistan is actively implementing national greening initiatives. One of the major programs is the "Yashil Makon", launched in 2021. This initiative aims to increase the country's green coverage to 30% by 2030, compared to the current level of about 12%. Under this program, Uzbekistan plans to plant around 200 million trees and shrubs each year, with a total target of 1 billion over five years.(Umarov et al., 2025)

Method and strategies of mitigation recommended in water erosion:

- **Soil protection in the periods when the rainfall is potentially more erosive,** During the high erosive rainfalls good green coverage is effective. (Duarte, 2022)
- **Crop rotations less intensive, according to the soil capacity use, incorporation in the soil the crops stubble,** Crop rotation according to soil capacity and climate condition is necessary for reaching adequate fertility level, leguminous crops are recommended to use. After the harvest, shrubs are recommended to leave for increasing and maintenance of organic matter. (Duarte, 2022)
- **Reduction of soil tillage operations,** minimum tillage is recommended for not destucting soil structure, and this increses breakdown of compost by oxygen. (Duarte, 2022)
- **Contouring crop operations,** field activities such as tillage, when performed along contour lines, create small concavities in the soil. These concavities temporarily hold water and trap soil particles, thereby helping to retain moisture

and reduce runoff, which contributes to increased water availability in the field. (Duarte, 2022). “Contour ploughing mitigates the impacts of floods, storms and landslides on the crops by reducing soil erosion up to 50 percent, controlling runoff water, increasing moisture infiltration and retention and thus enhancing soil quality and composition.” (FAO, 2008)

- **Use of simulation models,** it is considered to effective tool to reproduce a certain process, in this case soil water erosion. As results show no significant relationship was observed between average sediment production and average runoff volume across most basin cells. (Duarte, 2022)
- **Afforestation and sowing grass,** planting trees and grasses is a key method for conserving soil and water in the Loess Plateau. Trees and fruit crops should be planted in gullies, while grasses and shrubs should cover slopes. (Bojie Fu, 1989). Removing vegetation and practicing intensive farming in mountainous areas increases land degradation. (Zuazo & Pleguezuelo, 2008).

III. Discussion

3.1 Erosion types

Water Erosion	Rainfall intensity, soil texture, slope, vegetation cover, land use	Dregne (1987); Duarte (2022); Lal (2012); Bojie Fu (1989)
Wind Erosion	Wind speed, soil moisture, vegetation cover, land surface roughness	Dregne (1987); Mirzaev et al. (2019)
Gully Erosion	Concentrated runoff, slope gradient, soil type (duplex soils), land degradation	Eric Roose, Dazzi et al. (2008); Parwada & Van Tol (2016)
Raindrop (Splash) Erosion	Rainfall erosivity, drop size, soil erodibility, vegetation canopy	Duarte (2022); Zuazo & Pleguezuelo (2008)
Accelerated (Human-induced) Erosion	Deforestation, land-use change, intensive tillage, overgrazing, urbanization	Lal (2012); Zuazo & Pleguezuelo (2008);
Mass Movement (Landslides)	Slope gradient (>15°), soil saturation, vegetation loss, seismic activity	Eric Roose, Dazzi et al. (2008); Bojie Fu (1989)

**Done by author with assistance of AI tool*

3.2 Conservation methods

Contour Ploughing / Contouring	Water erosion, runoff	Duarte (2022); FAO (2008)
Crop Rotation & Cover Cropping	Water erosion, wind erosion, soil degradation	Duarte (2022); Lal (2012)
Reforestation & Vegetation Restoration	Water erosion, wind erosion, gully erosion, mass movement	Parwada & Van Tol (2016); Bojie Fu (1989); Zuazo & Pleguezuelo (2008)
Minimum / Conservation Tillage	Water erosion, wind erosion	Duarte (2022); Lal (2012);
Organic Matter Management	Water erosion, soil degradation	Parwada & Van Tol (2016); Eric Roose et al. (2008);
Engineering & Structural Measures	Gully erosion, water erosion, runoff, mass movement	Eric Roose et al. (2008); Bojie Fu (1989); Parwada & Van Tol (2016)
Land-Use Adjustment	Water erosion, mass movement, accelerated erosion	Bojie Fu (1989); Zuazo & Pleguezuelo (2008)
Soil pH & Fertility Management	Post-erosion soil restoration	Eric Roose et al. (2008); Parwada & Van Tol (2016)
Simulation & Predictive Models	All erosion types (planning/monitoring tool)	Duarte (2022); Duulatov et al. (2019)

** Done by author with assistance of AI tool*

CONCLUSION

The reviewed literature and data indicate that soil erosion remains as one of the important environmental challenges in various geographic continents, caused by natural processes and increased human activities. Water erosion consistently emerges as the dominant threat, while wind erosion, gully erosion, and mass movements pose significant regional concerns. However, a range of conservation methods and strategies have been recommended, including contour ploughing, reforestation, green covering, minimum tillage, and other engineering measures. Admittedly, each method is applied in accordance with local soil type, climate and topographic conditions of certain area. Nevertheless, several gaps in studied articles and data remain. Most of the studies focus on individual regions or single erosion types, limiting cross-regional comparisons. Thus, further studies should be focused on integrated, practical approaches on region-specific fields (areas) against soil erosion, particularly in Uzbekistan.

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UDK: 378.4:331.5

OLIY TA'LIM XIZMATLARINI MEHNAT BOZORI TALABLARIGA MOSLASHTIRISH ORQALI BITIRUVCHILAR BANDLIGI VA TADBIRKORLIK SALOHIYATINI OSHIRISH

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Annotatsiya. *Maqolada oliy ta'lim xizmatlarini mehnat bozori ehtiyojlari bilan uyg'unlashtirishning bitiruvchilar bandligi va tadbirkorlik salohiyatiga ta'sir etuvchi tashkiliy-iqtisodiy mexanizmlari tahlil qilindi. Kontent-tahlil, qiyosiy tahlil, tizimli yondashuv va strukturaviy sintez asosida ta'lim dasturlarini ish beruvchilar bilan yangilash, amaliy tayyorgarlik, universitet–biznes hamkorligi, karyera xizmatlari, bandlik monitoringi va tadbirkorlik ta'limini yagona mexanizmga birlashtiruvchi model ishlab chiqildi. Natijalar mazkur elementlarning alohida emas, o'zaro bog'langan qayta aloqa tizimi sifatida ishlashi bitiruvchining mehnat bozoriga moslashuvchanligini kuchaytirishini ko'rsatadi. Maqolada mexanizmni baholash uchun natijaviy indikatorlar va amaliy tavsiyalar taklif etilgan.*

Kalit so'zlar: *oliy ta'lim xizmatlari, mehnat bozori, bitiruvchilar bandligi, ta'lim sifati, kompetensiya, universitet–biznes hamkorligi, dual ta'lim, karyera xizmatlari, tadbirkorlik.*

Аннотация. *В статье проанализированы организационно-экономические механизмы согласования услуг высшего образования с потребностями рынка труда для повышения занятости выпускников и их предпринимательского потенциала. На основе контент-анализа, сравнительного анализа, системного подхода и структурного синтеза разработана интегрированная модель, объединяющая обновление образовательных программ с участием работодателей, практическую подготовку, сотрудничество университет–бизнес, карьерные услуги, мониторинг занятости и предпринимательское обучение. Результаты показывают, что наибольший эффект достигается при функционировании этих элементов как единой системы обратной связи. Предложены показатели оценки и практические рекомендации для вузов.*

Ключевые слова: *высшее образование, рынок труда, занятость выпускников, качество образования, компетенции, сотрудничество университет–бизнес, дуальное обучение, карьерные услуги, предпринимательство.*

Abstract. *This article analyses organizational and economic mechanisms for aligning higher education services with labour-market needs in order to improve graduate employment and entrepreneurial potential. Using content analysis, comparative analysis, a systems approach and structural synthesis, an integrated model is developed that combines employer-informed curriculum renewal, practical training, university–business collaboration, career services, graduate employment*

monitoring and entrepreneurship education. The results indicate that these elements are most effective when they operate as an interconnected feedback system rather than as isolated interventions. A set of outcome-oriented indicators and practical recommendations is proposed for higher education institutions.

Keywords: *higher education services, labour market, graduate employment, education quality, competence, university–business collaboration, dual education, career services, entrepreneurship.*

KIRISH

Raqamli transformatsiya, sun’iy intellekt, ishlab chiqarish va xizmat ko‘rsatish jarayonlarining avtomatlashtirilishi hamda biznes modellarining tez yangilanishi mehnat bozoridagi kasbiy talablarni keskin o‘zgartirmoqda. Natijada oliy ta’lim muassasasining vazifasi faqat nazariy bilim berish bilan cheklanmay, bitiruvchining yangi texnologiyalarni o‘zlashtira olishi, murakkab muammoni yechishi, jamoada ishlashi, mijoz bilan muloqot qilishi va o‘z kasbiy trayektoriyasini mustaqil boshqarishi uchun zarur kompetensiyalarni shakllantirishni ham qamrab oladi. Bu esa ta’lim xizmatlari sifati bilan mehnat bozori natijalari o‘rtasidagi bog‘liqlikni OTM boshqaruvining markaziy masalasiga aylantiradi.

Mehnat bozori talabi va oliy ta’lim taklifi o‘rtasidagi nomuvofiqlik bir vaqtning o‘zida bir necha iqtisodiy yo‘qotishlarni keltirib chiqaradi: ish beruvchi yangi xodimni qayta tayyorlash uchun qo‘shimcha xarajat qiladi, bitiruvchining ishga moslashish davri uzayadi, mutaxassislik bo‘yicha bandlik darajasi pasayishi mumkin, OTMning ta’lim dasturi esa real iqtisodiyotdagi o‘zgarishlardan ortda qoladi. Kichik biznes uchun mazkur muammo ayniqsa sezilarli, chunki u yangi xodimni uzoq vaqt tayyorlash uchun yirik korxonalardagi kabi resurslarga ega bo‘lmasligi mumkin. Shu sababli bitiruvchining amaliy tayyorgarligi va tez moslashuvchanligi biznes samaradorligiga bevosita ta’sir ko‘rsatadi.

Maqolaning maqsadi – oliy ta’lim xizmatlarini mehnat bozori talablariga moslashtirish orqali bitiruvchilar bandligi va tadbirkorlik salohiyatini oshirishning integratsiyalashgan mexanizmini asoslash, uning tarkibiy bloklarini aniqlash va natijadorligini baholash uchun amaliy ko‘rsatkichlar tizimini taklif etish. Tadqiqotning ilmiy vazifalari ta’lim dasturlarini ish beruvchi talabi bilan bog‘lash, amaliy tayyorgarlikni kuchaytirish, universitet–biznes hamkorligini institutsionallashtirish, karyera xizmatlari va bandlik monitoringini natijaga yo‘naltirish hamda tadbirkorlik kompetensiyalarini ta’lim jarayoniga integratsiya qilish yo‘llarini tizimlashtirishdan iborat.

ADABIYOTLARNING TAHLILI

Zamonaviy adabiyotlarda graduate employability tushunchasi oddiy “ishga joylashish” ko‘rsatkichidan kengroq talqin qilinadi. U bitiruvchining ish topishi bilan birga, kasbiy kompetensiyalarini namoyon etishi, o‘zgaruvchan mehnat sharoitiga moslashishi, kasbiy rivojlanishni davom ettirishi va yangi iqtisodiy imkoniyatlarni yaratish qobiliyatini ham anglatadi. World Bank [1] mehnatning o‘zgarayotgan tabiatini tahlil qilib, inson kapitaliga investitsiya va moslashuvchan ko‘nikmalarni iqtisodiy o‘sishning muhim sharti sifatida ko‘rsatadi. OECD Skills Outlook [2] ham

raqamli va yashil transformatsiya sharoitida ko‘nikmalarni muntazam yangilash zarurligini ta’kidlaydi.

Soft skills bo‘yicha Succi va Canovi [6] talabalar hamda ish beruvchilarning qarashlarini qiyoslab, ish beruvchilar yumshoq ko‘nikmalar ahamiyatini talabalarga nisbatan yuqoriroq baholashini ko‘rsatgan. Bu natija kommunikatsiya, jamoaviy ish, muammoni hal qilish va moslashuvchanlik kabi ko‘nikmalarni o‘quv dasturlarida faqat deklarativ natija sifatida emas, amaliy topshiriq va baholash mezonlari orqali shakllantirish zarurligini ko‘rsatadi. Rasul va hammualliflar [7] ham texnik va yumshoq ko‘nikmalar bitiruvchilarning employability darajasiga ijobiy bog‘liqligini aniqlagan.

Amaliy tajriba va work-integrated learning bo‘yicha tadqiqotlar bu yondashuvning mehnat bozoriga o‘tishni yengillashtirishini ko‘rsatadi. Jackson va Dean [8] katta milliy ma’lumotlar bazasi asosida work-integrated learningning turli shakllari bitiruvchilarning ko‘nikma va employability natijalariga hissa qo‘shishini qayd etadi. Jackson va Bridgstock [9] esa o‘quv dasturidagi, qo‘shimcha va darsdan tashqari tajribalar hamda haq to‘lanadigan ishning nisbiy qiymatini tahlil qilib, tajribaga asoslangan faoliyatlarning bitiruvchi tayyorgarligida alohida o‘rin tutishini ko‘rsatadi.

Universitet–biznes hamkorligi bo‘yicha Rebelo va hammualliflar [10] ta’lim dasturlarini ishlab chiqish va yetkazib berishda biznes bilan hamkorlik qilish mehnat bozori ehtiyojlarini ta’lim mazmuniga tezroq olib kirishini asoslaydi. 2025-yildagi sistematik sharh [11] esa amaliy tajriba beruvchi intervensionsiyalar graduate employability uchun eng barqaror ijobiy natijalarni ko‘rsatishini, to‘g‘ridan-to‘g‘ri mehnat bozori talabi bilan motivatsiyalangan choralar ko‘proq samarali bo‘lishini qayd etadi. 2026-yildagi yangi sistematik sharh [12] universitet–sanoat hamkorligi va employability skills rivoji bo‘yicha dalillarni umumlashtirib, oliy ta’lim va ish beruvchilar o‘rtasida muntazam aloqaning ahamiyatini yana bir bor ko‘rsatadi.

Adabiyotlarning umumiy xulosasi shundan iboratki, alohida vosita – faqat amaliyot, faqat karyera markazi yoki faqat o‘quv dasturini yangilash – barqaror natija berishi qiyin. Samarali model o‘quv dasturi, amaliy tayyorgarlik, ish beruvchi bilan institutsional hamkorlik, karyera xizmatlari, bandlik monitoringi va tadbirkorlik ko‘nikmalarini yagona qayta aloqa mexanizmiga birlashtirishi kerak. Mazkur maqolaning konseptual yangiligi aynan shu elementlarni bittadan tashabbus emas, o‘zaro bog‘langan boshqaruv sikli sifatida talqin qilishidadir.

TADQIQOT METODOLOGIYASI

Tadqiqot konseptual-analitik dizaynda amalga oshirildi. Birlamchi mazmuniy baza sifatida oliy ta’lim xizmatlarini mehnat bozori talablariga moslashtirish, kichik biznes ehtiyojlari va bitiruvchilar bandligini oshirishga bag‘ishlangan ikki mualliflik tezisidagi g‘oyalar olindi. Ular mazmunan bir-birini to‘ldiruvchi, biroq maqsadli natijasi jihatidan farqlanuvchi ikki yo‘nalishni ifodalaydi: birinchi yo‘nalish ta’lim–biznes–tadbirkorlik aloqalariga, ikkinchisi esa ta’lim sifati–bandlik–karyera xizmatlari aloqalariga qaratilgan.

Birinchi bosqichda kontent-tahlil yordamida takrorlanuvchi mazmuniy birliklar ajratildi. Kodlash birliklari sifatida “ish beruvchi ishtiroki”, “kompetensiya”, “amaliy

ta’lim”, “dual ta’lim”, “universitet–biznes hamkorligi”, “karyera xizmatlari”, “bandlik monitoringi”, “tadbirkorlik” va “uzluksiz ta’lim” kategoriyalari belgilandi. Mazkur kategoriyalar sabab–natija munosabatiga ko‘ra kirish omillari, jarayon mexanizmlari, oraliq natijalar va yakuniy mehnat bozori natijalariga ajratildi.

Ikkinchi bosqichda qiyosiy tahlil qo‘llanib, tezislarda taklif qilingan mexanizmlar 2019–2026-yillardagi xalqaro ilmiy adabiyotlar va xalqaro tashkilotlar hisobotlarida qayd etilgan yondashuvlar bilan solishtirildi. Manbalarni tanlashda uchta mezon qo‘llandi: mavzuning graduate employability yoki higher education–labour market linkage bilan bevosita bog‘liqligi; so‘nggi o‘n yillikda chop etilganligi; ilmiy jurnal, nufuzli xalqaro tashkilot yoki rasmiy hisobot sifatidagi ishonchliligi. Bu bosqich nazariy moslikni tekshirish va modelning tarkibiy elementlarini dalillar bilan mustahkamlashga xizmat qildi.

Uchinchi bosqichda strukturaviy sintez asosida elementlar yagona boshqaruv sikliga birlashtirildi. Modelda mehnat bozori talabi kirish signali sifatida, ta’lim dasturi va amaliy tayyorgarlik transformatsiya jarayoni sifatida, ish beruvchi hamkorligi va karyera xizmatlari institutsional ko‘prik sifatida, bandlik monitoringi esa qayta aloqa mexanizmi sifatida talqin qilindi. Tadbirkorlik va uzluksiz ta’lim komponenti natijani faqat yollanma ish bilan cheklamasdan, mustaqil bandlik va yangi biznes yaratish imkoniyatlari bilan kengaytiradi.

To‘rtinchi bosqichda modelning amaliy baholanishi uchun natijaviy indikatorlar tizimi ishlab chiqildi. Indikatorlar “jarayon” va “natija” ko‘rsatkichlariga ajratildi. Jarayon indikatorlari ish beruvchilar ishtirokida yangilangan dasturlar ulushi, real biznes loyihalari, dual ta’lim hamkorlari, karyera xizmatlari qamrovi kabi ko‘rsatkichlarni; natija indikatorlari esa 6 va 12 oy ichidagi ishga joylashish, mutaxassislik bo‘yicha bandlik, ish beruvchi qoniqishi, startap va o‘zini o‘zi band qilish holatlarini qamrab oladi. Tadqiqot empirik so‘rov yoki regressiya baholashiga da’vo qilmaydi; natijalar konseptual model va dalillarga asoslangan amaliy mexanizm sifatida talqin qilinadi.

TAHLIL VA NATIJALAR

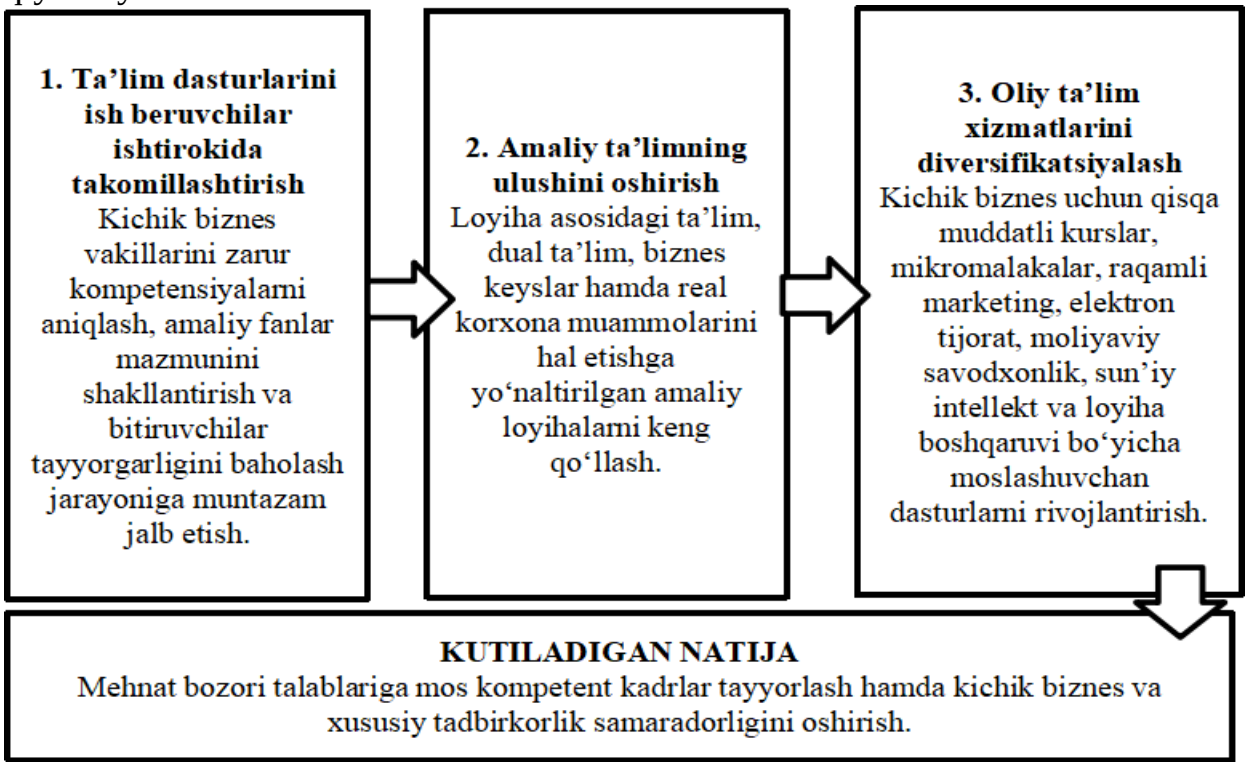
Joriy mehnat bozoridagi tarkibiy va texnologik o‘zgarishlar korxonalar tomonidan mutaxassislarga qo‘yiladigan talablarni ham tez o‘zgartirmoqda. Bugungi kunda ish beruvchilar faqat nazariy bilimga ega bitiruvchilarni emas, balki muammolarni mustaqil hal eta oladigan, raqamli texnologiyalardan foydalanadigan, jamoada ishlaydigan, mijozlar bilan samarali muloqot qiladigan, tadbirkorlik tashabbuslarini ilgari suradigan hamda o‘zgaruvchan biznes muhitiga moslasha oladigan mutaxassislarni talab qilmoqda. Shuning uchun oliy ta’lim xizmatlarini shakllantirishda an’anaviy yondashuvlardan mehnat bozori va biznes ehtiyojlariga asoslangan moslashuvchan modelga o‘tish zarur.

Mazkur jarayonda oliy ta’lim muassasalari bilan kichik biznes va xususiy tadbirkorlik subyektlari o‘rtasidagi hamkorlik alohida ahamiyat kasb etadi. Kichik biznes yirik korxonalarga nisbatan mehnat resurslari va moliyaviy imkoniyatlari cheklanganligi sababli tayyor mutaxassisning amaliy ko‘nikmalariga yuqori talab qo‘yadi. Yangi ishga qabul qilingan xodimni uzoq vaqt qayta tayyorlash kichik korxonalar uchun qo‘shimcha xarajat hisoblanadi. Shu sababli OTM bitiruvchilarining

ish joyiga imkon qadar tez moslashishi va amaliy vazifalarni mustaqil bajara olishi tadbirkorlik subyektlari faoliyati samaradorligiga bevosita ta’sir ko‘rsatadi.

Oliy ta’lim xizmatlarini mehnat bozori talablariga moslashtirishning birinchi muhim yo‘nalishi ta’lim dasturlarini ish beruvchilar ishtirokida takomillashtirish hisoblanadi. Bunda kichik biznes vakillarining faqat tayyor o‘quv dasturlariga fikr bildirish bilan cheklanmasdan, zarur kompetensiyalarni aniqlash, amaliy fanlar mazmunini shakllantirish va bitiruvchilar tayyorgarligini baholash jarayonlarida muntazam ishtirok etishini ta’minlash lozim. Bu esa ta’lim mazmuni bilan real ish jarayonlari o‘rtasidagi tafovutni kamaytiradi.

Ikkinchi yo‘nalish amaliy ta’limning ulushini oshirish bilan bog‘liq. An’anaviy qisqa muddatli amaliyot o‘rniga talabalarni korxonalarning real muammolarini hal etishga jalb qiluvchi loyiha asosidagi ta’lim, dual ta’lim, biznes keyslar va amaliy loyihalarni keng qo‘llash maqsadga muvofiq. Masalan, talabalar kichik korxonalar uchun marketing rejasi, xarajatlarni optimallashtirish modeli, raqamli savdo strategiyasi, biznes-reja yoki xizmat ko‘rsatish jarayonlarini takomillashtirish loyihalarini ishlab chiqishi mumkin. Bunday yondashuv talabaning amaliy kompetensiyasini oshirish bilan birga, kichik biznes uchun ham qo‘shimcha iqtisodiy qiymat yaratadi.



1-rasm. Oliy ta’lim xizmatlarini mehnat bozori talablariga moslashtirishning asosiy yo‘nalishlari

Uchinchi muhim yo‘nalish — oliy ta’lim xizmatlarini diversifikatsiyalash. Zamonaviy mehnat bozori faqat bakalavriat yoki magistratura dasturlari bilan cheklanmaydi. Kichik biznes vakillari va xodimlari uchun qisqa muddatli malaka oshirish kurslari, mikromalakalar, biznes boshqaruvi, raqamli marketing, elektron tijorat, moliyaviy savodxonlik, sun’iy intellekt vositalaridan foydalanish, eksport

faoliyati va loyiha boshqaruvi bo‘yicha moslashuvchan dasturlarni tashkil etish istiqbolli yo‘nalish hisoblanadi. Natijada OTM bir martalik diplom beruvchi muassasadan uzluksiz professional rivojlanish xizmatlarini ko‘rsatuvchi institutga aylanishi mumkin.

Shuningdek, ta’lim jarayonida tadbirkorlik kompetensiyalarini shakllantirish masalasiga alohida e’tibor qaratish zarur. Bitiruvchi faqat mavjud ish o‘rnini egallashga emas, balki yangi biznes tashabbusini amalga oshirishga ham tayyor bo‘lishi kerak. Buning uchun biznes-reja tuzish, bozorni o‘rganish, moliyaviy resurslarni boshqarish, mijozlar bilan ishlash, innovatsion g‘oyalarni tijoratlashtirish va tavakkalchilikni baholash ko‘nikmalarini ta’lim dasturlariga integratsiya qilish muhimdir. Universitet biznes-inkubatorlari va startap markazlarining faoliyatini ta’lim jarayoni bilan bog‘lash esa talabalar tashabbuslarini real tadbirkorlik loyihalariga aylantirish imkonini beradi.

Oliy ta’lim xizmatlarini mehnat bozori talablariga moslashtirishning yana bir zarur sharti doimiy qayta aloqa va monitoring tizimini shakllantirishdir. Ish beruvchilarning bitiruvchilar malakasidan qoniqish darajasi, talab qilinayotgan yangi ko‘nikmalar, kasblar tarkibidagi o‘zgarishlar hamda kelgusidagi kadrlar ehtiyoji muntazam tahlil qilinishi kerak. Mazkur ma’lumotlar asosida ta’lim dasturlari, amaliy mashg‘ulotlar va qo‘shimcha ta’lim xizmatlarini tezkor ravishda yangilab borish mumkin.

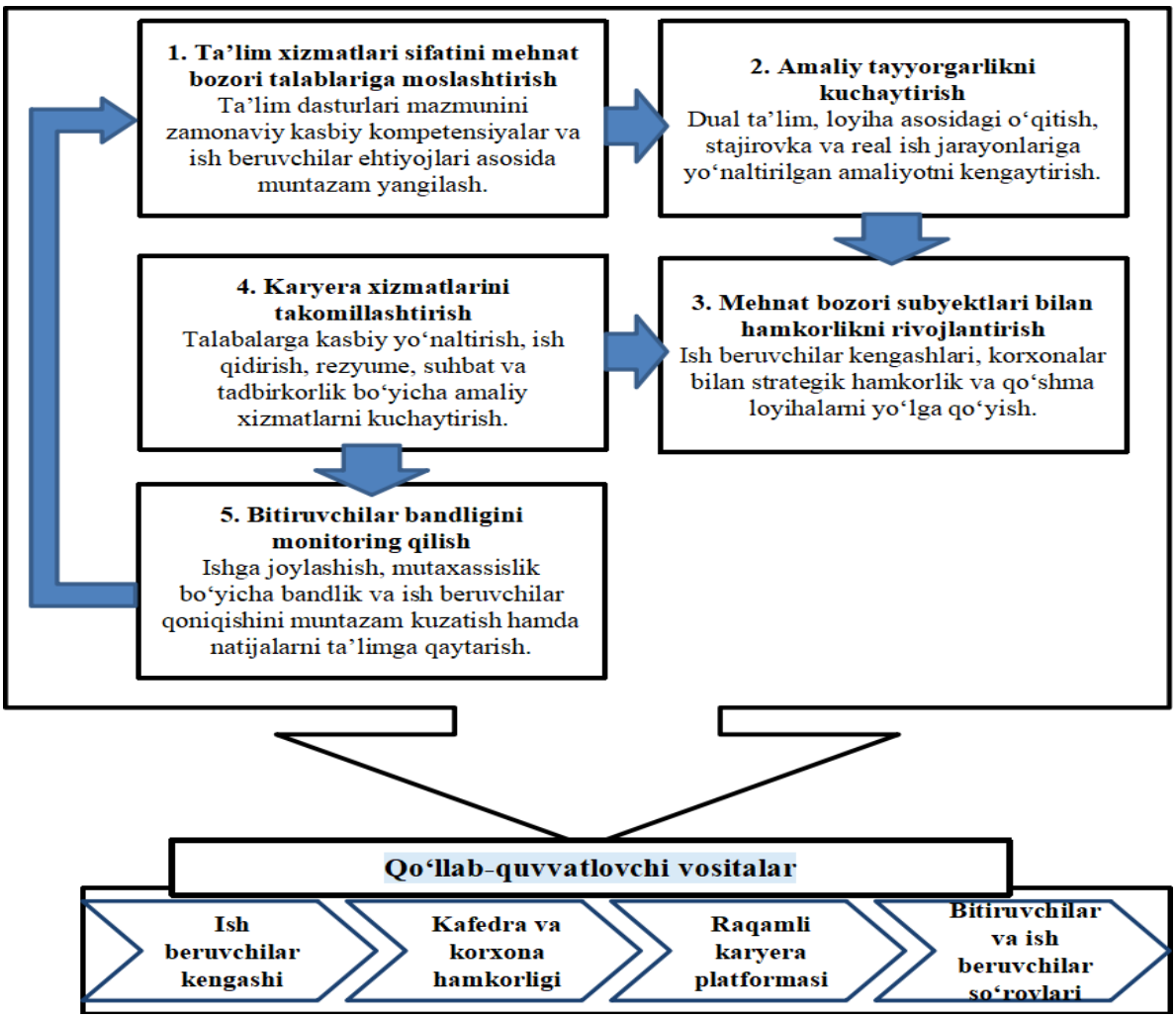
Mehnat bozorida sodir bo‘layotgan texnologik, tashkiliy va tarkibiy o‘zgarishlar mutaxassislarga qo‘yiladigan talablarni muntazam ravishda yangilab bormoqda. Ish beruvchilar nazariy bilimlardan tashqari amaliy muammolarni hal eta olish, raqamli texnologiyalar bilan ishlash, jamoada samarali faoliyat yuritish, mustaqil qaror qabul qilish, kommunikativ va tadbirkorlik ko‘nikmalariga ega bo‘lgan bitiruvchilarga ehtiyoj bildirmoqda. Bunday vaziyatda oliy ta’lim muassasalari tomonidan taklif etilayotgan xizmatlarning mazmuni va sifati mehnat bozori talablaridan ortda qolishi bitiruvchilarning ishga joylashish imkoniyatlarini cheklashi mumkin.

Shu jihatdan bitiruvchilar bandligini oshirishning asosiy shartlaridan biri ta’lim xizmatlari sifatini mehnat bozori ehtiyojlari bilan uyg‘unlashtirish hisoblanadi. Bunda ta’lim sifati faqat o‘quv dasturlarining mavjudligi yoki professor-o‘qituvchilarning malakasi bilan emas, balki bitiruvchida shakllangan kompetensiyalarning ish beruvchi talablari bilan qanchalik mos kelishi orqali ham baholanishi zarur. Bu esa oliy ta’lim muassasalarida natijaga yo‘naltirilgan sifat boshqaruvi tizimini kuchaytirishni talab etadi.

Mazkur yo‘nalishda birinchi navbatda ta’lim dasturlarini mehnat bozori subyektlari bilan hamkorlikda takomillashtirish muhimdir. Ish beruvchilar, xususiy korxonalar, davlat tashkilotlari, tadbirkorlik subyektlari va professional uyushmalar vakillari o‘quv dasturlarini ishlab chiqish va qayta ko‘rib chiqishda muntazam ishtirok etishi lozim. Bunday hamkorlik orqali korxonalarda talab qilinayotgan yangi kompetensiyalar aniqlanib, ularni fanlar mazmuni, amaliy mashg‘ulotlar va mustaqil

ta’lim topshiriqlariga kiritish mumkin. Natijada ta’lim mazmuni bilan real kasbiy faoliyat o‘rtasidagi tafovut kamayadi.

Ikkinchi muhim yo‘nalish amaliy tayyorgarlik sifatini oshirish bilan bog‘liq. Talabalarning ishlab chiqarish amaliyoti qisqa muddatli va rasmiy jarayon sifatida emas, balki kelajakdagi bandlikka tayyorlovchi muhim bosqich sifatida tashkil etilishi kerak. Talabalarni real ish jarayonlariga, korxona loyihalariga, muammoli vaziyatlarni hal etishga hamda jamoaviy faoliyatga jalb qilish ularning kasbiy tayyorgarligini mustahkamlaydi. Dual ta’lim, loyiha asosidagi o‘qitish, amaliy keyslar, stajirovka va ish beruvchi ishtirokidagi amaliy mashg‘ulotlarni kengaytirish ushbu vazifani amalga oshirishning samarali vositalaridan hisoblanadi.



2-rasm. OTM bitiruvchilari bandligini oshirishda ta’lim xizmatlari sifati va mehnat bozori bilan hamkorlikni rivojlantirish mexanizmi

Bitiruvchilar bandligini oshirishda OTM va mehnat bozori subyektlari o‘rtasidagi institutsional hamkorlikni rivojlantirish ham alohida ahamiyatga ega. Oliy ta’lim muassasalarida ish beruvchilar kengashlarini shakllantirish, korxonalar bilan uzoq muddatli hamkorlik shartnomalarini tuzish, kafedra filiallarini tashkil etish va qo‘shma loyihalarni amalga oshirish ta’lim jarayonini amaliyot bilan yaqinlashtiradi.

Shu bilan birga, ish beruvchilar talabalar tayyorgarligini baholash, bitiruv malakaviy ishlariga mavzular taklif etish va istiqbolli talabalarni oldindan tanlash imkoniyatiga ega bo‘ladi.

MUHOKAMA

Olingan natijalar xalqaro adabiyotlarda shakllangan graduate employability konsepsiyasi bilan mos keladi, biroq maqoladagi model bu yondashuvlarni boshqaruv sikli sifatida birlashtiradi. Succi va Canovi [6] ish beruvchilar yumshoq ko‘nikmalarni talabalar va bitiruvchilarga qaraganda yuqoriroq qadrlashini ko‘rsatgan. Mazkur natija taklif qilingan kompetensiya xaritasi va ish beruvchi ishtirokidagi o‘quv dasturlarini yangilash mexanizmini qo‘llab-quvvatlaydi. Ya’ni kompetensiya talabi universitet tomonidan bir tomonlama belgilanishi emas, ish beruvchi bilan muntazam muvofiqlashtirilishi lozim.

Amaliy tayyorgarlik bo‘yicha maqola natijalari Jackson va Dean [8] xulosalari bilan hamohang. Ularning katta ko‘lamli tadqiqoti work-integrated learningning turli shakllari employability va ko‘nikma natijalariga hissa qo‘shishini ko‘rsatadi. 2025-yildagi sistematik sharh [11] amaliy tajriba beruvchi intervensionsiyalar eng ijobiy natijalarni ko‘rsatishini qayd etgani ham ushbu maqoladagi “amaliyotning davomiyligi emas, real natijasi” tamoyilini kuchaytiradi. Shu nuqtada maqola natijalari mavjud adabiyotlardan bir qadam oldinga borib, amaliyotni ish beruvchi bilan birgalikda belgilangan learning outcomes, mentorlik va baholash bilan bog‘lashni taklif etadi.

Universitet–biznes hamkorligi bo‘yicha Rebelo va hammualliflar [10] ta’lim dasturlarini ishlab chiqish va yetkazib berishda hamkorlikning ahamiyatini ko‘rsatgan. Vlachopoulos va Tsitiridou [12] tomonidan e’lon qilingan yangi systematic review ham employability skills rivoji va university–industry collaborationni bir-biridan ajratib bo‘lmasligini ta’kidlaydi. Mazkur maqolada esa hamkorlikning samaradorligi memorandumlar yoki tadbirlar soni bilan emas, ish beruvchining o‘quv dasturi, amaliyot, baholash va bitiruvchi monitoringidagi real ishtiroki bilan o‘lchanishi kerakligi asoslanadi.

Karyera xizmatlari va monitoring bo‘yicha natijalar employabilityni faqat o‘qish davridagi kompetensiya bilan emas, “universitetdan mehnat bozoriga o‘tish” jarayoni bilan bog‘lash zarurligini ko‘rsatadi. Barachino va hammualliflar [11] employability intervensionsiyalarini operatsionlashtirish bo‘yicha dalillarni umumlashtirib, faqat ko‘nikma yoki karyera rejalashtirish dasturlarining natijalari aralash bo‘lishi mumkinligini, bevosita mehnat bozori talabi bilan bog‘langan choralar esa kuchliroq natija berishini ko‘rsatadi. Bu xulosa karyera markazi faoliyatini o‘quv dasturi va ish beruvchi bilan integratsiyalashgan holda tashkil etish taklifini asoslaydi.

Tadbirkorlik komponentining qo‘shilishi modelning muhim farqlovchi jihatidir. An’anaviy employability tadqiqotlarida asosiy natija ko‘pincha ishga joylashish yoki ish beruvchi bahosi bilan o‘lchanadi. Biroq raqamli platformalar, frilans va o‘zini o‘zi band qilish shakllarining kengayishi bitiruvchini nafaqat ish izlovchi, balki iqtisodiy qiymat yaratuvchi subyekt sifatida ko‘rishni talab etadi. Shu sababli universitetning startap, inkubator, mikromalaka va qisqa professional dasturlari bandlik siyosatining qo‘shimcha elementi emas, uning mantiqiy davomiga aylanishi kerak.

Tadqiqotning cheklovi shundaki, taklif etilgan model hozircha empirik regressiya, longitudinal kuzatuv yoki eksperimental dizayn bilan sinovdan o‘tkazilmagan. Shuning uchun “mexanizm – natija” aloqalari nazariy va dalillarga asoslangan konseptual munosabat sifatida talqin qilinadi. Keyingi tadqiqotda bir nechta OTM kesimida ish beruvchilar, bitiruvchilar va talabalar so‘rovlari, 6–12 oylik bandlik ma’lumotlari hamda ta’lim dasturlari bo‘yicha indikatorlarni birlashtirib, strukturaviy tenglamalar modeli yoki panel regressiyasi orqali mexanizmning ta’sir kuchini empirik baholash maqsadga muvofiq.

XULOSA VA TAKLIFLAR

Tadqiqot oliy ta’lim xizmatlarini mehnat bozori talablariga moslashtirish bitiruvchilar bandligi va tadbirkorlik salohiyatini birgalikda oshirishini ko‘rsatdi. Samarali model ish beruvchilar ishtirokidagi o‘quv dasturlari, amaliy tayyorgarlik, universitet–biznes hamkorligi, karyera xizmatlari, bandlik monitoringi va tadbirkorlik ta’limini yagona qayta aloqa tizimida birlashtiradi. OTMlar natijadorlikni tadbirlar soni bilan emas, ishga joylashish, mutaxassislik bo‘yicha bandlik, ish beruvchi qoniqishi va mustaqil bandlik ko‘rsatkichlari orqali baholashi lozim. Kompetensiya xaritalari, real biznes loyihalari, dual ta’lim, raqamli karyera platformalari va bitiruvchi kuzatuvi ushbu mexanizmning amaliy vositalaridir. Modelni O‘zbekiston OTMlarida empirik sinash keyingi tadqiqotlarning muhim yo‘nalishi bo‘lib, uning hududiy va tarmoq xususiyatlariga moslashuvchanligini ham chuqur baholash imkonini kelgusida yanada yaratadi.

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KORXONALARNI BOSHQARISHDA MARKETING STRATEGIYASINING AHAMIYATI VA O‘RNI

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Annotatsiya. *Ushbu maqolada zamonaviy bozor sharoitida korxonalarni boshqarishda marketing strategiyasining ahamiyati va o‘rni tahlil qilingan. Marketing strategiyasining korxonaning raqobatbardoshligini ta’minlashdagi roli, strategik boshqaruvning zamonaviy tamoyillari va O‘zbekiston sharoitida marketing yondashuvlarini qo‘llash imkoniyatlari muhokama qilingan. Tadqiqot natijasida korxonalarda marketing strategiyasini ishlab chiqish va joriy etishning ilmiy asoslangan yo‘nalishlari taklif etilgan.*

Kalit so‘zlar: *marketing strategiyasi, korxona boshqaruvi, raqobatbardoshlik, bozor segmentatsiyasi, marketing miks, strategik rejalashtirish, iste’molchilar bilan aloqa.*

Аннотация. *В данной статье проанализированы значение и роль маркетинговой стратегии в управлении предприятиями в условиях современного рынка. Рассмотрены роль маркетинговой стратегии в обеспечении конкурентоспособности предприятия, современные принципы стратегического управления, а также возможности применения маркетинговых подходов в условиях Узбекистана. В результате исследования предложены научно обоснованные направления разработки и внедрения маркетинговой стратегии на предприятиях.*

Ключевые слова: *маркетинговая стратегия, управление предприятием, конкурентоспособность, сегментация рынка, маркетинг-микс, стратегическое планирование, коммуникация с потребителями.*

Abstract. *This article analyzes the importance and role of marketing strategy in enterprise management under modern market conditions. The role of marketing strategy in ensuring the competitiveness of enterprises, modern principles of strategic management, and the possibilities of applying marketing approaches in the conditions of Uzbekistan are discussed. As a result of the research, scientifically substantiated directions for the development and implementation of marketing strategy in enterprises are proposed.*

Keywords: *marketing strategy, enterprise management, competitiveness, market segmentation, marketing mix, strategic planning, consumer relations.*

KIRISH

Zamonaviy bozor iqtisodiyoti sharoitida korxonalarning muvaffaqiyatli faoliyat yuritishi va raqobatbardoshligini ta’minlashda marketing strategiyasi muhim

ahamiyatga ega. Marketing strategiyasi korxonaning uzoq muddatli maqsadlariga erishish, bozorda mustahkam o‘rin egallash va iste’molchilarning ehtiyojlarini qondirish uchun zarur bo‘lgan kompleks tadbirlar majmuasidan iborat.

O‘zbekiston Respublikasida olib borilayotgan iqtisodiy islohotlar, xususiy tadbirkorlikning rivojlanishi va xalqaro bozorlarga integratsiya jarayonlari korxonalardan zamonaviy marketing yondashuvlarini qo‘llashni talab etmoqda.
O‘zbekiston Respublikasi Prezidentining tegishli farmon va qarorlarida kichik biznes va xususiy tadbirkorlikni rivojlantirish, mahsulot eksport salohiyatini oshirish vazifalari qo‘yilgan bo‘lib, bu marketing strategiyasini ishlab chiqish zaruriyatini yanada oshiradi.

Mazkur tadqiqotning maqsadi — korxonalarni boshqarishda marketing strategiyasining ahamiyati va o‘rnini ilmiy asosda tahlil qilish va O‘zbekiston sharoitida uni joriy etish bo‘yicha amaliy tavsiyalar ishlab chiqishdan iborat.

ADABIYOTLAR TAHLILI VA METODOLOGIYA

Marketing strategiyasi nazariyasi F. Kotler, M. Porter, I. Ansoff, J. Lamben kabi chet el olimlarining asarlarida keng yoritilgan. F. Kotler marketingni «iste’molchilar ehtiyojlarini aniqlash va ularni rentabelli qondirish jarayoni» sifatida ta’riflaydi. M. Porter esa raqobat strategiyasi nazariyasini ishlab chiqib, korxonalarning bozorda raqobatbardoshligini ta’minlashning uch asosiy strategiyasini (xarajatlar ustunligi, differensiatsiya, fokuslanish) taklif etgan.

MDH mamlakatlari olimlari, jumladan Ye.P. Golubkov, P.S. Zavyalov, I.V. Lipsis marketing strategiyasining milliy iqtisodiyotga moslashuvi muammolarini o‘rganganlar. O‘zbekistonlik olimlardan S.S. G‘ulomov, A.Sh. Bekmurodov, Sh.J. Ergashxo‘jaeva va boshqalar marketing strategiyasini milliy korxonalarda qo‘llash nazariyasi va amaliyotiga oid tadqiqotlar olib borganlar.

Tadqiqotda nazariy tahlil, tizimli yondashuv, statistik tahlil va muqoyasa usullaridan foydalanildi. Ilmiy adabiyotlar, normativ-huquqiy hujjatlar va statistik ma’lumotlar tadqiqot uchun asosiy manba sifatida xizmat qildi.

MARKETING STRATEGIYASINING MOHIYATI VA TARKIBI. Marketing strategiyasi — korxonaning uzoq muddatli maqsadlariga erishishni ta’minlovchi, bozor sharoitlari va raqobat vaziyatiga moslashgan tizimli yondashuv bo‘lib, u quyidagi asosiy elementlardan tashkil topadi:

• Bozor tahlili va segmentatsiyasi — iste’molchilar guruhlarini aniqlash, ularning ehtiyojlari va xatti-harakatlarini o‘rganish;
• Maqsadli bozor tanlash — korxona uchun eng foydali va istiqbolli bozor segmentini aniqlash;
• Pozitsionirovanie — mahsulot yoki xizmatning raqobatchilarga nisbatan noyob o‘rnini yaratish;
• Marketing miks (4P: mahsulot, narx, tarqatish, reklama) — korxonaning marketing faoliyatining asosiy vositalari;
• Bajarilishi va nazorati — strategiya amalga oshirilishi va natijalarini baholash.

Marketing strategiyasining korxonalar faoliyatidagi o‘rni quyidagi jadvalda ko‘rsatilgan:

Funksiya	Strategik roli	Amaliy natija
Bozor tahlili	Iste'molchi ehtiyojlarini aniqlash	Maqsadli bozorni belgilash
Raqobat tahlili	Raqobatchilar ustunligi va kamchiliklarini baholash	Noyob taklif ishlab chiqish
Mahsulot siyosati	Assortiment va sifatni boshqarish	Iste'molchi qanoatini oshirish
Narx siyosati	Optimal narx shakllanishi	Rentabellik va raqobatbardoshlik
Tarqatish siyosati	Samarali sotuv kanallari	Bozorga kirish kengayishi
Reklama siyosati	Brend tanilishi va imidji	Sotuv hajmi oshishi

1-jadval. Marketing strategiyasining korxona faoliyatidagi funksiyalari

KORXONALARNI BOSHQARISHDA MARKETING STRATEGIYASINING O'RNI. Zamonaviy korxonalarni boshqarishda marketing strategiyasi strategik menejmentning ajralmas qismi hisoblanadi. Marketing strategiyasi korxonaning umumiy strategiyasi bilan uzviy bog'liq bo'lib, uning asosiy maqsadlariga erishishga xizmat qiladi.

Tadqiqotlar shuni ko'rsatadiki, samarali marketing strategiyasini qo'llaydigan korxonalarning rentabelligi, bozor ulushi va mijozlar qoniqishi darajasi ancha yuqori bo'ladi. Xususan, xalqaro tajribaga ko'ra, marketing strategiyasiga jiddiy e'tibor beradigan korxonalarning sotuv hajmi o'rtacha yiliga 15–25% ga oshishi kuzatiladi. Marketing strategiyasining korxonalar boshqaruvidagi asosiy vazifalari quyidagilardan iborat:

1) Strategik rejalashtirish — korxonaning uzoq muddatli rivojlanish yo'nalishlarini belgilash va ular doirasidagi marketing maqsadlarini aniqlash;

2) Resurslarni optimal taqsimlash — moliyaviy, insoniy va moddiy resurslarni eng samarali yo'nalishlarga yo'naltirish;

3) Innovatsion yondashuvlar — yangi mahsulot va xizmatlar ishlab chiqish, ishlab chiqarish va sotuv jarayonlarini modernizatsiya qilish;

4) Mijozlar bilan aloqalarni boshqarish (CRM) — doimiy mijozlar bazasini shakllantirish va ular bilan uzoq muddatli hamkorlik o'rnatish;

5) Raqobat afzalliklarini rivojlantirish — korxonaning noyob taklifi va raqobat afzalliklarini yaratish va mustahkamlash.

Marketing strategiyasining asosiy turlari va ularning qo'llanilish sohalari 2-jadvalda keltirilgan:

Strategiya turi	Asosiy maqsad	Qo'llanilish sohasi
O'sish strategiyasi	Bozor ulushini oshirish	Rivojlanayotgan bozorlar
Differensiatsiya strategiyasi	Noyob mahsulot taklif etish	Yuqori sifatli segment
Xarajatlar ustunligi	Past narx orqali raqobat	Ommaviy bozor
Fokuslanish strategiyasi	Tor segmentga ixtisoslashish	Nisha bozorlar
Innovatsion strategiya	Yangi mahsulot va texnologiyalar	Yuqori texnologik sohalar
Eksport strategiyasi	Xalqaro bozorlarga kirish	Eksportga yo'naltirilgan korxonalar

2-jadval. Marketing strategiyasining asosiy turlari

O'ZBEKISTON SHHAROITIDA KORXONALARDA MARKETING STRATEGIYASINI JORIY ETISH. O'zbekistonda amalga oshirilayotgan iqtisodiy islohotlar korxonalarda zamonaviy marketing yondashuvlarini joriy etish uchun qulay shart-sharoit yaratmoqda. Xususan, kichik biznes va xususiy tadbirkorlikni

rivojlantirish, eksport salohiyatini oshirish, investitsiyaviy muhitni yaxshilash yo‘nalishidagi islohotlar marketing strategiyasini qo‘llash zaruriyatini oshiradi.

Biroq O‘zbekiston korxonalarida marketing strategiyasini joriy etishda bir qator muammolar mavjud:

— Malakali marketolog kadrlar yetishmasligi;

— Marketing tadqiqotlarini o‘tkazish uchun yetarli moliyaviy imkoniyatlarning cheklanganligi;

— Zamonaviy marketing axborot tizimlarining yetarli rivojlanmaganligi;

— Rahbarlarning marketing strategiyasiga yetarli e’tibor bermasligi;

— Xalqaro bozorlar talablarini o‘rganish va ularga moslashishdagi qiyinchiliklar.

Ushbu muammolarni hal etish uchun quyidagi yo‘nalishlarda ish olib borish tavsiya etiladi:

Birinchidan, marketing sohasidagi malakali kadrlar tayyorlashni kuchaytirish, oliy ta’lim muassasalarida marketing va menejment yo‘nalishlarini kengaytirish zarur. Ikkinchidan, korxonalarda marketing bo‘limlarini tashkil etish va ularning ishini rag‘batlantirish kerak. Uchinchidan, zamonaviy raqamli marketing vositalarini (internet-marketing, SMM, e-commerce) keng qo‘llashni yo‘lga qo‘yish lozim. To‘rtinchidan, xalqaro marketing standartlari va tajribasini o‘rganish va milliy sharoitga moslashtirish zarur.

NATIJALAR VA MUHOKAMA

Tadqiqot natijasida quyidagi asosiy xulosalarga kelindi: Birinchidan, marketing strategiyasi korxonalarni boshqarishning ajralmas qismi bo‘lib, uning samarali joriy etilishi korxonaning raqobatbardoshligi, rentabelligi va barqaror rivojlanishini ta’minlaydi. Zamonaviy bozor sharoitida marketing strategiyasisiz korxonaning mustahkam o‘rin egallashi mushkul.

Ikkinchidan, marketing strategiyasini ishlab chiqish va joriy etish jarayonida korxonaning ichki imkoniyatlari, tashqi muhit omillari va bozor ehtiyojlarini hisobga olish zarur. Bunda SWOT-tahlil, PEST-tahlil va boshqa zamonaviy tahlil usullaridan foydalanish tavsiya etiladi.

Uchinchidan, O‘zbekiston korxonalarida marketing strategiyasini joriy etishda milliy mentalitet, madaniy-iqtisodiy sharoit va xorijiy tajribaning optimal uyg‘unligini ta’minlash muhimdir. Xususan, agrar sektorda marketing strategiyasining o‘ziga xos xususiyatlari (mavsumiylik, tez buziluvchanlik, mintaqaviy o‘ziga xoslik) hisobga olinishi kerak.

XULOSA VA TAVSIYALAR

Ushbu tadqiqot natijalariga asosan quyidagi tavsiyalar ishlab chiqildi:

1. Korxonalarda marketing bo‘limlarini tashkil etish va ular faoliyatini samarali tashkil qilish;
2. Marketing tadqiqotlarini muntazam ravishda o‘tkazish va natijalarini boshqaruv qarorlari qabul qilishda foydalanish;
3. Zamonaviy raqamli marketing vositalarini keng qo‘llash (internet-marketing, ijtimoiy tarmoqlar, elektron savdo);
4. Mijozlar bilan aloqa tizimini (CRM) joriy etish va mijozlar sodiqligini oshirish;

5. Xalqaro bozorlarga kirish strategiyalarini ishlab chiqish va eksport marketingini rivojlantirish;

6. Malakali marketolog kadrlar tayyorlashni kuchaytirish va mavjud xodimlarning malakasini oshirish.

Xulosa qilib aytganda, korxonalarni boshqarishda marketing strategiyasi strategik boshqaruvning kalit elementi hisoblanadi. O‘zbekiston sharoitida zamonaviy marketing yondashuvlarini joriy etish korxonalarning raqobatbardoshligini oshirish, eksport salohiyatini kengaytirish va barqaror iqtisodiy o‘sishni ta’minlash uchun muhim ahamiyatga ega.

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PUBLIC MANAGEMENT EFFICIENCY AND REGIONAL ECONOMIC DEVELOPMENT IN UZBEKISTAN

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Abstract. *This article examines the relationship between the efficiency of public administration and regional economic development in Uzbekistan in the context of the reforms launched in 2017 and the Uzbekistan-2030 strategy. Drawing on official normative documents, OECD governance reviews and recent econometric panel evidence for 14 administrative units over 2017-2024, the study shows that regulatory quality, infrastructure provision and the investment climate are the main channels through which public management influences regional growth. Difference-in-differences estimates indicate that regions with higher reform intensity achieved approximately 23.4% higher gross regional product (GRP) growth and 41.2% higher foreign direct investment (FDI) attraction than low-reform regions (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024) . At the same time, persistent territorial disparities, the limited fiscal autonomy of local governments and the still centralized structure of public administration constrain the diffusion of these gains (OECD, 2024; Asian Development Bank, n.d.) . The article concludes with recommendations on fiscal decentralization, results-based management, digitalization of public services and spatially targeted investment policy.*

Keywords*: public management efficiency, regional economic development, gross regional product, fiscal decentralization, Uzbekistan-2030, regulatory reform, local governance.*

Annotatsiya. *Ushbu maqolada 2017-yilda boshlangan islohotlar va "O'zbekiston-2030" strategiyasi kontekstida davlat boshqaruvi samaradorligi va O'zbekistondagi mintaqaviy iqtisodiy rivojlanish o'rtasidagi bog'liqlik o'rganiladi. Rasmiy me'yoriy hujjatlar, OECD boshqaruv sharhlari va 2017–2024-yillar davomida 14 ta ma'muriy birlik bo'yicha o'tkazilgan so'nggi ekonometrik panel tadqiqotlariga tayangan holda, tadqiqot shuni ko'rsatadiki, tartibga solish sifati, infratuzilma bilan ta'minlanganlik va investitsion muhit davlat boshqaruvi mintaqaviy o'sishga ta'sir ko'rsatadigan asosiy kanallar hisoblanadi. "Farqdagi farq" (difference-in-differences) usuli bo'yicha hisob-kitoblar shuni ko'rsatadiki, islohotlar intensivligi yuqori bo'lgan*

hududlar islohotlar darajasi past bo'lgan hududlarga nisbatan yalpi hududiy mahsulot (YaHM) o'sishida taxminan 23,4% va to'g'ridan-to'g'ri xorijiy investitsiyalar (TXI) jalb qilishda 41,2% yuqori ko'rsatkichga erishgan (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024). Shu bilan birga, davom etayotgan hududiy nomutanosibliklar, mahalliy hokimiyat organlarining cheklangan fiskal avtonomiyasi va davlat boshqaruvining hanuz markazlashgan tuzilishi ushbu yutuqlarning tarqalishini cheklab qo'ymoqda (OECD, 2024; Asian Development Bank, n.d.). Maqola xulosasida fiskal markazsizlashtirish, natijalarga asoslangan boshqaruv, davlat xizmatlarini raqamlashtirish va hududiy yo'naltirilgan investitsion siyosat bo'yicha tavsiyalar berilgan.

Kalit so'zlar: *davlat boshqaruvi samaradorligi, mintaqaviy iqtisodiy rivojlanish, yalpi hududiy mahsulot, fiskal markazsizlashtirish, O'zbekiston-2030, tartibga solish islohoti, mahalliy boshqaruv.*

Аннотация. *В данной статье исследуется взаимосвязь между эффективностью государственного управления и региональным экономическим развитием в Узбекистане в контексте реформ, начатых в 2017 году, и стратегии «Узбекистан-2030». Опираясь на официальные нормативные документы, обзоры ОЭСР по вопросам управления и недавние эконометрические панельные данные по 14 административным единицам за 2017–2024 годы, исследование показывает, что качество регулирования, обеспечение инфраструктурой и инвестиционный климат являются основными каналами, через которые государственное управление влияет на региональный рост. Оценки с использованием метода разности разностей (difference-in-differences) показывают, что регионы с более высокой интенсивностью реформ достигли примерно на 23,4% более высокого роста валового регионального продукта (ВРП) и на 41,2% более высокого притока прямых иностранных инвестиций (ПИИ) по сравнению с регионами с низкой интенсивностью реформ (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024). В то же время сохраняющиеся территориальные диспропорции, ограниченная фискальная автономия местных органов власти и всё ещё централизованная структура государственного управления сдерживают распространение этих достижений (OECD, 2024; Asian Development Bank, n.d.). В заключении статьи предлагаются рекомендации по фискальной децентрализации, управлению по результатам, цифровизации государственных услуг и пространственно-ориентированной инвестиционной политике.*

Ключевые слова: *эффективность государственного управления, региональное экономическое развитие, валовой региональный продукт, фискальная децентрализация, Узбекистан-2030, регуляторная реформа, местное самоуправление.*

INTRODUCTION

Since 2017 Uzbekistan has carried out a broad program of economic and administrative transformation aimed at liberalizing the economy, attracting investment and reducing poverty. These reforms have been accompanied by sustained growth that has consistently outpaced the Central Asian average, while extreme poverty fell from

8% in 2016 to less than 1% in 2023 (OECD, 2024). The strategic framework of the Uzbekistan-2030 strategy and the accompanying regional programs set ambitious targets, including annual GRP growth of 6-7% for the regions, based on their natural, demographic, infrastructure and specialization potential (Presidential Decree, n.d.-a) . At the same time, the public administration remains centralized and hierarchical, and policymakers themselves have identified the reform of this concentrated governance system as a necessary step for addressing regional disparities, transparency gaps and uneven public service delivery (OECD, 2024) . The dominance of Tashkent relative to the rest of the country, the low level of decentralization and the weak financial and managerial capacity of subnational governments are repeatedly cited as structural obstacles to balanced territorial development (Asian Development Bank, n.d.).

The purpose of this article is to analyze how the efficiency of public management affects the pace and balance of regional economic development in Uzbekistan, and to formulate evidence-based recommendations. The study is based on official normative documents, international governance assessments and recent econometric evidence on regional growth dynamics.

LITERATURE REVIEW

The theoretical foundation of the study rests on two bodies of literature: the theory of public administration and the theory of regional development. Within the first, the efficiency of public management is treated as a function of the institutional environment, the quality of regulatory decisions, the qualifications of managerial personnel and the feedback received from the population. In the Uzbek context, research has shown that the ways to improve the efficiency of public administration depend directly on the qualifications of management staff and on feedback from the local population (Asadullina, 2019). A related line of work argues that market mechanisms are only one of many instruments for achieving socio-economic goals, and that the state must clearly define the boundaries within which market relations are introduced, where activity is regulated, and where the state itself produces goods and services (Rasulov & Voronin, 2021).

Within the regional development literature, a system approach to managing the socio-economic development of regions is regarded as essential for the competitiveness of the national economy, with long-term planning, strategic planning and programme-target planning identified as the main management tools (Mustafakulov, 2020). Empirical work on individual regions, such as Karakalpakstan and Surkhandarya, confirms that the effectiveness of state development programmes depends on the quality of their design, monitoring and implementation (Kalmuratov, 2023; Qosimov, 2019).

A particularly relevant finding is that the quality of public administration is the most influential factor in the intensive economic growth of Uzbekistan, ahead of other structural determinants (Sharipov, 2026). This result justifies the focus of the present study on management efficiency as the key lever of regional development.

METHODOLOGY

The study combines three groups of methods. First, an institutional and legal analysis of the normative framework of public administration reform, including the

Concept of Administrative Reform, the Uzbekistan-2030 strategy and the presidential decree of 14 July 2025 on increasing the efficiency, proactivity and results-orientation of the public administration system (Presidential Decree PF-111, 2025).

Second, a comparative analysis of regional development outcomes based on OECD governance assessments and international reviews of Uzbekistan's public sector (OECD, 2024).

Third, an econometric synthesis of recent panel evidence covering 14 first-level administrative units over 2017-2024. This evidence includes fixed-effects and GMM panel regressions of GRP per capita on FDI, industrial share, infrastructure, education and regulatory quality; unconditional and conditional beta-convergence analysis; and difference-in-differences estimation of the impact of post-2017 regulatory reforms (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024).

RESULTS AND ANALYSIS

4.1 The reform of public administration in Uzbekistan. Public administration reform remains a key priority, oriented towards a more efficient, effective, accountable and citizen-centred public sector. The reform agenda includes the modernization and reorganization of public administration, the strengthening of local governance, digitalization and the reinforcement of accountability and effective policy implementation (OECD, 2024).

The most recent stage of the reform is marked by the presidential decree of 14 July 2025, which established a Management Efficiency Agency on the basis of the Agency for Civil Service Development. The decree tasks the government with removing bureaucratic barriers, abolishing duplicative control functions, ensuring transparency in decision-making, expanding the economic, administrative and financial powers of local organizations in the comprehensive development of territories, and introducing modern digital tools, including artificial intelligence, into the work of state bodies (Presidential Decree PF-111, 2025).

4.2 Regional development and territorial disparities. Despite national progress, the benefits of growth have been distributed unevenly across territories. Regions that received substantial investment and possess better infrastructure and human capital, such as Tashkent and Samarkand, grew faster, while regions such as Karakalpakstan lagged due to institutional and human capital constraints (Regional Economic Growth Through Investment Policy, 2024).

The structural reasons for this imbalance are well documented. The dominant role of Tashkent relative to other regions tends to undermine social cohesion and growth potential; the low level of decentralization weakens the ability of regional and local governments to act proactively; and the dependence of local governments on central transfers is embedded in the fiscal relations between local and central authorities. Local governments in Uzbekistan have little autonomy in deciding their policies, and city administrations have little independence in financial matters (Asian Development Bank, n.d.).

To address this, the state has introduced a unified rating system for the socio-economic development of territories, which evaluates balanced economic growth, the

effectiveness of economic reforms, job creation, access to social services and the competitiveness of regional economies (Presidential Decree, n.d.-b).

4.3 Econometric evidence on the management-development link. Recent panel evidence quantifies the channels through which public management affects regional growth. The estimated elasticities of GRP per capita are 0.312 for FDI, 0.215 for infrastructure, 0.189 for regulatory quality, 0.142 for the industrial share and 0.104 for education (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024) . In other words, a 10% increase in FDI per capita is associated with approximately a 3.1% increase in GRP per capita, and improvements in the regulatory and institutional environment have a robust positive effect on regional output (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024).

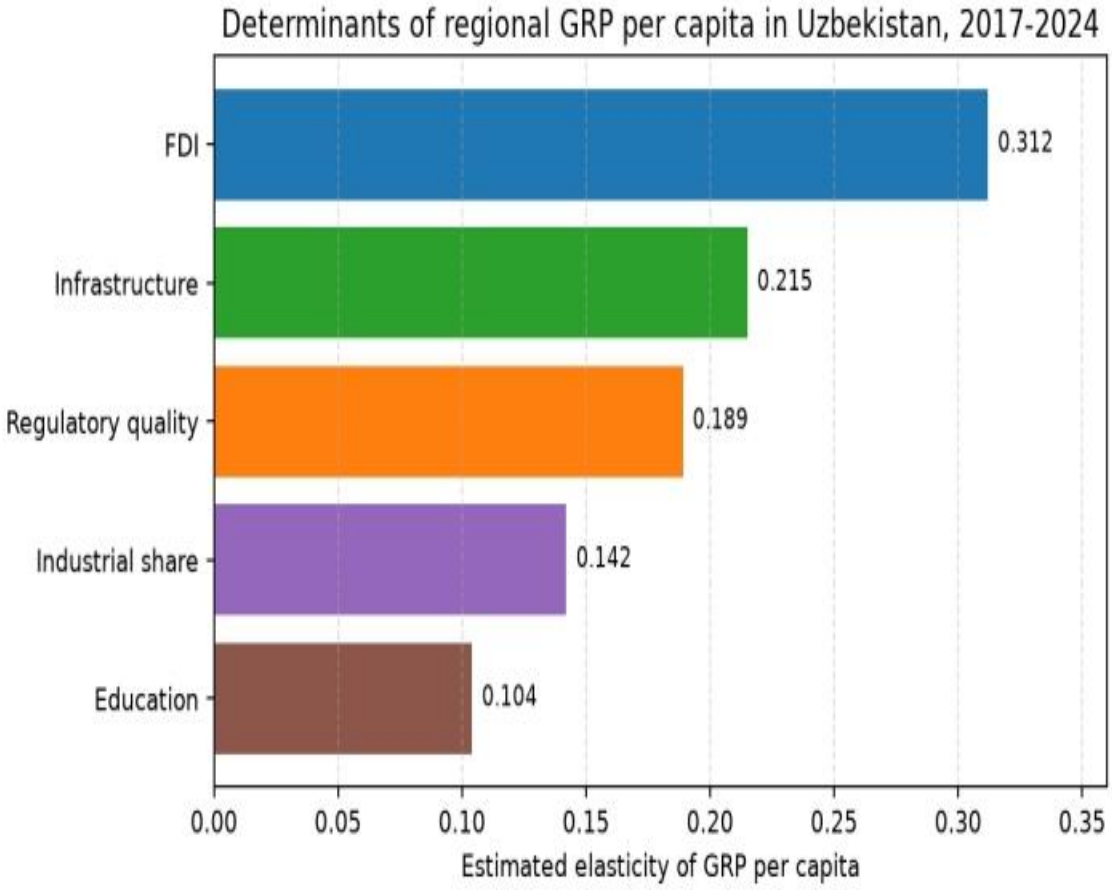

Figure 1. Estimated elasticities of GRP per capita by determinant (2017-2024)

The correlation analysis reinforces this picture: FDI shows the strongest positive correlation with GRP per capita (*r* = 0.847, *p* < 0.01), the regulatory quality index correlates significantly with FDI (*r* = 0.756, *p* < 0.01), and infrastructure correlates strongly with both FDI (*r* = 0.712) and GRP per capita (*r* = 0.658) (Regulatory

Reforms and Regional Economic Development in Uzbekistan, 2024).

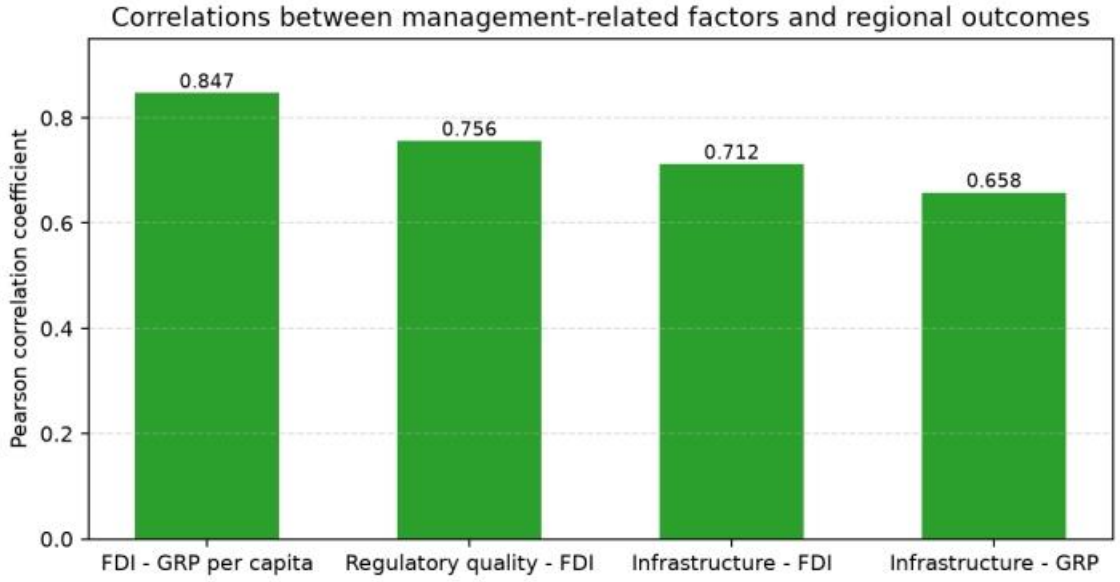

Figure 2. Correlations between management-related factors and regional outcomes

The difference-in-differences analysis provides causal evidence of the reform effect: administrative units with higher reform intensity experienced approximately 23.4% higher growth in per capita output and 41.2% higher FDI growth compared with low-reform units after 2017 (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024).

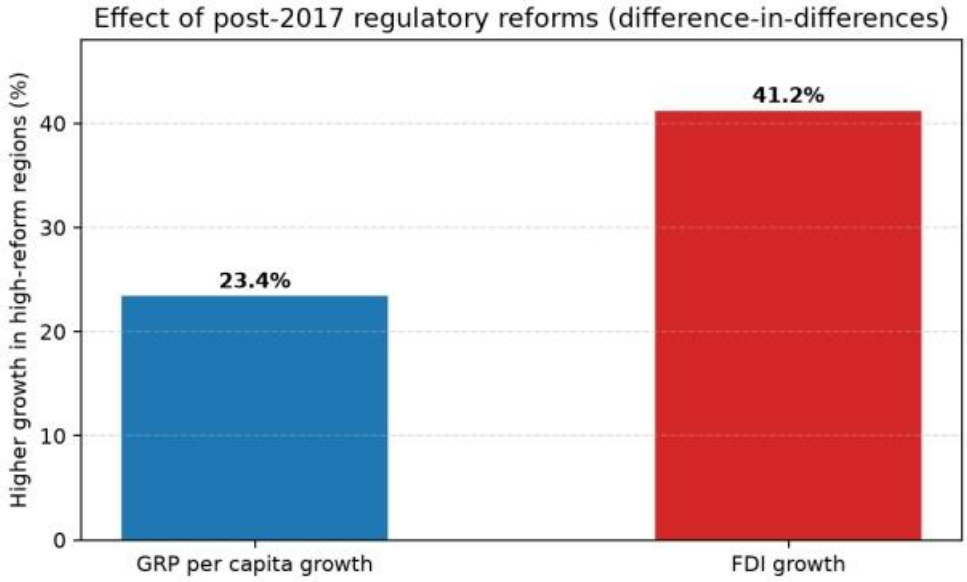

Figure 3. Effect of post-2017 regulatory reforms (difference-in-differences estimates)

Convergence analysis shows that unconditional beta-convergence among regions is statistically insignificant, meaning that disparities do not disappear by themselves. However, when structural factors are controlled for, conditional convergence proceeds at approximately 3.1% per year, with a half-life of 22.4 years (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024). This implies that lagging regions can catch up only if the underlying gaps in infrastructure, education and institutional quality are deliberately addressed.

4.4 Fiscal decentralization and local capacity. The econometric evidence points to the empowerment of local governments as a central policy lever. Subnational governments in Uzbekistan currently have limited revenue autonomy and depend heavily on central transfers. The recommended directions are: gradually increasing the share of taxes retained at the regional level; introducing formula-based equalization transfers that account for development needs; strengthening local capacity for project planning, implementation and monitoring; and promoting participatory budgeting to enhance citizen engagement and accountability (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024) . International experience indicates that fiscal decentralization, when accompanied by capacity building, can significantly improve public service delivery and local economic development outcomes (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024).
The 2025 decree follows this direction by expanding the economic, administrative and financial powers of local organizations and strengthening their role as owners of reforms in their territories (Presidential Decree PF-111, 2025; Presidential Decree, n.d.-a)

DISCUSSION

The results confirm that the efficiency of public management is not a purely administrative matter but a direct determinant of regional economic outcomes. The strong elasticity of regulatory quality and the causal DID estimates both indicate that institutional reform is a growth factor in its own right, not merely a background condition (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024). This is consistent with the finding that the quality of public administration is the most influential factor in intensive economic growth in Uzbekistan (Sharipov, 2026).
At the same time, the analysis reveals a tension. The reform impulse has been strongest in the most developed regions, where free economic zones and regulatory pilot programs are concentrated, which risks widening rather than narrowing territorial gaps (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024). The absence of unconditional convergence means that without active state intervention, the periphery will continue to lag. The estimated fiscal cost of differentiated incentives for lagging regions, in the range of 150-200 million dollars annually, is modest relative to the potential gains from induced investment and tax revenues (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024).

A further challenge is the sequencing of decentralization. Expanding the powers of local bodies without a corresponding strengthening of their managerial and financial capacity may reproduce the weaknesses of the centralized system at a lower level. The experience of the reform so far suggests that capacity building and accountability mechanisms must accompany the transfer of functions (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024).

CONCLUSION AND RECOMMENDATIONS

The study demonstrates that public management efficiency is a decisive factor in regional economic development in Uzbekistan. Improvements in regulatory quality, infrastructure and the investment climate, driven by the post-2017 reforms, have

produced measurable gains: high-reform regions achieved roughly a quarter higher GRP growth and more than 40% higher FDI growth than their low-reform counterparts (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024). However, persistent territorial disparities and the limited autonomy of local governments remain the main constraints on balanced development.

On the basis of the analysis, the following recommendations are proposed:

1. Continue the institutional reform of public administration, including the full implementation of the 2025 decree on efficiency, proactivity and results-orientation, and the work of the Management Efficiency Agency (Presidential Decree PF-111, 2025).
2. Implement gradual fiscal decentralization: increase the share of taxes retained at the regional level and introduce formula-based equalization transfers (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024).
3. Adopt spatially targeted investment incentives for lagging regions, including extended tax holidays and higher investment subsidies for Karakalpakstan, Surkhandarya, Jizzakh and Namangan (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024).
4. Prioritize infrastructure investment in peripheral areas to address the connectivity deficit, since infrastructure shows the highest elasticity among structural factors (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024).
5. Strengthen results-based management and monitoring: use the territorial rating system and participatory budgeting to link local budgets to measurable development outcomes (Presidential Decree, n.d.-b; Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024).
6. Deepen the digitalization of public services and administrative decision-making, including the use of modern analytical and artificial intelligence tools in state bodies (Presidential Decree PF-111, 2025).

The main limitation of this study is its reliance on published econometric evidence rather than original data collection; further research could extend the analysis with firm-level data and direct measurement of the quality of public services at the district level.

Appendix. Analyses and data tables

A.1 Key national governance and development indicators

Table 1. National indicators underlying the analysis

Indicator	Value	Period	Source
Extreme poverty rate	8% to <1%	2016 to 2023	[1]
Women's representation in parliament	16% to 33.3%	2019 to 2022	[1]
Annual GRP growth target for regions	6-7%	Uzbekistan-2030	[3]
Fiscal cost of differentiated incentives	USD 150-200 million / year	estimated	[4]

A.2 Determinants of regional GRP per capita

Table 2. Estimated elasticities of GRP per capita, panel regressions 2017-2024 [4]

Determinant	Elasticity	Interpretation
FDI (foreign direct investment per capita)	0.312	10% higher FDI is associated with ~3.1% higher GRP per capita
Infrastructure (roads, electricity, internet)	0.215	Highest elasticity among structural factors
Regulatory quality (permits, tax burden)	0.189	Institutional reform raises regional output
Industrial share of GRP	0.142	Structural composition effect
Education (higher education enrolment)	0.104	Human capital contribution

A.3 Correlation analysis

Table 3. Correlations between management-related factors and regional outcomes [4]

Pair of indicators	Pearson r	Significance
FDI - GRP per capita	0.847	$p < 0.01$
Regulatory quality - FDI	0.756	$p < 0.01$
Infrastructure - FDI	0.712	$p < 0.01$
Infrastructure - GRP per capita	0.658	$p < 0.01$

A.4 Convergence analysis

Table 4. Regional convergence results [4]

Specification	Beta coefficient	Significance	Implied speed	Half-life
Unconditional beta-convergence	-0.0124	$p > 0.10$ (insignificant)	none	n/a
Conditional beta-convergence	-0.0287	$p < 0.05$	3.1% per year	22.4 years

A.5 Difference-in-differences: effect of post-2017 regulatory reforms

Table 5. Causal impact of reform intensity [4]

Outcome	DID estimate	Effect for high-reform regions
GRP per capita growth	0.234 ($p < 0.01$)	23.4% higher than low-reform regions
FDI growth	not reported as coefficient	41.2% higher than low-reform regions

A.6 Summary of the evidence base. The econometric results are drawn from a balanced panel of 14 first-level administrative units of Uzbekistan over 2017-2024, using fixed-effects and GMM panel regressions, beta-convergence analysis and difference-in-differences estimation. The dependent variable is GRP per capita in constant prices (base year 2020); independent variables include FDI per capita, industrial share of GRP, an infrastructure index (road density, electricity access, internet penetration), higher education enrolment and a regulatory quality index (registration time, number of permits, tax administration burden) (Regulatory Reforms and Regional Economic Development in Uzbekistan, 2024) .

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UDK: 338.48:330.15

O‘ZBEKISTON TURIZM OBYEKTLARIDA SIRKULYAR TEXNOLOGIYALARNI JORIY ETISHGA TA’SIR ETUVCHI OMILLARNI EKONOMETRIK BAHOLASH

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Annotatsiya. *Maqolada O‘zbekiston turizm obyektlarida sirkulyar iqtisodiyotning amaliy elementi sifatida qayta tiklanuvchi energiya texnologiyalarini joriy etishga bog‘liq tashkiliy-iqtisodiy omillar empirik baholangan. Tadqiqot bazasi 2026-yilda energiya samaradorligi bo‘yicha o‘rganilgan turizm va xizmat ko‘rsatish obyektlarining hududiy ma’lumotlaridan shakllantirilib, ma’lumotlar auditi natijasida 658 ta kuzatuv asosiy ekonometrik modelga kiritilgan. Dastlab obyekt sig‘imi va quyosh paneli quvvati o‘rtasidagi bog‘lanish Spearman koeffitsienti, obyekt turi va hududiy joylashuv bilan texnologiya qaydi o‘rtasidagi farqlar Pearson χ^2 hamda Cramér V ko‘rsatkichlari orqali baholangan. Keyinchalik quyosh paneli bo‘yicha ijobiy ma’muriy qayd binar natijaviy o‘zgaruvchi sifatida olinib, hudud bo‘yicha klasterlangan standart xatolarga ega Logit modeli qurilgan. Natijalar obyekt turi eng barqaror differensial omil ekanini ko‘rsatdi: xostel/yotoqxona va oilaviy mehmon uylarida ijobiy qayd ehtimoli mehmonxonalarga nisbatan sezilarli past. Korxona sig‘imi hamda hududiy turistik yuklama esa asosiy spetsifikatsiyada 5 foizlik darajada statistik ahamiyatli bo‘lmadi. Natijalar turizmda sirkulyar transformatsiya siyosatini obyekt segmentlari bo‘yicha differensiallashtirish va mikro darajadagi monitoring tizimini kuchaytirish zarurligini asoslaydi.*

Kalit so‘zlar: *sirkulyar iqtisodiyot, turizm, qayta tiklanuvchi energiya, quyosh paneli, resurs samaradorligi, Logit modeli, marginal effekt, O‘zbekiston.*

Аннотация. *В статье эмпирически оцениваются организационно-экономические факторы, связанные с внедрением технологий возобновляемой энергетики как практического элемента циркулярной экономики на туристических объектах Узбекистана. Эмпирическая база сформирована на основе региональных данных туристических и сервисных объектов, обследованных в 2026 году с точки зрения энергоэффективности; после аудита данных в основную эконометрическую модель включено 658 наблюдений. Связь между вместимостью объекта и мощностью солнечных панелей оценивалась с помощью коэффициента Спирмена, а различия по типам объектов и регионам — посредством критерия Pearson χ^2 и коэффициента Cramér V. Далее положительная административная запись о солнечной панели использована как бинарная зависимая переменная в Logit-модели с кластеризованными по регионам стандартными ошибками. Результаты показывают, что тип объекта является наиболее устойчивым дифференцирующим фактором: для*

хостелов/общежитий и семейных гостевых домов вероятность положительной записи существенно ниже, чем для гостиниц. Размер объекта и региональная туристическая нагрузка в основной спецификации статистически незначимы на 5%-ном уровне. Полученные результаты обосновывают необходимость дифференцированной политики циркулярной трансформации и совершенствования микроуровневого мониторинга.

Ключевые слова: *циркулярная экономика, туризм, возобновляемая энергия, солнечные панели, ресурсоэффективность, Logit-модель, предельный эффект, Узбекистан.*

Abstract. *This article empirically assesses organizational and economic factors associated with the adoption of renewable-energy technologies as a practical component of the circular economy in tourism facilities in Uzbekistan. The empirical database was compiled from regional records of tourism and service facilities surveyed for energy efficiency in 2026; after data auditing, 658 observations were retained for the main econometric model. The relationship between facility capacity and recorded solar-panel capacity was examined using Spearman correlation, while differences across facility types and regions were assessed using Pearson's chi-square test and Cramér's V. A positive administrative record of solar-panel deployment was then specified as a binary dependent variable in a Logit model with region-clustered standard errors. The results identify facility type as the most robust differentiating factor: hostels/dormitories and family guesthouses exhibit substantially lower predicted probabilities of a positive solar record than hotels. Facility size and regional tourism intensity are not statistically significant at the 5 percent level in the main specification. The findings support a differentiated circular-transition policy by tourism segment and highlight the need for a unified micro-level monitoring architecture covering technologies, resource use, investment, incentives and institutional status.*

Keywords: *circular economy, tourism, renewable energy, solar panels, resource efficiency, Logit model, marginal effects, Uzbekistan.*

KIRISH

O‘zbekiston turizm tarmog‘ida tashriflar, joylashtirish vositalari va xizmatlar hajmining kengayishi iqtisodiy o‘sish manbai bo‘lishi bilan birga energiya, suv, oziq-ovqat, transport va moddiy resurslarga bo‘lgan talabni ham oshiradi. Bunday sharoitda turizmning barqaror rivojlanishi faqat tashriflar sonini ko‘paytirish bilan emas, balki bir birlik xizmatga to‘g‘ri keladigan resurs sarfini kamaytirish, mavjud aktivlardan uzoqroq foydalanish va chiqindilarni oldini olish kabi mezonlar bilan ham baholanishi zarur. Sirkulyar iqtisodiyot aynan shu masalani chiziqli “olish–ishlab chiqarish–iste’mol–chiqindi” modelidan resurs qiymatini iqtisodiyotda uzoqroq saqlovchi tizimga o‘tish orqali hal etishga intiladi [1, 2].

Turizm sirkulyar iqtisodiyot nuqtayi nazaridan o‘ziga xos tarmoqdir. Turistik xizmat ko‘pincha joylashtirish, ovqatlanish, transport, ko‘ngilochar faoliyat va hududiy infratuzilmaning birlashgan natijasi bo‘lib, resurslardan foydalanish korxona ichki qarorlari bilangina cheklanmaydi. Mehmonning xulqi, yetkazib beruvchilar zanjiri, mahalliy kommunal tizimlar va davlat standartlari ham yakuniy resurs

samaradorligiga ta’sir qiladi. Shu sababli zamonaviy ilmiy adabiyotlar sirkulyar turizmni faqat chiqindilarni qayta ishlash emas, balki biznes modeli, xizmat dizayni, iste’mol amaliyoti va hududiy boshqaruvni qamrab oluvchi tizimli transformatsiya sifatida talqin qilmoqda [3–6].

O‘zbekiston sharoitida qayta tiklanuvchi energiya texnologiyalarini turizm obyektlarida kengaytirish mazkur transformatsiyaning kuzatiladigan amaliy yo‘nalishlaridan biridir. Quyosh panellari va geliokollektorlar energiya xarajatlarini boshqarish, energiya ta’minoti xavflariga chidamlilikni oshirish hamda turizm xizmatlarining ekologik profilini yaxshilash imkonini beradi. Biroq texnologiyani joriy etish barcha turizm obyektlarida bir xil tezlikda kechmaydi. Korxona sig‘imi, obyekt turi, hududiy turistik yuklama, investitsion imkoniyat, bino xususiyatlari va boshqaruv salohiyati kabi omillar texnologiya qabul qilinishidagi tafovutlarni shakllantirishi mumkin.

Maqolaning maqsadi — O‘zbekiston turizm obyektlarida quyosh energetikasi texnologiyalarining joriy etilishi bilan bog‘liq korxona va hududiy omillarni statistik hamda ekonometrik usullar yordamida baholash. Tadqiqotning ilmiy yangiligi 14 hududni qamrab olgan obyekt darajasidagi ma’lumotlar asosida texnologiya qaydining determinantlarini binar tanlov modeli orqali baholash, natijalarni odds ratio va o‘rtacha marginal effektlar bilan izohlash hamda Logit, Probit va muqobil natijaviy indikatorlar orqali barqarorlikni tekshirishdan iborat. Tadqiqot natijalari O‘zbekistonda sirkulyar turizm siyosatini umumiy yondashuvdan obyekt segmentlari bo‘yicha differensial boshqaruvga o‘tkazish uchun empirik asos beradi.

MAVZUGA OID ADABIYOTLARNING TAHLILI

Geissdoerfer va hammualliflar sirkulyar iqtisodiyotni resurs kirimi, chiqindi, emissiya va energiya yo‘qotishlarini material hamda energiya sikllarini sekinlashtirish, yopish va toraytirish orqali kamaytirishga qaratilgan regenerativ tizim sifatida izohlaydi [1]. Kirchherr, Reike va Hekkert tomonidan 114 ta ta’rifning tahlili esa sirkulyar iqtisodiyotni faqat “reduce–reuse–recycle” uchligi bilan cheklash tizimli transformatsiyaning biznes modeli, iste’molchi va makro darajadagi elementlarini yetarli yoritmasligini ko‘rsatgan [2]. Ushbu yondashuvlardan kelib chiqib, turizmda qayta tiklanuvchi energiya texnologiyasini joriy etish sirkulyarlikning to‘liq o‘lchovi emas, balki resurs intensivligini kamaytirishga xizmat qiluvchi muhim operatsion komponent sifatida qaralishi lozim.

Sørensen va Bærenholdt sirkulyar turizmda turistlarning amaliyoti ham markaziy rol o‘ynashini asoslab, turistik tajriba ishlab chiqaruvchi va iste’molchi o‘rtasidagi hamkorlikda shakllanishini ta’kidlaydi [3]. Manniche, Larsen va Broegaard turizmning moddiy bo‘lmagan xizmat sektori sifatidagi ko‘rinishiga qaramay, uning katta hajmdagi tabiiy resurslar oqimiga tayanishini ko‘rsatib, sirkulyar iqtisodiyotni turizmda ijtimoiy-texnik o‘tish doirasida qo‘llashni taklif etadi [4]. Sorin va Sivarajahning Skandinaviya mehmonxona operatorlari bo‘yicha tadqiqoti esa sirkulyar iqtisodiyotning mehmondo‘stlik biznesida qiymat yaratish salohiyati mavjudligini, biroq bu salohiyat tashkiliy, axborot, texnologik va bozor shartlariga bog‘liqligini aniqlaydi [5].

Xu va hammualliflar turizm industriyasining ekologizatsiyasini DPSIR yondashuvi asosida o‘lchab, sirkulyar iqtisodiyotning turizmga tatbiqida hududiy heterogenlikni alohida hisobga olish zarurligini ko‘rsatgan [6]. Bu xulosa O‘zbekiston uchun ayniqsa muhim, chunki turistik oqimlar, joylashtirish quvvati va infratuzilma salohiyati hududlar kesimida keskin farqlanadi. Shu jihatdan faqat respublika bo‘yicha o‘rtacha ko‘rsatkichlar asosida siyosat ishlab chiqish obyektlar va hududlar o‘rtasidagi real differensial ehtiyojlarni yashirishi mumkin.

Xalqaro amaliy hujjatlar ham o‘lchash va monitoring masalasining muhimligini ko‘rsatadi. UNEPning Food Waste Index Report 2024 hisobotida chiqindini kamaytirish siyosati ishonchli bazaviy o‘lchov va takroriy monitoringga tayanishi kerakligi qayd etilgan [7]. GSTC mehmonxona standarti esa resurslardan foydalanish, atrof-muhit boshqaruvi va natijalarni hujjatlashtirishni xizmat sifati tizimining tarkibiy qismi sifatida ko‘radi [8]. O‘zbekiston turizm obyektlari bo‘yicha mavjud ma’muriy ma’lumotlar qayta tiklanuvchi energiya texnologiyalarini kuzatish imkonini bersa-da, investitsiya, energiya xarajati, audit, subsidiya va raqamli boshqaruv kabi mikro omillarni birlashtiruvchi yagona ma’lumot qatlami hali to‘liq shakllanmagan.

Mavjud adabiyotlar sirkulyar iqtisodiyotning turizm uchun nazariy ahamiyatini va korxona darajasidagi amaliy salohiyatini yetarlicha asoslaydi, biroq Markaziy Osiyo, xususan O‘zbekiston turizm obyektlari kesimida qayta tiklanuvchi energiya texnologiyalarini qabul qilishdagi strukturaviy tafovutlarni katta mikro-ma’lumotlar bazasida ekonometrik baholagan tadqiqotlar cheklangan. Mazkur maqola aynan shu empirik bo‘shliqni qisman to‘ldirishga qaratilgan.

TADQIQOT METODOLOGIYASI

Tadqiqotda O‘zbekiston Respublikasi Turizm qo‘mitasi doirasida 2026-yilda energiya samaradorligi bo‘yicha o‘rganilgan turizm va xizmat ko‘rsatish obyektlarining 14 hududiy varaqdan iborat mikro-ma’lumotlar bazasidan foydalanildi [9]. Dastlabki bazada 707 ta xom yozuv mavjud bo‘lgan. Rasmiy hududiy kontur bilan moslashtirish jarayonida Navoiy bo‘yicha konturdan tashqaridagi 48 yozuv chiqarildi va 659 ta obyekt qoldi. Toshkent viloyatidagi bitta obyektning quyosh quvvati va geliokollektor qiymatlari hududiy jamlanma bilan aynan ustma-ust tushgani sababli texnologik maydonning obyektga tegishliligi tasdiqlanmagan va ushbu kuzatuv asosiy ekonometrik modeldan chiqarildi. Natijada yakuniy tanlanma N=658 ni tashkil etdi.

Natijaviy o‘zgaruvchi CE_SOLAR binar indikator sifatida shakllantirildi: agar obyekt bo‘yicha quyosh paneli quvvati musbat qiymat bilan qayd etilgan bo‘lsa CE_SOLAR=1, aks holda CE_SOLAR=0. Bunda 0 qiymati “quyosh paneli mutlaqo mavjud emas” degan fizik tasdiq emas, balki “ijobiy ma’muriy qayd mavjud emas” mazmunini anglatadi. Ushbu farq measurement error xavfini kamaytirmaydi, biroq natijani ehtiyotkor va ma’lumot manbasiga mos talqin qilish imkonini beradi. 658 ta obyektning 209 tasida quyosh paneli bo‘yicha ijobiy qayd mavjud.

Asosiy tushuntiruvchi omillar sifatida obyekt sig‘imi — o‘rinlar sonining natural logarifmi lnSIZE; obyekt turi — mehmonxona (bazaviy toifa), xostel/yotoqxona, oilaviy mehmon uyi va boshqa toifalar; hududiy turistik yuklama — 2026-yil yanvar–iyun ichki turistlar oqimining natural logarifmi lnTOUR olindi [9, 10]. Obyekt yoshi AGE=2026−foydalanishga topshirilgan yil shaklida hisoblandi, biroq 308 ta missing

qiymat sababli u asosiy modelga emas, N=350 bo‘lgan complete-case sezgirlik modeliga kiritildi. Elektr va gaz tejamkorligi maydonlarida o‘lchov birligi hamda hisoblash metodikasi bir xil bo‘lmagani sababli ular regressiyadan chiqarildi.

Dastlabki statistik tahlilda obyekt sig‘imi va musbat qayd etilgan quyosh paneli quvvati o‘rtasidagi monotonic bog‘lanish Spearman ρ yordamida baholandi. Obyekt turi hamda hudud bilan CE_SOLAR o‘rtasidagi mustaqillik Pearson χ^2 testi, bog‘lanish kattaligi esa Cramér V orqali tekshirildi. Hududiy jadvalning ayrim kataklarida kutilayotgan chastotalar kichik bo‘lgani uchun hudud testi 20 000 ta qayta taqsimlashga asoslangan Monte-Karlo tekshiruvi bilan mustahkamlandi.

Binar natijaviy o‘zgaruvchi uchun asosiy ekonometrik spetsifikatsiya Logit modeli shaklida baholandi. Model quyidagicha ifodalanadi: $P(CE_i=1)=\Lambda[\beta0+\beta1\ln(BEDS_i)+\beta2HOSTEL_i+\beta3FAMILY_i+\beta4OTHER_i+\beta5\ln(TOUR_r)]$. Bu yerda Λ — logistika taqsimotining kumulyativ funksiyasi, r — obyekt joylashgan hudud. Koeffitsientlarning iqtisodiy talqini odds ratio $OR_k=\exp(\beta_k)$ va o‘rtacha marginal effektlar AME_k orqali berildi. 658 ta kuzatuv obyekt darajasida bo‘lsa-da, lnTOUR atigi 14 ta hududiy qiymatdan iborat bo‘lganligi sababli asosiy inferensiyada standart xatolar hudud bo‘yicha klasterlandi. Bu 14 klaster bilan bog‘liq cheklovni to‘liq bartaraf etmaydi, shu sababli ayniqsa hududiy koeffitsientlar p-qiymati ehtiyotkor talqin qilindi [11].

Robustness tekshiruvlari uch yo‘nalishda amalga oshirildi: Logit o‘rniga Probit modeli; natijaviy indikatorni quyosh paneli yoki geliokollektordan kamida bittasi bo‘yicha ijobiy qayd mavjudligini bildiruvchi CE_ANY bilan almashtirish; AGE o‘zgaruvchisini N=350 complete-case Logit modeliga kiritish. Mazkur yondashuv asosiy xulosaning model shakli, natijaviy indikator va qisman missing ma’lumotlarga sezgirligini tekshirish imkonini berdi.

TAHLIL VA NATIJALAR

Tahlilning birinchi bosqichida turizm obyektlarida quyosh paneli texnologiyasining qayd etilishi obyekt sig‘imi, obyekt turi va hududiy joylashuv bilan qanchalik bog‘langanligi baholandi. Natijalar alohida ko‘rsatkichlarning statistik ahamiyatidan tashqari, sirkulyar transformatsiya uchun qaysi segmentlarda investitsion va tashkiliy to‘siqlar kuchliroq ekanini aniqlashga xizmat qiladi.

2.10-jadval. Tekshirilgan statistik gipotezalar natijalari

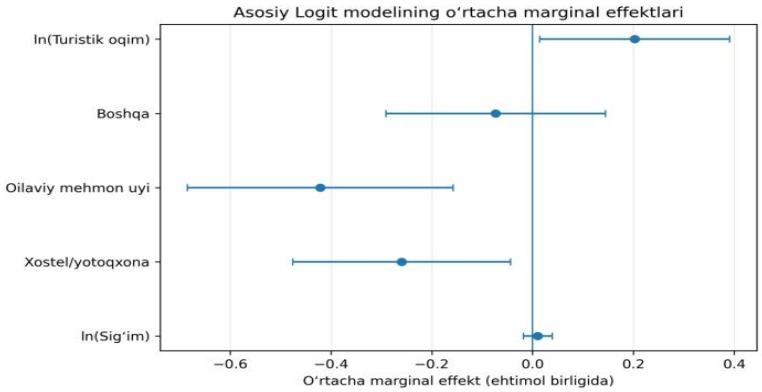
Gipoteza	Usul va N	Natija	p-qiymat	Bog‘lanish kuchi	Ilmiy talqin
H1: obyekt sig‘imi – quyosh paneli quvvati	Spearman, N=190	ρ=0,264	0,00023	Kuchsiz musbat	Bog‘lanish mavjud
H1: sezgirlik tekshiruvi	Spearman, N=176	ρ=0,206	0,0060	Kuchsiz musbat	Natija saqlanadi
H2: obyekt turi – quyosh paneli mavjudligi	χ^2, N=659	χ^2=256,87 ; df=3	<0,001	Cramér V=0,624 — kuchli	Kuchli tafovut

Gipoteza	Usul va N	Natija	p-qiymat	Bog‘lanish kuchi	Ilmiy talqin
H3: hudud – quyosh paneli mavjudligi	χ^2, N=659	χ^2=497,24 ; df=13	<0,001	Cramér V=0,869 — juda kuchli	Juda kuchli tafovut
H3: barqarorlik tekshiruvi	Monte-Karlo, 20 000	Kuzatilgan χ^2 dan yuqori yoki unga teng holat: 0 ta	<0,00005 *	—	Natija barqaror

Manba: muallif hisob-kitoblari; Turizm qo‘mitasining obyekt darajasidagi bazasi.

Iqtisodiy izoh. Jadval natijalariga ko‘ra, obyekt sig‘imi bilan quyosh paneli quvvati o‘rtasidagi bog‘lanish musbat, biroq kuchsiz. Bu yirik obyektlarda energiya talabi va investitsiya ehtiyoji yuqoriroq bo‘lishi mumkinligini ko‘rsatsa-da, texnologiyani joriy etish faqat obyekt hajmiga bog‘liq emasligini bildiradi. Obyekt turi bo‘yicha Cramér V=0,624 va hudud bo‘yicha V=0,869 natijalari esa sirkulyar texnologiyalar tarqalishida segment va hudud omillari ancha kuchli ekanini ko‘rsatadi. Iqtisodiy siyosatda yagona subsidiya yoki yagona texnologik talabdan ko‘ra, obyekt turi hamda hududiy infratuzilmaga mos differensial yondashuv samaraliroq bo‘lishi mumkin.

Bivariativ natijalarni ko‘p omilli sharoitda tekshirish uchun binar Logit modeli qo‘llandi. Asosiy spetsifikatsiyada obyekt sig‘imi, obyekt turi va hududiy turistik yuklama birgalikda nazorat qilindi. Standart xatolar 14 hudud bo‘yicha klasterlandi; bu hudud ichidagi kuzatuvlarning o‘zaro bog‘liqligini hisobga olish imkonini beradi.



2.11-rasm. Asosiy Logit modelining o‘rtacha marginal effektlari va 95 foizlik ishonch oraliqlari

Manba: muallif hisob-kitoblari. Nuqta – AME, gorizontal chiziq – 95% ishonch oralig‘i.

Iqtisodiy izoh. Marginal effektlar obyekt turining iqtisodiy ahamiyatini ko‘rsatadi. Xostel/yotoqxona segmentida hisoblangan ehtimol mehmonxonalarga nisbatan o‘rtacha 26 foiz punktga, oilaviy mehmon uylarida esa 42,1 foiz punktga past. Bu tafovut kichik joylashtirish vositalarida boshlang‘ich kapital, kreditga kirish, texnik xizmat va investitsiyaning qoplanish muddati kabi omillar qayta tiklanuvchi

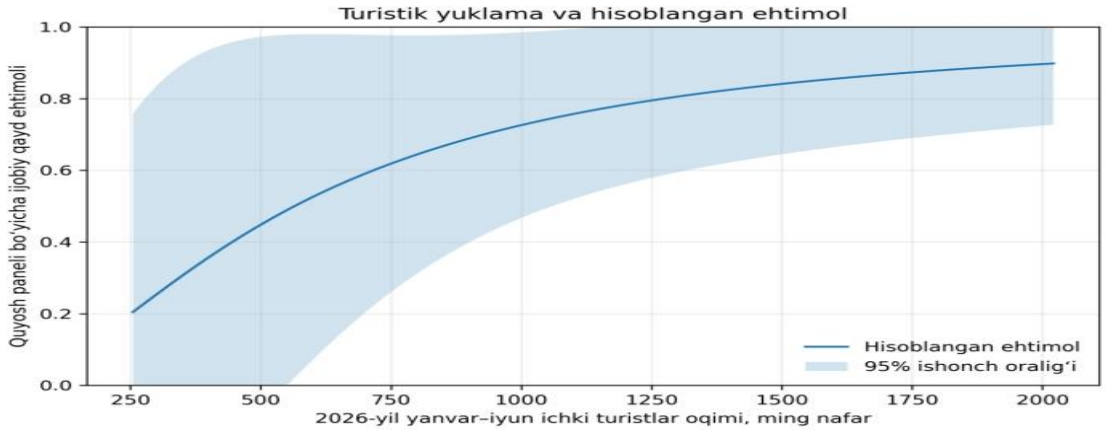
energiyaga o‘tishni cheklashi mumkinligini anglatadi. Shu sababli kichik turizm biznesi uchun past foizli yashil moliyalashtirish, texnik audit va guruhli xarid mexanizmlarini birlashtirish iqtisodiy jihatdan asosli yo‘nalishdir.

2.16-jadval. Sirkulyar texnologiya qaydiga ta’sir etuvchi omillarning asosiy Logit bahosi

Omil	β	Klaster SE	p	Odds ratio [95% CI]	AME	Natija
lnSIZE	0,088	0,119	0,461	1,092 [0,864; 1,379]	0,010	H1 tasdiqlanmadi
Xostel/yotoqxona	-1,873	0,718	0,009	0,154 [0,038; 0,627]	-0,260	H2: farq mavjud
Oilaviy mehmon uyi	-3,771	0,707	<0,001	0,023 [0,006; 0,092]	-0,421	H2: kuchli farq
Boshqa	-0,642	1,038	0,537	0,526 [0,069; 4,029]	-0,073	Mustaqil farq tasdiqlanmadi
lnTOUR	1,706	1,107	0,123	5,509 [0,629; 48,261]	0,203	H4: 5% da tasdiqlanmadi

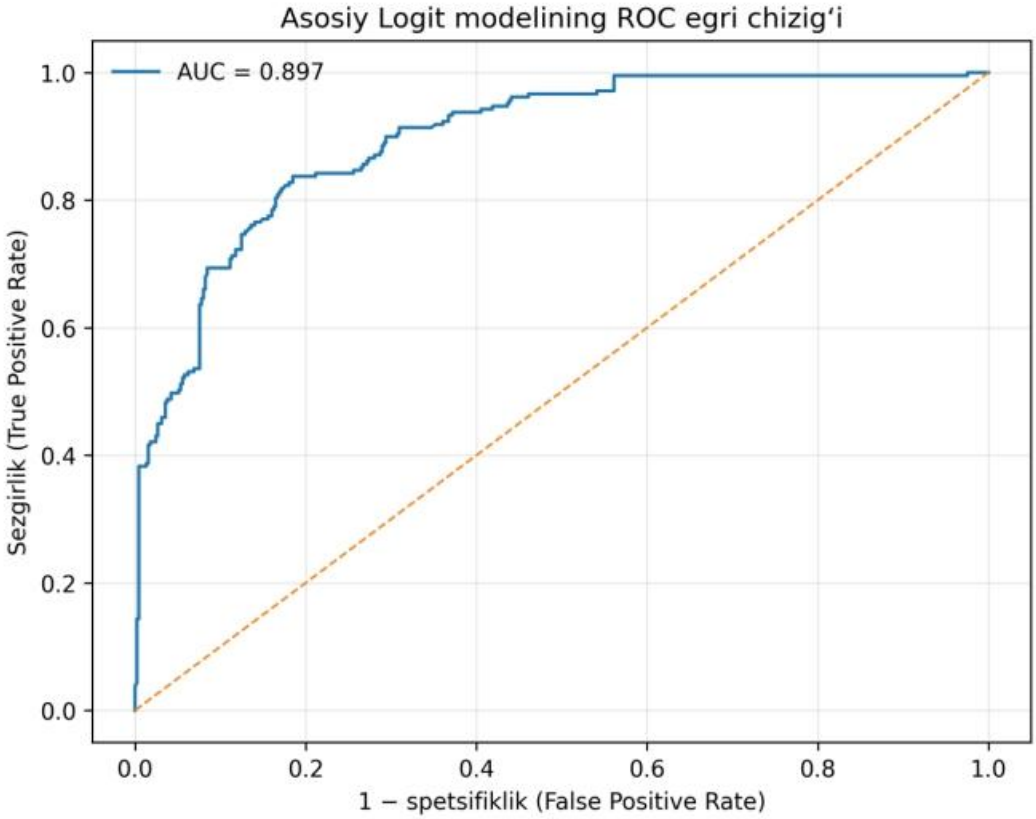
Manba: muallif hisob-kitoblari. N=658; standart xatolar 14 hudud bo‘yicha klasterlangan; mehmonxona bazaviy toifa.

Iqtisodiy izoh. Logit baholari obyekt turi eng barqaror differensial omil ekanini tasdiqlaydi. Xostel/yotoqxona uchun odds ratio 0,154, oilaviy mehmon uyi uchun 0,023 bo‘lib, bu segmentlarda musbat texnologik qayd odds’i mehmonxonalarga qaraganda sezilarli pastligini bildiradi. Sig‘imning mustaqil koeffitsienti statistik ahamiyatli bo‘lmagani esa “katta obyekt avtomatik ravishda sirkulyarroq” degan xulosani rad etadi. Demak, texnologik yangilanishning iqtisodiy mexanizmi korxona turi, kapitalga kirish va boshqaruv imkoniyatlari bilan birgalikda shakllanadi.



2.12-rasm. Turistik yuklama o‘zgarishi bilan quyosh paneli bo‘yicha hisoblangan ijobiy qayd ehtimoli *Manba: muallif hisob-kitoblari.*

Iqtisodiy izoh. Grafik turistik yuklama oshgani sari quyosh texnologiyasi bo‘yicha hisoblangan ehtimolning musbat yo‘nalishini ko‘rsatadi. Biroq 14 hududli kesimda ishonch oralig‘ining kengligi bu bog‘lanishni qat’iy sababiy ta’sir sifatida talqin qilishga imkon bermaydi. Iqtisodiy nuqtayi nazardan, turist oqimi yuqori hududlarda energiya talabi va kommunal yuklama oshishi qayta tiklanuvchi energiya investitsiyasining potensial foydasini kuchaytiradi, ammo investitsiya qarori hududiy elektr infratuzilmasi, moliyalashtirish va obyektlar tarkibiga ham bog‘liq.



2.13-rasm. Asosiy Logit modelining ROC egri chizig‘i
Manba: muallif hisob-kitoblari.

Iqtisodiy izoh. ROC-AUC=0,897 modelning musbat va musbat bo‘lmagan qaydlarni farqlash qobiliyati yuqori ekanini ko‘rsatadi. Iqtisodiy tahlilda bu ko‘rsatkich modelning siyosiy segmentatsiya uchun yetarli diagnostik salohiyatga ega ekanini anglatadi: resurslarni barcha obyektlarga teng taqsimlash o‘rniga, texnologik joriy etish ehtimoli past segmentlarni aniqlab, ularga maqsadli qo‘llab-quvvatlash paketlarini yo‘naltirish mumkin. Shu bilan birga, ROC natijasi sababiylikni isbotlamaydi va investitsiya samaradorligini alohida baholash zarur.

2.17-jadval. Asosiy xulosalarning robustness tekshiruvi

Spetsifikatsiya	Natijaviy	N	Muhim natija	Robustness talqini
Logit M1	CE_SOLAR	658	lnSIZE p=0,113; xostel p=<0,001; family p=<0,001	Korxona turi barqaror; hajm zaif
Logit M2 (asosiy)	CE_SOLAR	658	lnTOUR β=1,706, p=0,123	Hududiy klasterlashda 5% da tasdiqlanmadi
Probit	CE_SOLAR	658	xostel p=0,008; family p=<0,001; lnTOUR p=0,093	Tur bo‘yicha xulosa saqlanadi; TOUR 10% atrofida
Logit, keng natija	CE_ANY	658	family p=0,012; lnTOUR p=0,067	Family manfiy barqaror; TOUR chegaraviy
Complete-case Logit	CE_SOLAR	350	AGE β=0,0035, p=0,891	H3 mavjud ma’lumotda tasdiqlanmadi

Manba: muallif hisob-kitoblari.

Iqtisodiy izoh. Robustness tekshiruvi obyekt turi bo‘yicha asosiy xulosa model spetsifikatsiyasiga nisbatan barqaror ekanini ko‘rsatadi. Logit va Probit natijalarida xostel/yotoqxona hamda oilaviy mehmon uyi segmentlari bo‘yicha tafovut saqlanadi.

Bu iqtisodiy tavsiyalarni aynan korxona segmentlari kesimida ishlab chiqishga asos beradi. Ayni paytda obyekt yoshi va hududiy turistik yuklama bo‘yicha natijalar yetarlicha barqaror bo‘lmagani sababli ularga asoslangan qat’iy moliyaviy yoki normativ qarorlar qo‘shimcha ma’lumotlar bilan tekshirilishi lozim.

MUHOKAMA

Olingan natijalar sirkulyar iqtisodiyotning turizmda faqat ekologik chora sifatida emas, balki korxona iqtisodiy imkoniyatlari va hududiy institutlar bilan bog‘liq transformatsiya jarayoni ekanini tasdiqlaydi. Adabiyotlarda sirkulyarlik resurs oqimlarini kamaytirish, yopish va sekinlashtirish bilan izohlanadi; mazkur tadqiqot esa O‘zbekiston turizm obyektlari misolida texnologik joriy etishning obyekt turlari bo‘yicha keskin farqlanishini empirik ko‘rsatadi.

Mehmonxonalarda yuqori qamrovning kuzatilishi ularning kapital bazasi, standartlashtirilgan boshqaruv jarayonlari va energiya xarajatlarini uzoq muddatli optimallashtirish imkoniyati bilan izohlanishi mumkin. Oilaviy mehmon uylarida esa past qamrov kichik hajmning o‘zi bilan emas, balki boshlang‘ich investitsiya, texnik axborot va moliyalashtirish instrumentlariga kirish cheklovlari bilan bog‘liq bo‘lishi ehtimoli yuqori. Shu sababli sirkulyar iqtisodiyotni rivojlantirish siyosati “bir xil talab – bir xil rag‘bat” modelidan voz kechib, segmentlarga mos vositalar paketiga o‘tishi lozim.

Tadqiqotning muhim cheklovi shundaki, natijaviy indikator haqiqiy fizik “panel mavjud/panel mavjud emas” holatini emas, ma’muriy bazadagi ijobiy qaydni ifodalaydi. Shuningdek, investitsiya, energiya xarajatlari, kredit yoki subsidiya, mulk shakli va energiya auditi kabi mikroiqtisodiy o‘zgaruvchilar bazada to‘liq mavjud emas. Shu bois natijalar statistik assotsiatsiya sifatida talqin qilindi va sababiy ta’sir haqida xulosa chiqarilmadi.

XULOSA VA TAKLIFLAR

Tadqiqot O‘zbekiston turizm obyektlarida qayta tiklanuvchi energiya texnologiyalarining joriy etilishi bir tekis emasligini va obyekt turi bilan kuchli statistik bog‘langanini ko‘rsatdi. Bivariativ tahlilda obyekt turi uchun Cramér V=0,624, hudud uchun esa Cramér V=0,869 qayd etildi. Asosiy Logit modelida xostel/yotoqxona hamda oilaviy mehmon uyi toifalarining mehmonxonalarga nisbatan manfiy differensiali boshqa kuzatiladigan omillar nazorat qilinganda ham saqlanib qoldi. Ayniqsa oilaviy mehmon uylari uchun AME=-0,421 bo‘lishi ushbu segmentda texnologik transformatsiya bo‘yicha alohida yondashuv talab etilishini ko‘rsatadi.

Natijalar asosida birinchi taklif — qayta tiklanuvchi energiya va resurs samaradorligini qo‘llab-quvvatlash instrumentlarini obyekt segmentlari bo‘yicha differensiallashtirishdir. Yirik mehmonxonalar uchun energiya auditi, energetika menejmenti va natijaga bog‘liq moliyalashtirish instrumentlari qo‘llansa, oilaviy mehmon uylari va xostellar uchun soddalashtirilgan texnik paketlar, kichik hajmdagi imtiyozli moliya, standart loyiha yechimlari va kollektiv xarid mexanizmlari samaraliroq bo‘lishi mumkin.

Ikkinchi taklif — hududiy monitoring platformasida har bir turizm obyektining texnologiya mavjudligi, o‘rnatilgan quvvat, energiya va suv sarfi, investitsiya manbai, kredit/subsidiya, energiya auditi, sertifikat va texnik xizmat ko‘rsatish holatini yagona

identifikator asosida yuritishdir. Mavjud ma’lumotlarda bo‘sh katak “mavjud emas” yoki “ma’lumot kiritilmagan” holatini aniq ajratmagani uchun keyingi kuzatuvlarda status maydonlarini majburiy kiritish zarur.

Uchinchi taklif — hududiy turistik yuklama va sirkulyar texnologiyalarni alohida emas, destinatsiya darajasida birgalikda rejalashtirishdir. Turistlar oqimi yuqori hududlarda resurs yuklamasini kamaytiruvchi investitsiyalarni tezlashtirish, oqim nisbatan past, biroq energetik tayyorgarlik yuqori hududlarda esa mavjud yashil infratuzilmani barqaror turizm brendi va yangi xizmatlar bilan bog‘lash mumkin.

Kelgusidagi tadqiqotlarda obyekt darajasidagi energiya xarajatlari, investitsiya, mulk shakli, bino maydoni, kredit/subsidiya, raqamli boshqaruv, sertifikat va xodimlar kompetensiyasi kabi ko‘rsatkichlarni yig‘ish tavsiya etiladi. Bunday ma’lumotlar mavjud bo‘lganda texnologiyani qabul qilishning moliyaviy, institutsional va boshqaruv kanallarini ajratish, panel ma’lumotlar asosida dinamik baholash hamda sababiy inferensiyaga yaqinroq identifikatsiya strategiyalarini qo‘llash imkoniyati kengayadi.

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STRUCTURAL SYSTEMS IN CONTROLLED ENVIRONMENT AGRICULTURE

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Abstract. *Controlled Environment Agriculture (CEA) has emerged as an innovative approach to sustainable food production by providing precise control over environmental conditions, enabling year-round crop cultivation regardless of external climate. This review aims to evaluate the major structural systems used in modern CEA, including greenhouses, indoor vertical farms, modular container farms, and underground farming facilities. The study was conducted through a comprehensive review of scientific literature published between 2004 and 2025, with emphasis on the structural characteristics, operational performance, advantages, and limitations of each system. The analysis indicates that each structural system offers distinct benefits depending on production objectives, climatic conditions, and resource availability. Greenhouses provide cost-effective production through natural sunlight, while indoor vertical farms achieve high productivity through intensive environmental control. Container farms offer flexibility and localized food production, whereas underground farming presents opportunities for utilizing existing infrastructure with improved environmental stability. The review concludes that no single structural system is universally optimal; instead, selecting an appropriate CEA structure should depend on local environmental, economic, and technological conditions. Integrating these systems into sustainable urban agriculture can contribute significantly to future food security and climate resilience.*

Keywords: *Controlled Environment Agriculture, CEA, greenhouse, vertical farming, container farming, underground farming, urban agriculture, structural systems, sustainable agriculture, food security.*

Annotatsiya. *Nazorat qilinadigan muhit qishloq xo'jaligi (Controlled Environment Agriculture – CEA) tashqi iqlim sharoitidan qat'i nazar yil davomida qishloq xo'jaligi mahsulotlarini yetishtirish imkonini beruvchi zamonaviy texnologik yondashuv hisoblanadi. Mazkur maqolaning maqsadi CEA tizimlarida qo'llaniladigan asosiy konstruktiv yechimlar, jumladan issiqxonalar, yopiq vertikal fermalar, konteyner fermalari va yer osti fermalarining tuzilishi, ishlash xususiyatlari, afzalliklari hamda cheklovlarini tahlil qilishdan iborat. Tadqiqot 2004–2025-yillarda chop etilgan ilmiy adabiyotlarni tahlil qilish asosida amalga oshirildi. Tahlil natijalari shuni ko'rsatdiki, har bir konstruktiv tizim ishlab chiqarish maqsadi, iqlim sharoiti va mavjud resurslarga qarab o'ziga xos ustunliklarga ega. Issiqxonalar tabiiy yorug'lik hisobiga energiya sarfini kamaytirsa, vertikal fermalar sun'iy boshqariladigan muhitda yuqori hosildorlikni ta'minlaydi. Konteyner fermalari moslashuvchan va*

mahalliy oziq-ovqat ishlab chiqarishga qulay bo'lsa, yer osti fermalari mavjud infratuzilmadan samarali foydalanish imkonini beradi. Xulosa qilib aytganda, barcha sharoitlar uchun yagona ideal konstruktiv tizim mavjud emas. Eng maqbul CEA tizimini tanlash mahalliy ekologik, iqtisodiy va texnologik omillarga asoslanishi lozim. Ushbu tizimlarning uyg'un qo'llanilishi barqaror shahar qishloq xo'jaligi va oziq-ovqat xavfsizligini ta'minlashga xizmat qiladi.

Kalit so'zlar: *Nazorat qilinadigan muhit qishloq xo'jaligi, CEA, issiqxona, vertikal ferma, konteyner ferma, yer osti fermasi, shahar qishloq xo'jaligi, konstruktiv tizimlar, barqaror qishloq xo'jaligi, oziq-ovqat xavfsizligi.*

Аннотация. *Сельское хозяйство с контролируемой средой (Controlled Environment Agriculture, CEA) представляет собой современный подход к производству сельскохозяйственной продукции, обеспечивающий круглогодичное выращивание культур независимо от внешних климатических условий. Цель данной статьи заключается в сравнительном анализе основных конструктивных систем, применяемых в современных CEA, включая теплицы, вертикальные фермы, контейнерные фермы и подземные фермы. Исследование выполнено на основе анализа научных публикаций, опубликованных в период с 2004 по 2025 год, с акцентом на конструктивные особенности, эксплуатационные характеристики, преимущества и ограничения каждой системы. Результаты обзора показывают, что каждая конструктивная система обладает своими преимуществами в зависимости от целей производства, климатических условий и доступности ресурсов. Теплицы обеспечивают экономичное производство благодаря использованию естественного освещения, вертикальные фермы позволяют добиться высокой продуктивности за счёт полного контроля условий выращивания, контейнерные фермы отличаются мобильностью и возможностью локального производства, а подземные фермы эффективно используют существующую инфраструктуру и обеспечивают стабильный микроклимат. Сделан вывод о том, что универсальной конструктивной системы для всех условий не существует. Выбор оптимального решения должен учитывать местные экологические, экономические и технологические особенности. Комплексное использование различных CEA-систем может способствовать развитию устойчивого городского сельского хозяйства и укреплению продовольственной безопасности.*

Ключевые слова: *сельское хозяйство с контролируемой средой, CEA, теплица, вертикальная ферма, контейнерная ферма, подземная ферма, городское сельское хозяйство, конструктивные системы, устойчивое сельское хозяйство, продовольственная безопасность.*

INTRODUCTION

CEA is an acronym for Controlled Environment Agriculture. CEA is a crop production system that is separated from outside environment and has regulated environmental conditions including light, temperature, humidity, and carbon dioxide. CEA systems allow year-round production in almost every climate, weather it is arid, polar, or densely populated city (McCartney & Lefsrud, 2018). Even in urban regions, structural systems are able to support food production in warehouses, high-rise

buildings, rooftops, and underground spaces. This report critically discusses different structural systems in modern CEA, analysing their types, materials, advantages, and limitations.

LITERATURE REVIEW

Structural systems are backbones of Controlled Environment Agriculture. They are engineered frameworks that support artificial environment. Their design determines resource efficiency, and the adaptability of crops (McCartney & Lefsrud, 2018).

Greenhouses are ethe prominent and widely known type of CEA because it is one of the most widely utilised structures (Fadel et al., 2016). Ther are less known yet more advanced CEA systems including indoor vertical farming, which rely on multilayer growing racks and LED lighting. This kind of systems are popular in urban areas because of their ability to maximise vertical space (Kabir et al., 2023).

Other structural systems include growth chambers, which are popular with precise and isolated environments for research (Thiel et al., 1996), and modular container farms offering portable units (Song et al., 2023). Finally, there are underground farms.

RESEARCH METHODOLOGY

This study employed a qualitative literature review methodology to examine structural systems used in Controlled Environment Agriculture (CEA). Relevant scientific publications were collected from internationally recognized databases, including Google Scholar, Scopus, Web of Science, SpringerLink, and ScienceDirect. The reviewed literature primarily consisted of peer-reviewed journal articles published between 2004 and 2025, with emphasis on studies investigating greenhouse structures, indoor vertical farming, modular container farms, and underground farming systems.
The collected publications were screened based on their relevance to structural design, operational performance, resource efficiency, environmental control, and sustainability. A comparative analytical approach was used to evaluate the structural characteristics, advantages, limitations, and practical applications of each CEA system. The findings were synthesized using descriptive and comparative methods to identify the strengths and weaknesses of different structural systems and their potential contribution to sustainable urban agriculture.

ANALYSIS AND RESULTS.

1. Greenhouse Structures

Overview. Greenhouses consist of a metal frame (often steel or aluminium) covered with transparent or translucent cladding materials. Types of materials used in greenhouse coverage strongly influence light transmission and heat flow into the growing space. Those materials include glass, polyethylene, and polycarbonate, (Fadel et al., 2016). Some research shows that there would be up to 50% change in internal temperature with certain polycarbonate combinations (Fadel et al., 2016). Frames, foundations, cladding, and ventilation must withstand wind and structural loads as well as enabling effective light entry and climate control (Dalai et al., 2020; Waaijenberg, 2004).

Operational performance. Greenhouses combine solar gain with mechanical controls (fans, shading, cooling pads). Coverings regulate heat and light but, without ventilation, temperatures can be as high as 45°C (Fadel et al., 2016). properly ventilated and insulated greenhouses can sustain relatively stable microclimates, but controlled climate is highly sensitive to external weather and the quality of structural design (Waaijenberg, 2004).

Benefits and limitations.

Greenhouses offer lower capital cost per area and rely on natural light which reduces energy use. However, they are sensitive to availability of the sun and weather conditions, and cooling loads. poor design may lead to overheating or low light eventually reduced yields (Fadel et al., 2016; Dalai et al., 2020).

Picture 1. Greenhouses

a) types of greenhouse b) industrial greenhouses in Netherlands

2. Indoor Vertical Farming Facilities

Overview. Indoor vertical farms are distinguished by fully enclosed structures, where crops are grown on stacked racks. One key difference between greenhouses and indoor farming is exposure to the sun: greenhouses have access to sunlight whereas indoor farms have to rely on artificial led lights. Structural systems consisted of multi-tiered shelving, irrigation pipes, and LEDs (Kabir et al., 2023).

Operational performance. Vertical farms allow high level of climate control. lighting, and nutrient delivery, CO^2 concentrations are adjustable to maximize productivity year-round. Thanks to the advancements in sensors, automation, and environmental control, operational reliability and crop uniformity is being improved (Kabir et al., 2023). Recent work on indoor agriculture mentions the need for more

research on integrating crop cycles with energy-management to optimise the system (Wang et al., 2025).

Benefits and limitations. Extremely high yield per unit ground area is the key benefit of vertical farms. The ability to locate production in the city area is another advantage to consider. In today's global food systems agricultural products travel thousands of kilometres to get to the consumers which increases the cost of the product and contributes to the climate change. Vertical farms can solve this very problem by lowering food miles (Kalantari et al., 2017). Yet, economically vertical farms can not compete in the market because of its high initial investment and high labour, energy costs (Moghimi & Asiabanpour, 2023).

Picture 2. Example of vertical farming facility
Retrieved from: https://share.google/laSVPfap2xO19AgDP

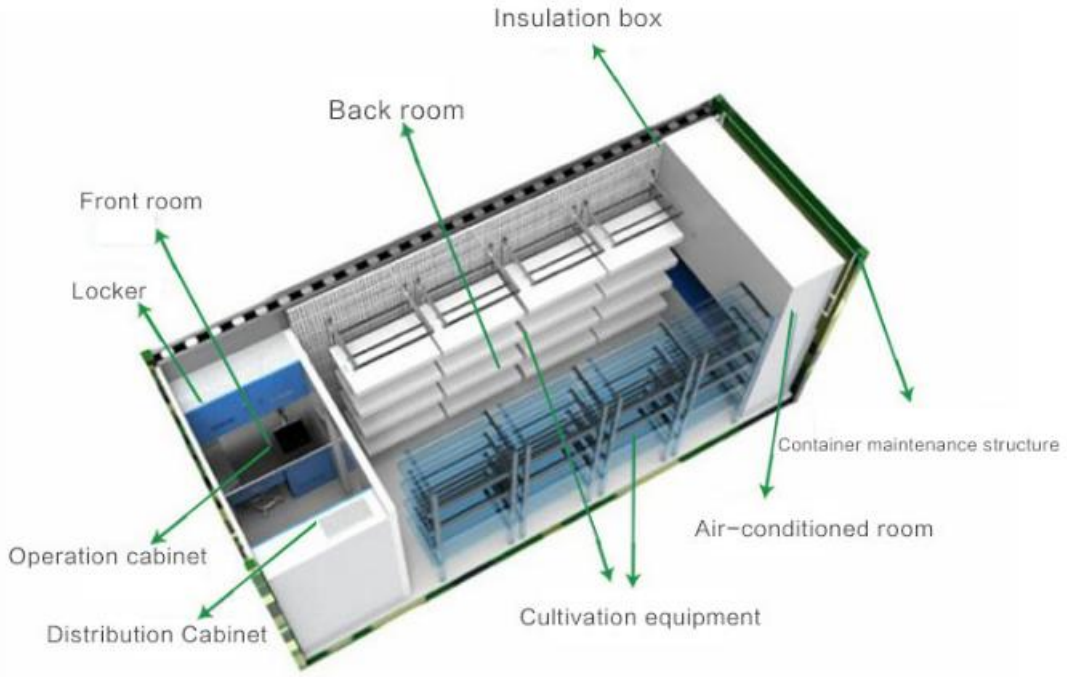
3. Modular Container Farms

Overview. Modular CEA systems in shipping containers or similar structures are called Container farms. What set them apart is their walls and roof which are covered with insulation and integrated HVAC systems. Similar to vertical farms the interior can be equipped with multi-layer growing racks and LED lighting (Song et al., 2023).

Operational performance. Energy modelling studies shows that container farms can support ideal growing conditions, but they have a tendency to have high energy demand, especially in warmer regions (Song et al., 2023). Thanks to their compact and uniform design they are ideal to conduct research on different plant varsities.

Benefits and limitations. Portability, rapid deployment, and standardisation are the main benefits of container farms. The location of placement can vary widely from parking lots, vacant plots, to next to distribution centres which provides extra localised production. Regarding the structural viewpoint, their unique design allows avoiding

complex building integration. However, because of their limited internal volume total output is much less compared to other CEA structures, (Song et al., 2023).



Picture 3. Structure of Container farm
Retrieved from: https://www.omana.cn/en/product/product-90-923.html

4. Underground Farming Structures

Overview. Underground farming is relatively new frontier in CEA which makes use of subsurface spaces for example abandoned mines, tunnels, car parks, or other underground spaces. However, new cavities would also be created (Langefeld & Tegtmeier, 2019). In underground farming structures the main structural task is retrofitting these spaces with internal frames for growing racks, lighting, and irrigation, along with ventilation. The rock or concrete surrounding the structure provides structural strength and insulation, similar in function to the envelope of other CEA facilities (McCartney & Lefsrud, 2018; Langefeld & Tegtmeier, 2019).

Operational performance. Subsurface environments usually have relatively stable temperatures which eliminates the need for energy intensive climate control systems. on top of that, this type of environments protects the farm from external weather (Langefeld & Tegtmeier, 2019). HVAC and control systems are utilized to control the micro-climate within underground farms, comparable to those in other indoor farms.

Benefits and limitations. There are several advantages of underground farms a major one is being the reutilization of existing infrastructure (Langefeld & Tegtmeier, 2019). The external weather patterns such as thermal changes and precipitation is physically blocked which can enhance resilience in extreme climates (McCartney & Lefsrud, 2018). On the other hand there are some limitations that worth mentioning including significant retrofit costs for ventilation, safety, LED lights and limited

real-world experience, since relatively few underground facilities has been built (Langefeld & Tegtmeier, 2019).

Picture 4. Structure of Underground farms

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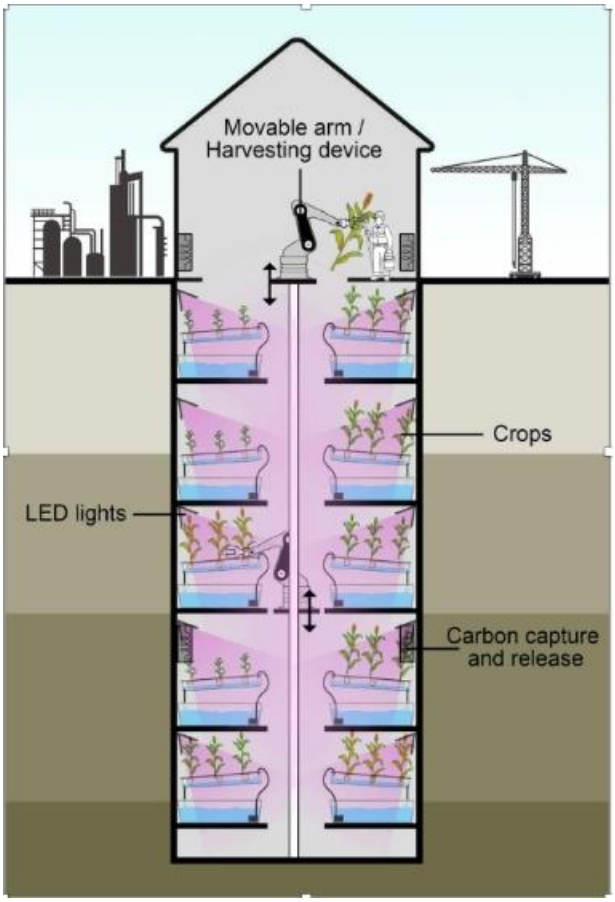

CONCLUSION

Structural systems build the essential foundation of contemporary Controlled Environment Agriculture (CEA). The analysis of four key structure types—greenhouses, vertical farming facilities, container farms, and underground farms—shows how each system offers specific advantages, operational differences, and unique limitations. Greenhouses are the most efficient structures, because they benefit from natural illumination yet they are the most sensitive to external weather. Vertical farms, in contrast, fully enclosed and that enable high-density production but economic contains remains to be the biggest challenge. Creating decentralised urban production is the main advantage of container farms. Moreover, they introduce a flexible, modular approach, though governments can not provide enough calories with container farms because they are small and energy intensive. Another unique CEA system is underground farms which repurpose subsurface infrastructure already in place. However just like vertical farms underground farm's initial investment and operational costs comes with a high price tag attached. As discussed in this report, no Controlled Environment Agriculture (CEA) system can feed the entire city. However, when applied in harmony and deployed according to suitable conditions, these systems can build sustainable urban agriculture.

Based on the reviewed literature, several recommendations can be proposed for improving the implementation of Controlled Environment Agriculture systems. Select CEA structural systems according to local climatic conditions, economic capacity, and

production objectives rather than applying a single approach in all situations. Increase investment in energy-efficient technologies, including advanced LED lighting, renewable energy systems, and automated environmental control, to improve the economic sustainability of indoor farming.

Encourage the integration of Controlled Environment Agriculture into urban planning by utilizing rooftops, vacant buildings, shipping containers, and underground spaces for local food production. Promote interdisciplinary collaboration among engineers, agronomists, architects, and policymakers to design more efficient and resilient CEA facilities. Support further research on reducing energy consumption, optimizing structural design, and improving the long-term economic feasibility of vertical and underground farming systems. Develop government policies and financial incentives that encourage investment in sustainable Controlled Environment Agriculture technologies and strengthen urban food security.

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THE ROLE OF EMPLOYMENT AGENCIES IN ENHANCING EMPLOYMENT RATES IN THE AGRICULTURE SECTOR: A PATHWAY FOR RESIDENTS OF TASHKENT REGION

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Abstract. *Agriculture has long been one of the main sources of employment in the Tashkent region of Uzbekistan. However, economic instability, seasonal employment, relatively low wages for agricultural employees have been driving patterns for residents to seek appropriate vacancies in foreign countries. The article represents the importance of employment agencies both public and private to facilitate international labor migration for potential workers in Tashkent region, focusing on improving employment rates in agriculture. International Labor Organization (ILO), in coordination with the External Labor Migration Agency of Uzbekistan, has deeply examined the implementation of this process. Including, the operation of employment agencies, teaching methods regarding specific skills and language for potential workers abroad, informing employee about their rights and acting based on foreign countries laws and standards, introducing employee endorsing programs such as available incentives, subsidies, loans to establish their business after they have returned to their homeland etc. This article identifies main challenges, unethical employment practices, specific skills and language barriers, policy recommendations under ILO Convention No. 181 on Non-Government Employment Agencies. Through research it is clarified that recruitment agencies not only attractive for transparency, ethically trustworthy and immediate regulation for migration, but also strategic drivers for improvement of employment, reducing poverty and remittance based economic development for residents of Tashkent region.*

Keywords. *Employment agencies, agricultural sector, labor migration, Tashkent region, international employment, ILO, remittances, AELM, vocational skills and language proficiency.*

Annotatsiya. *Qishloq xo'jaligi uzoq vaqtdan beri Toshkent viloyati, O'zbekistonda bandlikning asosiy manbalaridan biri bo'lib kelgan. Biroq, iqtisodiy beqarorlik, mavsumiy bandlik, qishloq xo'jaligi xodimlarining nisbatan past ish haqi aholining xorijiy mamlakatlarda munosib bo'sh ish o'rinlarini izlashiga turtki bo'lib kelmoqda. Maqolada Toshkent viloyatidagi potentsial ishchilar uchun xalqaro mehnat*

migratsiyasini osonlashtirishda davlat va xususiy bandlik agentliklarining ahamiyati, qishloq xo'jaligida bandlik darajasini oshirishga e'tibor qaratilganligi ta'kidlangan. Xalqaro mehnat tashkiloti (XMT) O'zbekiston Tashqi mehnat migratsiyasi agentligi bilan hamkorlikda ushbu jarayonni amalga oshirishni chuqur o'rganib chiqmoqda. Jumladan, bandlik agentliklarining faoliyati, chet eldagi potentsial ishchilar uchun maxsus ko'nikmalar va tilni o'qitish usullari, xodimlarni ularning huquqlari haqida xabardor qilish va xorijiy davlatlar qonunlari va standartlariga asoslanib harakat qilish, mavjud imtiyozlar, subsidiyalar, vataniga qaytgandan keyin biznesini yo'lga qo'yish uchun kreditlar kabi qo'llab-quvvatlovchi dasturlarni joriy etish va boshqalar ustida ish olib borilmoqda. Ushbu maqolada asosiy to'siqlar, norasmiy ishga yollash amaliyotlari, maxsus ko'nikmalar va til to'siqlari, XMTning 181-sonli Nodavlat bandlik agentliklari to'g'risidagi konventsiyasi bo'yicha siyosat tavsiyalari muhokama qilingan. Tadqiqotlar orqali aniqlanishicha, bandlik agentliklari nafaqat shaffoflik, ahloqiy jihatdan ishonchlilik va migratsiyani darhol tartibga solishga yondashgan bo'lishi kerak, hamda yangi ish o'rinlarini yaratish, qashshoqlikni kamaytirish va Toshkent viloyatidagi aholi uchun pul o'tkazmalariga asoslangan tizimning iqtisodiy rivojlantiruvchi muhim drayveri bo'lib qoladi.

Kalit so'zlar. *Bandlik agentliklari, qishloq xo'jaligi sektori, mehnat migratsiyasi, Toshkent viloyati, xalqaro bandlik, XMT, pul o'tkazmalari, AELM, kasbiy ko'nikmalar va til bilish darajasi*

Аннотация. *Сельское хозяйство долгое время являлось одним из основных источников занятости в Ташкентской области Узбекистана. Однако экономическая нестабильность, сезонная занятость и относительно низкая заработная плата сельскохозяйственных рабочих побудили население искать достойную работу за границей. В статье подчеркивается важность государственных и частных агентств по трудоустройству в содействии международной трудовой миграции потенциальных работников в Ташкентской области, с акцентом на повышение уровня занятости в сельском хозяйстве. Международная организация труда (МОТ) проводит углубленное исследование реализации этого процесса в сотрудничестве с Агентством Узбекистана по внешней трудовой миграции. В частности, ведется работа по изучению деятельности агентств по трудоустройству, методов обучения потенциальных работников за рубежом конкретным навыкам и языку, информирования работников об их правах и действий в соответствии с законами и стандартами зарубежных стран, внедрения программ поддержки, таких как существующие льготы, субсидии, кредиты на открытие бизнеса после возвращения на родину и т. д. В статье рассматриваются основные препятствия, неформальные методы найма, специфические профессиональные и языковые барьеры, а также рекомендации по политике в отношении Конвенции МОТ № 181 о негосударственных агентствах по трудоустройству. Исследование показало, что агентства по трудоустройству должны не только быть прозрачными, этически безупречными и оперативно регулировать миграцию, но и стать важным двигателем экономического развития системы, основанной на денежных переводах, для населения Ташкентской области.*

Ключевые слова. *Агентства по трудоустройству, сельскохозяйственный сектор, трудовая миграция, Ташкентская область, международная занятость, МОТ, денежные переводы, АЭММ, профессиональные навыки и знание языка.*

INTRODUCTION

The shortage of agricultural employees worldwide is rising, as developed and emerging country's economy requires more and more work force. Strong and emerging economies such as United Kingdom, Germany, Japan, South Korea, Poland, Slovakia, Slovenia and other middle east countries like United Arab Emirates, Saudi Arabia have been hiring thousands of employee to fill the agricultural gap, food processing, plant cultivation and agri-industrial sector. This demand gives a chance to the residents of Tashkent region with the help of recruitment agencies being employed in above-mentioned countries, receiving high-paying salaries, gain international work experience, learning international standards, which simultaneously reduces regional poverty and enhances household revenue through remittances.

Uzbekistan's population has surpassed more than 38 million people and approximately 25-28 percentage of them have been working in agriculture sector. Most parts of Tashkent region, substantial demographic proportion of residents, have been working in horticulture, viticulture, livestock management and other agri-industrial sector. Although agriculture has a significant role in economy, it distinguishes with low wages in comparison with international standards and stable employment is not ensured due to seasonal works and fulfilling positions with new flows of youth even for less salaries (International Labor Organization [ILO], 2021). Consequently, existing challenges like this stimulate local residents to seek international job offers.

The government of Uzbekistan gradually recognized the significance of structural labor migration as a development strategy for Uzbekistan's economy. Based on Presidential Decree PP-3473 in 2018 the Agency for External Labor Migration (AELM) was established, under the Ministry of Employment and Labor Relations, and then renamed as the Ministry of Employment a Poverty Reduction. The AELM was dominant driver on regulation of labor migration abroad, licensing private employment agencies, teaching and training potential workers to obtain necessary skills and overcome language barriers, and advocating about the rights of our citizens while working in foreign countries (Government of Uzbekistan, 2018). In 2024, another new presidential decree released to improve transition process of employment abroad regarding facilitation of private employment agencies, representing the government's acknowledgement of the private sector's importance to enhance international labor employment (Ministry of Justice of Uzbekistan, 2024).

Including all these factors, the role of employment agencies to enhance employment rate in agriculture for the residents of Tashkent region is critical, timely and policy-relevant. The article proposes a solution through analyzing five core functions of recruitment agencies: labor market demand, specific skills and language courses, legal and documentary facilitation, potential worker's rights recognition, and economic significance through remittances. Each category is evaluated through both international and national practices to check their functionality. This article represents

also political and economic recommendations to enhance the role of recruitment agencies to maximize employment outcomes for potential workers of Tashkent region.

1.1 Aim and Research Questions

The dissertation intends to critically investigate the role of public and private recruitment agencies play in improving employing rates in the agricultural sector for the residents of the Tashkent region of Uzbekistan, with spectacular reference to global labor migration.

RQ1: What kind of functions do public and private recruitment agencies carry out in facilitating labor migration in agriculture from the Tashkent region?

RQ2: What kind of challenges and issues have residents of Tashkent region been facing when seeking better positions in agriculture in foreign countries, and how efficiently do licensed recruitment agencies resolve these issues compared with illegal or unlicensed channels?

RQ3: What kind of legislation policy and institutional standards could strengthen the efficiency, transparency and developmental program of recruitment agencies running in the Tashkent region?

LITERATURE REVIEW

2.1 Theoretical Foundations of Labour Migration. Lee's (1966) push-pull model determines unfavorable working conditions at local areas and favorable working conditions in foreign countries as primary reasons for migration decisions; de Haas (2007) confirms this model remains robust for understanding how migration directions upgrade over time. Classical economic hypothesis frames labor migration as a response to the salary gap between sending and receiving labor markets. The New Economics of Labor Migration (NELM), developed by Stark and Bloom (1985) and expanded by Taylor (1999), instead represents migration as a family-based, risk-diversification decision rather than a personal one — a model critically relevant to Tashkent region households facing seasonal income variability and high credit costs. Massey et al. (1993) add that global labor markets shift toward high-income core sectors and insecure peripheral sectors that local workers are reluctant to fill, sustaining demand for agricultural labor in the EU, East Asia and Gulf states; migration systems theory further argues that these sustained flows build socioeconomic bridges between sending and receiving states through remittances (Wickramasinghe & Wimalaratana, 2016).

2.2 Labour Market Intermediaries and the Functionality of Employment Agencies.

Employment agencies increasingly function as labor market intermediaries (LMIs) that organize who migrates, under what circumstances, and to where. Coe et al. (2010) and Mense-Petermann (2020) describe LMIs as performing labor market brokerage, job-bank documentation, skills and language training, and matching employee demand and supply across borders. Van den Broek et al. (2016) note intermediaries are often overlooked despite handling recruitment, selection and contracting for migrants, while Groutsis et al. (2015) argue this reflects a shift from regulative bureaucracy toward network-based administration in which agencies coordinate with international donors to enhance employment.

2.3 Ethical Recruitment, Regulation, and Worker Protection

Governance of employment agencies is anchored in ILO Convention No. 181 (1997), which requires licensing, oversight and complaint mechanisms and forbids charging recruitment fees to migrants under the "Employer Pays Principle" (International Organization of Employers & Responsible Business Alliance, 2018), underpinning the ILO's Fair Recruitment Initiative against trafficking and exploitation. Matuszczyk (2026) argues the practical value of these principles depends heavily on enforcement rather than the existence of the rules themselves, since an extending "grey economy" of unlicensed brokers remains the main threat to the transparency of licensed agencies — a tension directly relevant to Uzbekistan's ongoing shift of labor-migration governance from AELM to private agencies.

2.4 Research Gap

The literature establishes the significance of legal-channel documentation, agencies' intermediary role with donors and governments, pre-departure training, migrant-rights compliance, and remittance-based development, but says less about the operation of illegal agencies and the skills/language gaps migrants continue to face. This article addresses that gap by examining how recruitment agencies in Tashkent region perform across labor-market mediation, skills and language training, legal documentation, migrant-rights protection, and remittance-driven economic development.

METHODOLOGY

This study uses a qualitative research approach based on secondary data analysis — academic literature, government reports, legal documents, publications of international organizations and statistical data — combined with experience-based interviews, to examine the role of employment agencies in expanding agricultural employment abroad for Tashkent region residents. A descriptive and comparative method assesses agency activity against international experience and Uzbek practice, drawing on the ILO, IOM, World Bank and relevant government institutions, alongside document analysis of policies and regulations, to identify key challenges, best practices and policy recommendations.

3.1 Research Design and Data Collection.

A qualitative exploratory design was used, consistent with Creswell and Poth's (2018) guidance that such designs suit phenomena needing contextual rather than large-scale statistical understanding. Interview data were analysed using Braun and Clarke's (2006) six-phase thematic analysis, generating codes such as fee amount, working conditions, language proficiency, documentation procedure and salary delays, which structured five recurring themes: labor market intermediation, skills development, legal facilitation, worker's-rights protection and economic impact. Data collection proceeded in two stages: first, secondary statistical data and policy documents from the ILO, IOM, World Bank and the Statistics Agency of Uzbekistan; second, structured interviews (Appendix B) designed to probe ambiguities or contradictions surfaced by the secondary record, such as the gap between the officially stated cost of AELM documentation and the substantially higher fees reported for private and illegal operators.

3.2 Participant Overview

Characteristic	Detail
Number of named interview participants	22
Additional agency-perspective informants	2 (Madadjon Mamatjonov, Baxodir)
Destination countries represented	United Kingdom, Finland, Russia, Türkiye, Bulgaria
Recruitment channels represented	AELM (official), licensed private agency, unlicensed broker, personal/kinship network
Interview length	20 minutes to 1 hour
Interview format	In-person / phone, personal communications, 2025

3.3 Ethical Considerations and Limitations

Respondents were informed of the research aims, gave verbal consent, and could decline or withdraw at any point; only those who explicitly agreed were named, and details that could expose respondents who paid unofficial or unlicensed coordinators were kept confidential. As all respondents are cited as personal communications, self-reported data on wages, fees and working conditions should be read as illustrative rather than as a representative statistical sample, and the ongoing transfer of labor-migration governance from AELM to licensed private agencies means some administrative details may continue to evolve after publication.

RESULTS

The Agricultural Workforce and Labour Migration Trends in Tashkent Region

Tashkent region borders the capital and encircles a large fertile area where cotton, wheat, fruits and vegetables are cultivated (Statistics Agency, 2023). The sector employs a substantial share of residents, but seasonal work and locally-regulated wages leave earnings well below what comparable agricultural jobs pay abroad. In 2024, approximately 6.2 million Uzbek residents worked abroad — a 29% rise on 2023 — and remittances reached $14.9 billion, a 30% increase, confirming remittances (not foreign investment, at $7.2 billion in 2023) as the country's dominant external revenue source (Statistics Agency, 2023; Development Strategy Center, 2025).

Indicator	2023	2024
Labor migrants working in foreign countries	~4.8 million (implied)	6.2 million
Remittance inflows (USD)	>$11.4 billion	$14.9 billion
Foreign investment amount (USD)	$7.2 billion	not reported in cited sources
Agricultural placements through legal channels (Jan–Mar)	not reported	6,858

Table 1. Key Labor-Migration Indicators, Uzbekistan, 2023–2024. Source: Statistics Agency of Uzbekistan (2023, 2025); Development Strategy Center (2025); IOM Uzbekistan (2024).

Russia remains the dominant destination (78% of 2024 remittances), but EU markets are growing — Poland (21%), Lithuania (17%) and Germany (16%) of 2023 EU visa issuance — and 4,094 UK seasonal-worker visas went to Uzbeks (13% of all UK seasonal visas that year), pointing to a shift toward better-paid markets that agencies can accelerate (Statistics Agency, 2025). Agriculture was the second-largest

sector for legally deployed workers in early 2024, with 6,858 placements in the first quarter alone, behind only manufacturing (IOM Uzbekistan, 2024; Kun.uz, 2025). Tashkent region does not send the highest volume of migrants nationally (Andijan, Fergana and Samarkand rank higher), but its proximity to the capital gives residents comparatively better access to consulting, language and skills training, and document facilitation.

4.2 Updated National Indicators (2025–2026)

These trends continued into 2025: total remittances reached $18.9 billion, a 28% rise on 2025 and more than triple the 2020 figure, with particularly fast growth from the UK (+39%) and the EU (+37%), including Ireland (2.6-fold) and Slovakia (+67%) (UzDaily.uz, 2026; Kun.uz, 2026). At the same time, the World Bank (2025) reports that the total number of Uzbek migrants working abroad fell 34% year-on-year to 1.35 million by early 2025, driven by a sharp fall in Russia-bound migration amid tightening conditions there — meaning migrants are earning more overall while relying less on the traditional Russian market, a shift directly relevant to RQ3. Meanwhile, the share of Uzbekistan's workforce in agriculture has continued a slow, steady decline (25.71% in 2019 to 25.2% in 2025; Statbase.org, 2025; World Bank Group, 2025b), so the workers who remain in the sector represent a proportionally more significant pool of candidates for the overseas placements agencies facilitate.

4.3 Interview Findings: Experiences of Labour Migrants from Tashkent Region

Fee structures diverge sharply by channel. Official AELM postings for UK, German and Finnish jobs typically require only visa costs, tickets and under $100 in documentation fees, while private agencies can charge $1,000–3,000 for the same service. Aziz Anvarov, interviewed for this study, paid around $80 in documentation fees and $600 for his visa through AELM before travelling to the UK, where he has earned $2,200–2,500 monthly on a six-month fruit-cutting contract (early departure carries an $18,000 penalty). He described organized housing and transport, weekend access to language classes and social activities with migrants from Bulgaria, Serbia, Romania and Moldova, but also named language proficiency and a tight budget in high-cost cities as recurring difficulties, alongside physically demanding conditions in wet weather that some employers pushed staff to work through regardless. A second respondent, Almazov Shakhzod, took an unofficial family-arranged job at an olive-oil factory in Bursa, Türkiye (2020–2022) without any agency involvement; when his seasonal contract could not be renewed, he continued working without a valid visa, was arrested and deported in 2022, and is now barred from re-entering Türkiye for five years — an outcome neither public nor private agencies could help him avoid, and a cautionary case agencies should proactively disseminate to migrants considering informal channels.

4.3.1 The UK Seasonal Worker Route in National Context

Anvarov's experience matches the national pattern: 35,561 UK Seasonal Worker visas were issued in 2024, 78% to four Central Asian countries (Uzbekistan 18%, Kyrgyzstan 18%, Kazakhstan 16%, Tajikistan 16%), almost all (98.7%) in horticulture (GOV.UK, 2025a, 2025b; Migration Observatory, 2025) — confirming his low-cost,

AELM-driven placement reflects a genuine, fast-growing channel available at scale to other Tashkent region residents who have not yet used it.

4.4 The Functions of Employment Agencies in Agricultural Labour Placement Abroad. As **labor market intermediaries**, agencies match candidates to vetted vacancies abroad; since November 2024 the AELM has run a data-driven platform where job seekers can browse openings and submit applications online, widening access for rural residents previously excluded by physical distance (Alliancerecruitmentagency.com, 2025; Ministry of Justice of Uzbekistan, 2024). On **skills and language training**, the AELM was mandated in January 2024 to train 100,000 workers in vocational skills and foreign languages within a year, reflecting recognition that language proficiency (Korean, Japanese, Polish, German, English) is as essential as physical farming skill (IOM Uzbekistan, 2024). For **legal and documentary facilitation**, licensed private agencies now hold full authority to conclude contracts and prepare visas and documentation, and migrants can apply to the AELM migration fund to cover visa, language and medical costs (Ministry of Justice of Uzbekistan, 2024). On **protection of workers' rights**, properly managed agencies act as a bulwark against exploitation, extra fees and contract breaches under ILO Convention No. 181's licensing and complaint-handling requirements (ILO, 2023). Finally, the **economic impact** is substantial: 2024 remittances of $14.9 billion far exceeded foreign investment, disproportionately benefiting low-income and rural households — the same demographic as most Tashkent region agricultural workers (Development Strategy Center, 2025). The earnings gap is stark: local agricultural work pays roughly $300–600 a month against $2,000–2,500 for seasonal placements in the UK, Germany or South Korea (Table 2), a difference that, net of pre-departure costs, still funds local consumption, housing, training and small business investment in line with the "Uzbekistan-2030" development strategy (Global Voices, 2025).

Employment location	Approx. monthly earnings (USD)
Tashkent region (local farms and plantations)	300–600
United Kingdom (seasonal work, fruit-picking)	2,000–2,500
Germany (food-processing sector)	2,000–2,500
South Korea (greenhouse cultivation)	2,000–2,500

Table 2. Indicative Monthly Earnings: Local Agricultural Employment vs. Selected Overseas Placements (USD). Source: Author's compilation from interview data.

DISCUSSION

Information asymmetries leave many residents unaware of legitimate recruitment pathways despite official announcements, creating an opening for informal brokers and, in some cases, exploitation, forced work or debt bondage (The Diplomat, 2024); agencies could close this gap through local webinars, partnerships with district authorities and active use of social media. **Skills mismatches and credential non-recognition** persist because foreign employers often require certifications (occupational safety, driving, food safety) that Uzbek training does not automatically satisfy (IOM Uzbekistan, 2024); the AELM's 100,000-worker training target is a step toward closing this gap but needs more funding and stronger links to vocational institutions to reach full capacity. **Language barriers** remain the most consistently cited obstacle: most Uzbeks speak functional Russian but lack the A2/B1 proficiency

in English, German, Polish, Korean or Japanese that higher-paid roles require, and agencies that treat language training as core rather than optional — as the AELM's Xorijda ish platform partly does by subsidizing certification costs — produce better outcomes (The Diplomat, 2024). Finally, **regulatory capacity** has not kept pace with the shift of placement responsibility from AELM to private agencies (mandated for completion by January 2026): in 2023 the AELM placed only 38,000 of a 200,000 target, reflecting dissemination and staffing gaps rather than lack of demand (Global Voices, 2025), and continuous audits, feedback platforms and clear sanctions will be needed to keep pace with a rapidly growing number of licensed operators (ILO, 2023; Ministry of Justice of Uzbekistan, 2024).

These patterns are consistent with the New Economics of Labor Migration (Stark & Bloom, 1985; Taylor, 1999): Tashkent region households appear to treat overseas agricultural placement as a income-diversification strategy against seasonal local risk rather than a simple wage-maximizing choice. The gap between legal AELM fees (under $100) and the $1,000–3,000 charged by unlicensed channels illustrates the enforcement problem identified by Matuszczyk (2026) and Sadovskaya (2024): the ILO's "Employer Pays Principle" has force on paper, but its real effect depends on enforcement against a persistent grey economy of brokers. At the same time, these findings coincide with an institutional transition: the former AELM became the Agency for Migration in 2024, gained inspection authority over private agencies from January 2025, and is due to hand over overseas vacancy allocation entirely to licensed private agencies by January 2026, alongside a reduced licensing capital requirement intended to widen access for new operators (Ministry of Justice of Uzbekistan, 2024; UzDaily.uz, 2024). By late 2025, however, only 17 licensed private agencies were registered against 6.2 million Uzbeks who migrated in 2024 (Statistics Agency, 2023; Private Employment Agencies Association of Uzbekistan, 2025) — a capacity gap that will determine how quickly the sector can absorb this handover, and one that sharpens rather than resolves the ethical-recruitment debate framed by the ILO's Employer Pays Principle (International Labor Organization, 1997; International Organization of Employers & Responsible Business Alliance, 2018). The findings also point to a three-tier system — compliant official channel, inconsistent licensed private channel, and non-compliant unofficial channel — that is more granular than the "licensed versus unlicensed" binary common in the literature (Sha, 2024; Van den Broek et al., 2016), suggesting oversight should target agency-level rather than sector-level compliance.

RECOMMENDATIONS FOR THEORY AND PRACTICE

6.1 Recommendations for Practice

- Establish a dedicated agricultural labor-migration union that builds up-to-date databases of labor demand abroad, concludes bilateral agreements, and accredits agencies for agriculture-specific placement.
- Require agencies to bundle occupational-skills certification, A2/B1 language training, visa and documentation support, rights information, and migrant-community contacts into a single pre-departure package, with preferential licensing and financial support for agencies that do so.

- Prioritize public-awareness campaigns — through AELM's website, the Xorijda ish platform, local webinars and social media — that clearly distinguish licensed agencies from fraudulent ones.
- Require the Agency for Migration to publish a yearly, publicly accessible register of licensed agencies together with per-agency complaint rates, consistent with ILO Convention No. 181's transparency provisions (International Labor Organization, 1997, Art. 10; 2024), giving Tashkent region residents a verifiable reference point before they pay any fees.
- Disaggregate the Agency for Migration's planned yearly licensing and inspection reporting by gender: all interviewees in this study were men, consistent with World Bank (2025) findings on the male-dominated profile of Central Asian short-term labor migration, and future research should specifically examine the risks facing women migrants from Tashkent region, who are not represented in these findings.

6.2 Recommendations for Theory

Future labor-market-intermediary research would benefit from a typology distinguishing formal-licensed, formal-unlicensed and informal kinship-based operators, since this study finds these three categories differ substantially in cost, risk and protection (Coe et al., 2010; Mense-Petermann, 2020). The New Economics of Labor Migration framework could also be extended to explicitly model channel choice (legal versus illegal) as part of a household's risk-diversification decision, alongside its existing focus on the migration decision itself.

CONCLUSION

Employment agencies play a strategic, multifaceted role in improving agricultural employment outcomes for Tashkent region residents abroad — coordinating with foreign enterprises, building skills and language capacity, ensuring legal and documentary compliance, protecting migrants from exploitation, and generating remittance income that supports rural and suburban households. Realizing this potential fully will require continued public-awareness investment, stronger agency governance, and integration of overseas experience into regional agricultural development, so that properly governed agencies can connect more Tashkent region migrants to high-demand, well-paid positions abroad.

7.1 Limitations and Future Research

As noted in the Methodology, interviewees were drawn largely from Kibray district and the author's own social network, self-reported financial data could not be independently verified, and the AELM-to-private-agency transition was still underway while writing. Future research should (a) survey a larger, randomly sampled population of Tashkent region agricultural workers, (b) track individual migrants across a full migration-and-return cycle, and (c) compare Tashkent region findings with those of other major sending regions (Samarkand, Andijan, Fergana) to test whether the drivers and barriers identified here are regional or national in scope.

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Data Availability Statement

The statistical data supporting this study are openly available from the cited sources (Statistics Agency of Uzbekistan, IOM Uzbekistan, World Bank). Interview data are not publicly available in order to protect participant confidentiality. If readers are curious to communicate with any of these interview respondents they could ask phone numbers or emails of these candidates from the author.

Declaration on the Use of Artificial Intelligence

AI language-model assistant was used (Claude, Chatgpt) to restructure and condense data from the author's master's dissertation into a journal-article format — reorganising sections, cutting non-essential content, and building summary tables — under the author's direction. All substantive materials including, text, findings, and interpretations originate from the author's original dissertation research; no new claims, data, or citations were generated by the AI tool. The author reviewed and edited all content and takes full responsibility for the final manuscript, consistent with COPE and ICMJE requirements that AI tools are not listed as authors and cannot bear accountability for published work.

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QASHQADARYO VILOYATI UCHUN YASHIL TADBIRKORLIKNI RIVOJLANTIRISHNING STRATEGIK YO‘NALISHLARI

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Annotatsiya: *Ushbu maqola Qashqadaryo viloyatida yashil tadbirkorlikni rivojlantirishning iqtisodiy, ekologik va institutsional asoslarini o'rganadi va mintaqaning tabiiy resurs salohiyati, iqtisodiyotning tarmoq tuzilishi, investitsiya faoliyati va suv va energiyadan foydalanish shakllariga asoslangan strategik yo'nalishlarni taklif qiladi. Tadqiqotda tizim tahlili, qiyosiy tahlil, statistik guruhlash, trend tahlili, SWOT tahlili va strategik ustuvorlik usullari qo'llaniladi. Tadqiqot natijalari shuni ko'rsatadiki, Qashqadaryo viloyati iqtisodiyotining qishloq xo'jaligi, sanoat, energetika va xizmatlarga asoslangan tuzilishi yashil transformatsiya uchun katta imkoniyatlar yaratadi. Shu bilan birga, suv tanqisligi, sug'orish tizimlarining energiya sarfi, tuproqning sho'rlanishi va an'anaviy energiya resurslariga yuqori darajada bog'liqlik yashil tadbirkorlikni rivojlantirishni tezlashtirish zaruratini oshiradi.*

Kalit so'zlar: *yashil tadbirkorlik, yashil iqtisodiyot, Qashqadaryo viloyati, qayta tiklanadigan energiya, yashil investitsiya, suvni tejaydigan texnologiyalar, aylanma iqtisodiyot, ekologik innovatsiya, yashil moliya, iqlimga asoslangan qishloq xo'jaligi, resurslar samaradorligi, yashil sanoat.*

Аннотация*: В данной статье рассматриваются экономические, экологические и институциональные основы развития «зеленого» предпринимательства в Кашкадарьинской области и предлагаются стратегические направления, основанные на природно-ресурсном потенциале региона, отраслевой структуре экономики, инвестиционной активности и моделях водо- и энергопотребления. В исследовании используются методы системного анализа, сравнительного анализа, статистической кластеризации, анализа тенденций, SWOT-анализа и стратегического приоритизации. Результаты исследования показывают, что структура экономики Кашкадарьинской области, основанная на сельском хозяйстве, промышленности, энергетике и сфере услуг, создает большие возможности для «зеленой» трансформации. В то же время дефицит воды, энергопотребление ирригационных систем, засоление почв и высокая зависимость от традиционных источников энергии повышают необходимость ускорения развития «зеленого» предпринимательства.*

Ключевые слова: *«зеленое» предпринимательство, «зеленая» экономика, Кашкадарьинская область, возобновляемая энергия, «зеленые» инвестиции, водосберегающие технологии, циркулярная экономика, экологические инновации, «зеленое» финансирование, климатически устойчивое сельское хозяйство, ресурсоэффективность, «зеленая» промышленность.*

Abstract: *This article examines the economic, environmental and institutional foundations of green entrepreneurship development in Kashkadarya region and proposes strategic directions based on the natural resource potential of the region, the sectoral structure of the economy, investment activity and patterns of water and energy use. The study uses the methods of system analysis, comparative analysis, statistical clustering, trend analysis, SWOT analysis and strategic prioritization. The results of the study show that the structure of the Kashkadarya region's economy based on agriculture, industry, energy and services creates great opportunities for green transformation. At the same time, water scarcity, energy consumption of irrigation systems, soil salinization and high dependence on traditional energy resources increase the need to accelerate the development of green entrepreneurship.*

Keywords: *green entrepreneurship, green economy, Kashkadarya region, renewable energy, green investment, water-saving technologies, circular economy, ecological innovation, green finance, climate-smart agriculture, resource efficiency, green industry.*

KIRISH

Iqlim o'zgarishi, tabiiy resurslar tanqisligi va ortib borayotgan ekologik bosim global iqtisodiyotning an'anaviy rivojlanish modellaridan resurslarni tejaydigan, kam uglerodli va ekologik barqaror modellarga o'tishini tezlashtirmoqda. Bu jarayonda yashil tadbirkorlik tobora ko'proq nafaqat salbiy ekologik ta'sirlarni kamaytirishga qaratilgan biznes faoliyati shakli, balki yangi bozorlar, innovatsiyalar, investitsiyalar va bandlikni yaratishga qodir iqtisodiy mexanizm sifatida ham qaralmoqda.

Yashil tadbirkorlikning o'ziga xos xususiyati uning iqtisodiy qiymat yaratish maqsadini energiya va suv samaradorligini oshirish, chiqindilarni kamaytirish, qayta tiklanadigan energiya manbalaridan foydalanish, ekologik toza mahsulotlar ishlab chiqarish va tabiiy kapitalni saqlash kabi maqsadlar bilan birlashtirish qobiliyatidadir.

O'zbekistonda bu masalaning dolzarbligi ayniqsa yuqori. Jahon bankining O'zbekistondagi iqlim va rivojlanish bo'yicha hisobotida mamlakat nisbatan yuqori energiya va resurslar intensivligiga ega ekanligi ta'kidlangan va suv tanqisligi, qurg'oqchilik, haddan tashqari issiqlik va boshqa iqlim bilan bog'liq xavflar uzoq muddatli iqtisodiy o'sishga salbiy ta'sir ko'rsatishi mumkinligi ta'kidlangan. Shuning uchun xususiy sektorning yashil transformatsiyaga faol jalb qilinishi va energiya samaradorligi, qayta tiklanadigan energiya, suvni tejash va iqlimga mos qishloq xo'jaligiga investitsiyalarni ko'paytirish strategik ustuvorliklarga aylanmoqda [1].

Yashil transformatsiya allaqachon O'zbekistonda davlat siyosatining muhim sohasiga aylangan. 2025-yilgi Davlat dasturida energiya tejamkor texnologiyalarni joriy etish, yashil hududlarni yaratish, atrof-muhitga ta'sirni kamaytirish va ishlab chiqarishda aylanma iqtisodiyotning "7R" tamoyillarini qo'llash kabi mezonlar asosida korxonalarga "yashil tadbirkor" maqomini berish mexanizmlari joriy etilgan. Bundan

tashqari, 2025-yil 1-apreldan boshlab quyosh va shamol manbalaridan ishlab chiqarilgan chiqindilarni utilizatsiya qilish va elektr energiyasi uchun "yashil tariflar"ni joriy etish ko'zda tutilgan edi [2]. Ushbu chora-tadbirlar yashil tadbirkorlikni sof ekologik tashabbusdan iqtisodiy rag'batlantiruvchi biznes modeliga aylantirish uchun muhim institutsional sharoitlarni yaratadi.

Qashqadaryo viloyati bu borada alohida strategik ahamiyatga ega. 2026-yil 1-yanvar holatiga ko'ra, mintaqaning doimiy aholisi 3 716 949 kishiga yetdi. 2025-yilda yalpi hududiy mahsulot 6,8 foizga, sanoat ishlab chiqarishi 7,2 foizga, qishloq xo'jaligi, o'rmonchilik va baliqchilik 4,3 foizga va bozor xizmatlari 13,6 foizga o'sdi. 2026-yil boshida mintaqada 30 424 ta korxona va tashkilot faoliyat yuritgan [3]. Bu ko'rsatkichlar yashil mahsulotlar va xizmatlar bozorlarini rivojlantirish uchun yetarlicha keng tadbirkorlik bazasi mavjudligidan dalolat beradi.

2025-yil yanvar-iyun oylari natijalariga ko'ra, Qashqadaryo viloyati yalpi mintaqaviy mahsulotining 27,7 foizini qishloq xo'jaligi, o'rmon xo'jaligi va baliqchilik, 19,4 foizini sanoat, 7,7 foizini qurilish va 45,2 foizini xizmatlar sohasi tashkil etgan [4]. Shuning uchun mintaqaning yashil transformatsiyasi faqat energetika sektori bilan cheklanib qolmasligi kerak. U qishloq xo'jaligi, sanoat, qurilish, transport, turizm, kommunal xizmatlar va chiqindilarni boshqarishni qamrab oluvchi keng qamrovli mintaqaviy siyosat sifatida amalga oshirilishi kerak.

Shu asosda, ushbu tadqiqotning asosiy maqsadi Qashqadaryo viloyatida yashil tadbirkorlikni rivojlantirishning ustuvor strategik yo'nalishlarini, uning iqtisodiy va tabiiy resurs xususiyatlarini hisobga olgan holda aniqlash va ularni amalga oshirish uchun tashkiliy va iqtisodiy mexanizmlarni taklif qilishdan iborat.

Ushbu maqsadga erishish uchun tadqiqot quyidagi vazifalarni hal qiladi: Qashqadaryo viloyatining yashil tadbirkorlik salohiyatini baholash; yashil transformatsiya uchun eng mos mintaqaviy iqtisodiyot tarmoqlarini aniqlash; suv, energetika va yer resurslari bilan bog'liq cheklovlarni tahlil qilish; mavjud investitsiya va institutsional imkoniyatlarni baholash; va yashil tadbirkorlikni rag'batlantirish uchun mintaqaga xos mexanizmlarni ishlab chiqish.

ADABIYOTLAR SHARHI

Akademik adabiyotlarda yashil tadbirkorlik odatda iqtisodiy qiymat yaratishga qaratilgan innovatsion biznes faoliyati sifatida ta'riflanadi va shu bilan birga ekologik muammolarni hal qiladi. An'anaviy tadbirkorlik asosan rentabellik va iqtisodiy samaradorlikka qaratilgan bo'lsa, yashil tadbirkorlik biznes faoliyatini iqtisodiy, ekologik va ijtimoiy natijalar kombinatsiyasi orqali baholaydi. Shu nuqtai nazardan, yashil tadbirkorlik barqaror rivojlanish, ekologik innovatsiyalar, aylanma iqtisodiyot va yashil moliya tushunchalarining amaliy kesishishini ifodalaydi.

Jahon bankining O'zbekiston bo'yicha iqlim va rivojlanish bo'yicha tadqiqoti yashil iqtisodiyotga o'tishning beshta asosiy yo'nalishini belgilaydi: energiya transformatsiyasi; suv va sug'orish tizimlarini takomillashtirish; iqlimga asoslangan qishloq xo'jaligi; barqaror shaharlar va transport tizimlari; va yashil iqtisodiyot uchun inson kapitalini rivojlantirish. Hisobotga ko'ra, qishloq xo'jaligida iqlimga asoslangan texnologiyalar va integratsiyalashgan landshaft boshqaruvini keng ko'lamda qo'llash qishloq xo'jaligi mahsulotlarini o'n yil ichida 4,6 milliard AQSh dollariga oshirishi va

yiliga 1,8 milliard kubometrdan ortiq suvni tejashi mumkin [1]. Bu topilma, ayniqsa, iqtisodiyoti qishloq xo'jaligi va suv resurslariga kuchli bog'liq bo'lgan Qashqadaryo kabi mintaqalar uchun dolzarbdir.

O'zbekistonning Birlashgan Millatlar Tashkilotining Iqlim o'zgarishi bo'yicha Doiraviy Konventsiyasi doirasida taqdim etilgan yangilangan iqlim majburiyatlari 2035-yilga kelib issiqxona gazlari chiqindilarini kamaytirishning bir nechta rivojlanish stsenariylarini baholaydi. Ambitsiy stsenariy bo'yicha chiqindilar energetika, sanoat, transport va boshqa sohalarni yashil transformatsiya qilish orqali 2022-yilgi darajalarga nisbatan kamaytirilishi mumkin [5]. Ushbu yondashuv mintaqaviy biznes siyosatini milliy dekarbonizatsiya maqsadlari bilan uyg'unlashtirish muhimligini ta'kidlaydi.

Suvni boshqarishga bag'ishlangan tadqiqotlar va davlat dasturlari suvni tejaydigan texnologiyalarni kengaytirish, sug'orish infratuzilmasini modernizatsiya qilish, nasos tizimlarida energiya samaradorligini oshirish va suvni hisobga olishni raqamlashtirishga urg'u beradi. 2025–2028-yillarga mo'ljallangan milliy dastur doirasida 2551 kilometrlik sug'orish tarmoqlarini rekonstruksiya qilish, suvni tejaydigan texnologiyalar bilan qoplangan maydonlarni kengaytirish va eskirgan nasos uskunalarini energiya tejaydigan tizimlar bilan almashtirish rejalari mavjud [6].

Adabiyotlar va strategik siyosat hujjatlari yashil tadbirkorlikning muvaffaqiyati nafaqat qat'iyroq ekologik talablarga, balki biznes uchun samarali iqtisodiy rag'batlantirishni yaratishga ham bog'liqligini ko'rsatadi. Yashil kreditlar, imtiyozli moliyalashtirish, kafolatlar, soliq imtiyozlari, texnologik konsalting, yashil sertifikatlash va davlat-xususiy sheriklik mexanizmlaridan kompleks foydalanish yashil biznes loyihalarining investitsiya jozibadorligini sezilarli darajada oshirishi mumkin.

Mavjud tadqiqotlarning aksariyati O'zbekistonda milliy darajada yashil iqtisodiyot siyosatiga qaratilgan. Biroq, Qashqadaryo viloyatining sanoat va energetika ixtisoslashuvi, yuqori sug'orish talabi, yerlarning meliorativ holatidagi muammolar, quyosh energiyasi salohiyati va mavjud tadbirkorlik bazasini birlashtirgan integratsiyalashgan mintaqaviy yashil tadbirkorlik modeli hali yetarlicha o'rganilmagan. Shuning uchun ushbu tadqiqotning ilmiy hissasi ushbu kamchilikni bartaraf etishda yotadi.

TADQIQOT METODOLOGIYASI

Tadqiqot obyekti Qashqadaryo viloyatining tadbirkorlik va mintaqaviy iqtisodiy tizimi bo'lib, tadqiqot predmeti esa yashil tadbirkorlikning shakllanishi va rivojlanishiga ta'sir qiluvchi iqtisodiy, ekologik, investitsiya va institutsional omillar majmuidir.

Tadqiqot stol tadqiqoti yondashuviga amal qiladi va asosan ikkilamchi ma'lumotlarga tayanadi. Empirik baza O'zbekiston Respublikasi Milliy statistika qo'mitasi va Qashqadaryo viloyat statistika boshqarmasi ma'lumotlari, O'zbekiston Prezidenti va hukumatining rasmiy materiallari, shuningdek, Jahon banki, BMTning Iqtisodiy taraqqiyot bo'yicha konventsiyasi va Yevropa tiklanish va taraqqiyot banki kabi xalqaro institutlarning ochiq kirish ma'lumotlaridan iborat.

Metodik jihatdan tadqiqotda quyidagi yondashuvlar qo'llaniladi:

Yashil tadbirkorlikni energetika, qishloq xo'jaligi, sanoat, xizmatlar, chiqindilarni boshqarish, moliya va inson kapitalini bog'laydigan mintaqaviy ekotizim sifatida baholash uchun tizimli tahlil qo'llanildi.

Statistik tahlil iqtisodiy o'sishni, korxonalar sonini, investitsiya faoliyatini, iqtisodiyotning tarmoq tuzilishini va boshqa mintaqaviy ko'rsatkichlarni baholash uchun qo'llanildi.

Milliy yashil iqtisodiyot ustuvorliklari va Qashqadaryo viloyatida mavjud bo'lgan aniq imkoniyatlar o'rtasidagi muvofiqlik darajasini aniqlash uchun qiyosiy tahlil qo'llanildi.

SWOT tahlili yashil tadbirkorlikni rivojlantirishga ta'sir qiluvchi kuchli, zaif tomonlar, imkoniyatlar va tahdidlarni aniqlash uchun qo'llanildi.

Atrof-muhitga ta'sir, bozor salohiyati, mintaqaviy resurslar mavjudligi, investitsiya jozibadorligi va bandlik yaratish salohiyatiga asoslangan ustuvor yo'nalishlarni shakllantirish uchun strategik ustuvorlik qo'llanildi.

Kontseptual maqsadlar uchun yashil tadbirkorlikni rivojlantirish salohiyati quyidagi funktsional munosabatlar orqali ifodalanadi:

$$YTS = f(RE, WE, CE, GI, IN, HC, IS),$$

bu yerda:

YTS – yashil tadbirkorlik salohiyati;

RE – qayta tiklanadigan energiya salohiyati;

WE – suv va resurslardan foydalanish samaradorligi;

CE – aylanma iqtisodiyotni rivojlantirish darajasi;

GI – yashil investitsiya;

IN – innovatsion faoliyat;

HC – yashil inson kapitali;

IS – institutsional qo'llab-quvvatlash.

Ushbu yondashuv yashil tadbirkorlikni nafaqat individual ekologik loyihalar to'plami, balki mintaqaviy iqtisodiyotni tarkibiy o'zgartirish vositasi sifatida ham ko'rib chiqish imkonini beradi.

Tadqiqotning bir qator cheklovlari ham mavjud. Mintaqaviy statistika tizimlari hali “yashil korxonalar”, “yashil ish o‘rinlari”, “yashil investitsiyalar” va “yashil mahsulotlar” kabi ko‘rsatkichlar bo‘yicha yetarlicha keng qamrovli va uzluksiz ma’lumotlar seriyasini taqdim etmagani sababli, ba’zi xulosalar mavjud sektoral statistika va rasman e’lon qilingan investitsiya loyihalaridan kelib chiqadi.

NATIJALAR VA MUHOKAMA

Tadqiqot natijalari shuni ko'rsatadiki, Qashqadaryo viloyati katta qishloq xo'jaligi bazasi, sanoat quvvati, o'sib borayotgan investitsiya faolligi va qayta tiklanadigan energiya uchun qulay sharoitlar tufayli yashil tadbirkorlikni rivojlantirish uchun katta salohiyatga ega. Shu bilan birga, suv tanqisligi, tuproqning sho'rlanishi, yuqori energiya iste'moli va an'anaviy ishlab chiqarish usullariga bog'liqlik yashil texnologiyalar va resurslarni tejaydigan biznes modellariga kuchli talabni yaratadi.

1-jadval. Qashqadaryo viloyatida yashil tadbirkorlikni rivojlantirishning ustuvor yo‘nalishlari va kutiladigan natijalar

№	Strategik yo‘nalish	Hudud uchun dolzarbligi	Amalga oshirish mexanizmi	Kutiladigan natija
1	Qayta tiklanuvchi energiya va energiya samaradorligi	Quyosh energetikasi salohiyatidan foydalanish hamda tadbirkorlik subyektlarining energiya xarajatlarini kamaytirish zarurati.	Quyosh panellari, energiya tejamkor uskunalar, yashil kredit va investitsiya mexanizmlarini joriy etish.	Energiya xarajatlari kamayadi, biznesning barqarorligi va raqobatbardoshligi oshadi.
2	Suv tejovchi texnologiyalar va yashil qishloq xo‘jaligi	Suv resurslaridan samarali foydalanish qishloq xo‘jaligiga ixtisoslashgan hudud uchun muhim omil hisoblanadi.	Tomchilatib sug‘orish, aqlli monitoring, suvni qayta ishlatish va resurs-tejamkor agrotexnologiyalarni kengaytirish.	Suv sarfi qisqaradi, hosildorlik va resurs samaradorligi oshadi.
3	Chiqindilarni qayta ishlash va aylanma iqtisodiyot	Ishlab chiqarish va maishiy chiqindilarni iqtisodiy resursga aylantirish yangi biznes yo‘nalishlarini yaratadi.	Saralash, yig‘ish, qayta ishlash korxonalari va ikkilamchi xomashyo bozorini qo‘llab-quvvatlash.	Chiqindi hajmi kamayadi, yangi ish o‘rinlari va qo‘shimcha qiymat yaratiladi.
4	Yashil moliyalashtirish	Yashil loyihalarning boshlang‘ich xarajatlari yuqoriligi tadbirkorlar uchun moliyaviy qo‘llab-quvvatlashni talab qiladi.	Imtiyozli yashil kreditlar, grantlar, kafolatlar, davlat-xususiy sheriklik va investitsiya fondlarini rivojlantirish.	Yashil loyihalar soni va xususiy investitsiyalar hajmi oshadi.
5	Ekoturizm va yashil xizmatlar	Qashqadaryoning tabiiy, tarixiy va rekreatsion salohiyatidan ekologik tamoyillar asosida foydalanish imkoniyati mavjud.	Ekoturistik marshrutlar, eko-mehmonxonalar, mahalliy mahsulotlar va ekologik servis xizmatlarini rivojlantirish.	Hududiy xizmatlar diversifikatsiyalanadi, bandlik va turizm daromadlari oshadi.
6	Yashil innovatsiyalar va kadrlar salohiyati	Yangi texnologiyalarni joriy etish uchun tadbirkorlarning ekologik bilimlari va innovatsion kompetensiyalarini oshirish zarur.	OTM–biznes hamkorligi, startap inkubatorlari, treninglar, konsalting va raqamli ekologik monitoringni yo‘lga qo‘yish.	Innovatsion yashil bizneslar ko‘payadi va malakali kadrlar bazasi shakllanadi.

Jadval tahlili shuni ko‘rsatadiki, Qashqadaryo viloyatida yashil tadbirkorlikni rivojlantirishda qayta tiklanuvchi energiya, suv va resurslarni tejash, chiqindilarni qayta ishlash, yashil moliyalashtirish hamda ekoturizm ustuvor ahamiyatga ega. Ushbu yo‘nalishlarni izchil rivojlantirish tadbirkorlarning xarajatlarini kamaytirish, yangi ish o‘rinlarini yaratish va hududning investitsion jozibadorligini oshirish imkonini beradi. Shu bilan birga, yashil innovatsiyalar va malakali kadrlarni qo‘llab-quvvatlash viloyatda barqaror va ekologik yo‘naltirilgan iqtisodiy o‘sish uchun muhim asos bo‘lib xizmat qiladi.

Aylanma iqtisodiyot tadbirkorlik uchun yana bir muhim sohani ifodalaydi. Chiqindilarni saralash, plastmassa, qog'oz, shisha, metallar va organik chiqindilarni

qayta ishlash, shuningdek, kompost, biogaz va ikkilamchi qurilish materiallarini ishlab chiqarish ekologik muammolarni foydali biznes imkoniyatlariga aylantirishi mumkin. Bundan tashqari, ekoturizm, agroturizm, yashil mehmonxonalar va ekologik toza mahalliy xizmatlar mintaqaning tog'li va turizmga yo'naltirilgan tumanlarida bandlikning o'sishiga hissa qo'shishi mumkin.

Umuman olganda, natijalar Qashqadaryo uchun eng samarali model ekologik muammolarni biznes imkoniyatlari bilan bog'lash ekanligini ko'rsatadi. Suv tanqisligi suvni tejaydigan texnologiyalar bozorini rag'batlantirishi, yuqori energiya talabi qayta tiklanadigan energiya va energiya samaradorligi xizmatlarini qo'llab-quvvatlashi mumkin, chiqindilarning to'planishi esa dumaloq biznes modellarini rag'batlantirishi mumkin. Shuning uchun, yashil tadbirkorlikni nafaqat ekologik siyosat vositasi, balki mintaqaviy iqtisodiyotni diversifikatsiya qilish, innovatsiyalar, investitsiyalarni jalb qilish va ish o'rinlarini yaratish mexanizmi sifatida ham ko'rib chiqish kerak.

XULOSA VA TAVSIYALAR

Tadqiqot natijalari Qashqadaryo viloyatining yashil tadbirkorlikni rivojlantirish uchun katta iqtisodiy, tabiiy va institutsional salohiyatga ega ekanligini ko'rsatadi. Mintaqaning qishloq xo'jaligi va sanoat bilan chambarchas bog'liq bo'lgan iqtisodiy tuzilishi, qulay quyosh energiyasi sharoitlari, keng tadbirkorlik bazasi va mavjud investitsiya loyihalari yashil iqtisodiyotga o'tish uchun muhim imkoniyatlar yaratadi. Shu bilan birga, suv tanqisligi, sug'oriladigan yerlarning katta qismining sho'rlanishi, energiya talab qiladigan nasos tizimlariga bog'liqlik va ayrim sanoat tarmoqlarida yuqori resurs zichligi yashil transformatsiyani iqtisodiy zaruratga aylantiradi.
Natijalarga asoslanib, quyidagi tavsiyalar taklif etiladi.

Birinchidan, Qarshi Yashil Texnologiyalar Sanoat Zonasi mintaqaviy yashil iqtisodiyotning asosiy ishlab chiqarish va innovatsiya markaziga aylanishi kerak. Quyosh energiyasi texnologiyalari, suvni tejaydigan uskunalar, ekologik toza qurilish materiallari va qayta ishlash texnologiyalarini mahalliylashtirishga ustuvor ahamiyat berilishi kerak.

Ikkinchidan, qishloq xo'jaligida suvni tejaydigan texnologiyalarni joriy etish subsidiyaga asoslangan yondashuvdan keng qamrovli tadbirkorlik ekotizimiga aylanishi kerak. Mahalliy kompaniyalarni tomchilatib sug'orish va boshqa suvni tejaydigan tizimlarni ishlab chiqarish, o'rnatish, texnik xizmat ko'rsatish va raqamli monitoring qilishga undash kerak.

Uchinchidan, qayta tiklanadigan energiya va energiya samaradorligi sohasida kichik va o'rta biznes uchun ESCO modelini joriy etish kerak. Quyosh panellari va energiya tejaydigan texnologiyalarni o'rnatish uchun uzoq muddatli yashil kreditlardan foydalanish imkoniyati ham kengaytirilishi kerak.

To'rtinchidan, Qashqadaryo Yashil Biznes Jamg'armasi yoki ixtisoslashgan mintaqaviy yashil moliyalashtirish oynasi yaratilishi kerak. Atrof-muhit samaradorligi ko'rsatkichlari loyiha va kreditlarni baholash tartib-qoidalariga kiritilishi kerak.

Beshinchidan, Qarshi va boshqa yirik shahar hududlarida chiqindilarni saralash va qayta ishlash aylanma iqtisodiyot klasterlari asosida tashkil etilishi, chiqindilarni yig'ishdan tortib ikkilamchi materiallar ishlab chiqarishgacha bo'lgan qiymat zanjiri bo'ylab xususiy biznesning faolroq ishtiroki bilan amalga oshirilishi kerak.

Oltinchidan, Shahrisabz, Kitob, Qamashi, Yakkabog' va tog'li hududlar uchun yashil turizm standartlari ishlab chiqilishi kerak. Qayta tiklanadigan energiya manbalari bilan ishlaydigan mehmonxonalar, agroturizm, ekologik toza transport va mahalliy yashil mahsulotlar maqsadli qo'llab-quvvatlanishi kerak.

Yettinchidan, qayta tiklanadigan energiya, suvni tejaydigan texnologiyalar, energiya auditi, ESG, chiqindilarni boshqarish va ekologik sertifikatlash bo'yicha mutaxassislarni tayyorlash uchun mintaqaviy "Yashil ko'nikmalar" o'quv dasturini yaratish kerak.

Sakkizinchidan, "yashil tadbirkorlik" uchun statistik monitoring tizimini joriy etish kerak. "Yashil" korxonalar soni, "yashil" investitsiyalar hajmi, yaratilgan "yashil" ish o'rinlari, tejalgan suv va energiya, qayta ishlangan chiqindilar va chiqindilarni kamaytirish bo'yicha alohida ko'rsatkichlar saqlanishi kerak.

Umuman olganda, Qashqadaryo viloyati uchun "yashil tadbirkorlik" strategiyasining asosiy tamoyili "ekologik muammolarni iqtisodiy imkoniyatlarga aylantirish" konsepsiyasiga asoslanishi kerak.

Suv tanqisligi suvni tejaydigan texnologiyalar bozoriga; yuqori energiya talabi qayta tiklanadigan energiya va ESCO xizmatlari uchun imkoniyatlarga; chiqindilarni aylanma iqtisodiyot biznesiga; qishloq xo'jaligi resurslarini ekologik sertifikatlangan va yuqori qo'shimcha qiymatga ega mahsulotlarga; tabiiy va rekreatsion aktivlarni "yashil turizm" imkoniyatlariga aylantirish kerak. Bunday yondashuv ostida "yashil" tadbirkorlik nafaqat Qashqadaryo viloyatidagi ekologik muammolarni yumshatish vositasi, balki iqtisodiy diversifikatsiya, xususiy investitsiyalar, texnologik modernizatsiya, ish o'rinlarini yaratish va uzoq muddatli mintaqaviy raqobatbardoshlikning muhim omili bo'lishi mumkin.

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