UO‘K 581.9.056

JANUBIY O‘ZBEKISTON TOG‘LI FLORASI KAMYOB VA ENDEM TURLARIGA GLOBAL IQLIM O‘ZGARISHINING TA’SIRINI BAHOLASH

F.I. Akbarov, K.Sh. Tojibayev

Maqolada janubiy O‘zbekiston tog‘li florasi kamyob va ayrim endem turlariga iqlim o‘zgarishlari ta’siri baholangan, turlarning bioiqlimiy modeli yaratilgan. Turlarning iqlim o‘zgarishlariga nisbatan ta’sirchanligini baholashda SSP1-RCP2.6 (o‘rta) va SSP5-RCP8.5 (yuqori) emissiya iqlim ssenariylaridan foydalanilgan. Tadqiqot natijalariga ko‘ra turlar ikki guruhga ajratildi: 1) hozirgi davrga nisbatan iqlim ssenariylari ta’sirida potensial tarqalishi mumkin bo‘lgan maydonlari ortib boradigan (Astragalus pseudanthylloides, Oxytropis vvedenskyi) turlar; 2) global iqlim o‘zgarishi natijasida tarqalish areali qisqarib borishi kutilayotgan (Calispepla aegacanthoides, Scutellaria villosissima, Moluccella bucharica, Calophaca reticulata, Dionysia hissarica, Eremurus iae) turlar.

Kalit so‘zlar: *MaxEnt, RCP, WorldClim, endem, areal, harorat, SSP1-RCP2.6, SSP5-RCP8.5.*

В статье оценено влияние изменения климата на редкие и эндемичные виды горной флоры юга Узбекистана, созданы биоклиматические модели вида. Климатические сценарии выбросов SSP1-RCP2.6 (средний) и SSP5-RCP8.5 (высокий) использовались для оценки уязвимости видов к изменению климата. По результатам исследования виды были разделены на две группы: 1.Виды (Astragalus pseudanthylloides, Oxytropis vvedenskyi), ареалы потенциального распространения которых увеличиваются под влиянием климатических сценариев по сравнению с текущим периодом. 2. Виды, ареал распространения которых, как ожидается, сократится в результате глобального изменения климата (Calispepla aegacanthoides, Scutellaria villosissima, Moluccella bucharica, Calophaca reticulata, Dionysia hissarica, Eremurus iae).

Ключевые слова: *MaxEnt, RCP, WorldClim, эндем, ареал, температура, SSP1-RCP2.6, SSP5-RCP8.5.*

KIRISH

Iqlim o‘zgarishi va uning ta’siri XXI asr oxiriga kelib global darajada biologik xilmaxillik va ekotizimlardagi o‘zgarishlarning asosiy omili bo‘lishi mumkin [13]. Iqlim o‘zgarishlari sharoitida tabiiy populyatsiyalar va jamoalarning yangi muhitga moslashishi turlicha bo‘ladi. Haroratning ortishi, ehtimol, ayrim turlarning yo‘q bo‘lib ketishiga olib kelishi mumkin [7, 18], ayniqsa, tarqalish areali cheklangan endem turlar uchun bu jiddiy xavf tug‘diradi [10, 14]. Zamonaviy botanik tadqiqotlarda o‘simlik namunalari mavjud nuqtalar va atrof-muhit o‘zgaruvchilarining raqamli qatlamlari kombinatsiyasi yordamida turlarning tarqalishini modellashtirish [3, 16] va o‘simlik turlarining real vaqt rejimi hamda kelajakdagi holatini turli iqlim ssenariylari yordamida bashoratlash ommalashib ulgurdi [15]. O‘zbekiston Respublikasi Fanlar akademiyasi Botanika institutida ham bu borada maqsadli tadqiqotlar [20, 21] amalga oshirilmoqda. Ushbu tadqiqot ham Surxondaryo viloyati florasining kamyob va ayrim endem turlariga global iqlim o‘zgarishining ta’sirini baxolash va ularning bioiqlimiy modelini yaratishga qaratilgan. Tadqiqot “Janubi-g‘arbiy Hisor, Hisor-Darvoz va Panj oldi okruglari florasini to‘r tizimli xaritalash” dasturi doirasida amalga oshirilgan.

TADQIQOT METODLARI

2.1. Modellashtirish uchun tanlab olingan turlar.

Turlarning bioiqlimiy modelini yaratish va iqlim o‘zgarishini ularning potensial tarqalishiga ta’si-

rini bashorat qilish maqsadida Surxondaryo viloyati florasi uchun endem bo‘lgan 8 tur tanlab olingan (1-jadval).

1-jadval

Modellashtirish uchun tanlab olingan turlar

№	Turlar	Namunalar soni	O‘zR QK maqomi	BGR
1	*Astragalus pseudanthylloides*	10	2	Б
2	*Calispepla aegacanthoides*	11	1	Б
3	*Calophaca reticulata*	4	1	Б
4	*Dionysia hissarica*	27	2	СТ
5	*Eremurus iae*	7	2	Б, СТ
6	*Moluccella bucharica*	25	2	Б
7	*Oxytropis vvedenskyi*	10	3	Б
8	*Scutellaria villosissima*	11	2	СТ

B – Boysun, Bb – Bobotog‘, ST – Sangardak-To‘palang, O‘zR QK – O‘zbekiston Respublikasi “Qizil kitob”idagi maqomi, BGR – botanik geografik rayon.

2.2. Atrof-muhit o‘zgaruvchilari.

Real vaqt (current) iqlim ma’lumotlari CHELSA-BIOCLIM+ (https://chelsa-climate.org) [1,2], balandlik ko‘rsatkichlari WorldClim v2.1 (www.worldclim.org) [5], topografik va tuproq rasterlari HWSD v1.2 (http://webarchive.iiasa.ac.at) [6] (fazoviy piksellar 0.30 daqiqalik, 1x1 км) hamda tuproqning fizik-kimyoviy xossalari SoilGrids (https://soilgrids.org; 250 м o‘lchamda) [8] onlayn platformalardan yuklab olingan. Bu ma’lumotlarning barchasi QGIS v3.22.9 dasturida GeoTIFF dan ASCII formatiga o‘tkazilgan.

2.3. Kelajak iqlim ssenariylari.

Iqlim o‘zgarishlari bo‘yicha hukumatlararo panel (Intergovernmental Panel on Climate Change (IPCC AR6)) oltinchi hisobotida keltirilgan WCRP birlashtirilgan modellararo taqqoslash loyihasi (6-bosqich) CMIP6 [4] simulyatsiyalarining yangilangan umumiy ijtimoiy-iqtisodiy yo‘llar (Shared Socio-economic Pathways (SSPs) [12] SSP1-RCP2.6 (o‘rta) va SSP5-RCP8.5 (yuqori) emissiya iqlim ssenariylaridan foydalanilgan. SSP1-RCP2.6 aholi o‘sishining o‘rtacha darajasini va juda past issiqxona gazlari konsentratsiyasini ifodalovchi optimistik bashoratni tavsiflaydi; SSP5-RCP8.5 esa aholining yuqori o‘sishi va issiqxona gazlari konsentratsiyasining yuqori darajasi bilan tavsiflangan pessimistik prognozni ifodalaydi [17]. Bunda turlarning kelajakda potensial tarqalishini bashorat qilish uchun o‘rta muddatli global iqlim o‘zgarishlariga (2041–2060 yy.) tegishli iqlim simulyatsiyalari tanlangan [11].

2.4. Turlarning tarqalishini modellashtirish.

Turlarning potensial tarqalishi MaxEnt modellashtirish algoritimining 3.4.1 versiyasi bilan modellashtirilgan [13]. Modelda tur mavjudligi haqidagi ma’lumotlarning 75% i o‘quv, 25% i test ma’lumotlari sifatida ishlatilgan [9]. Xaritalarda tadqiqot hududi turning o‘sish muhitiga moslik darajasiga ko‘ra besh toifaga ajratildi. Ular yaroqsiz (0.0–20), past mos (21–40), o‘rtacha mos (41–60), yuqori mos (61–80) va juda yuqori mos (81–100) yaroqlilikga ega bo‘lgan maydonlardan iborat [19].

OLINGAN NATIJALAR VA ULARNING MUHOKAMASI

Modelning taxminiy bashorat qilish aniqligi.

Barcha SDM algoritmlarining bashoratli aniqligi, odatda, AUC (egri ostidagi maydon) qiymatiga ko‘ra baholandi. SDM diskriminatsiya darajasini baholashda 1.0 AUC qiymati mukammal 0.5 AUC va undan past ko‘rsatkich ishonchsiz bashorat hisoblanadi. Eko-iqlimiy modeli yaratilgan turlarning AUC qiymatlariga asoslangan o‘rtacha aniqligi joriy davrda AUC=0.861, SSP1-RCP2.6 iqlim ssenariysida AUC=0.998 va SSP5-RCP8.5 bo‘yicha AUC=0.992 ga teng (2-jadval). Bu modelning yuqori aniqlik darajasiga ega ekanligini ko‘rsatadi.

2-jadval

MaxEnt modellarining ishlash aniqligi

Turlar	Current	SSP1-RCP2.6	SSP5-RCP8.5
	AUC	AUC	AUC
Astragalus pseudanthylloides	0.715	0.999	0992
Calispepla aegacanthoides	0.795	1.000	0.992
Calophaca reticulata	0.738	0.998	0.997
Dionysia hissarica	0.983	0.998	0.998
Eremurus iae	0.912	0.998	0.962
Moluccella bucharica	0.890	0.930	0.996
Oxytropis vvedenskyi	0.807	0.990	0.997
Scutellaria villosissima	0.810	0.999	0.999
O‘rtacha	**0.861**	**0.998**	**0.992**

Turlarning hozirgi va kelajakdagi potensial tarqalishini modellashtirish.

MaxEnt tomonidan bashorat qilingan turlarning o‘sishi uchun optimal sharoit mavjud hududlar va indekslar soni joriy davr va kelajak iqlim ssenariylarida bir-biridan keskin farq qiladi (3-jadval).

3-jadval

Turlarning o‘sishi uchun optimal sharoit mavjud hududlar

№	Turlar	Optimal sharoit mavjud maydonlar, km.kv		
		Joriy davr	SSP1-RCP2.6	SSP5-RCP8.5
1	*Astragalus pseudanthylloides*	105	151	261
2	*Calispepla aegacanthoides*	194	77	72
3	*Calophaca reticulata*	199	83	84
4	*Dionysia hissarica*	139	21	48
5	*Eremurus jae*	99	10	62
6	*Moluccella bucharica*	24	57	26
7	*Oxytropis vvedenskyi*	39	114	1094
8	*Scutellaria villosissima*	279	194	176

Natijalarga ko‘ra turlarni ikki guruhga ajratish mumkin: joriy davrga nisbatan iqlim ssenariylari ta’sirida potensial tarqalishi mumkin bo‘lgan maydonlar ortib boradigan va qisqaradigan turlar. Shuningdek, bu jaryonga proporsional tarzda optimal sharoitga ega bo‘lgan indekslar sonida ham o‘zgarishlar yuz beradi (4-jadval). Qulay sharoit mavjud indekslar sonini aniqlashda bunday hududlarning indekslarda egallagan maydonining hajmi hisobga olinmagan.

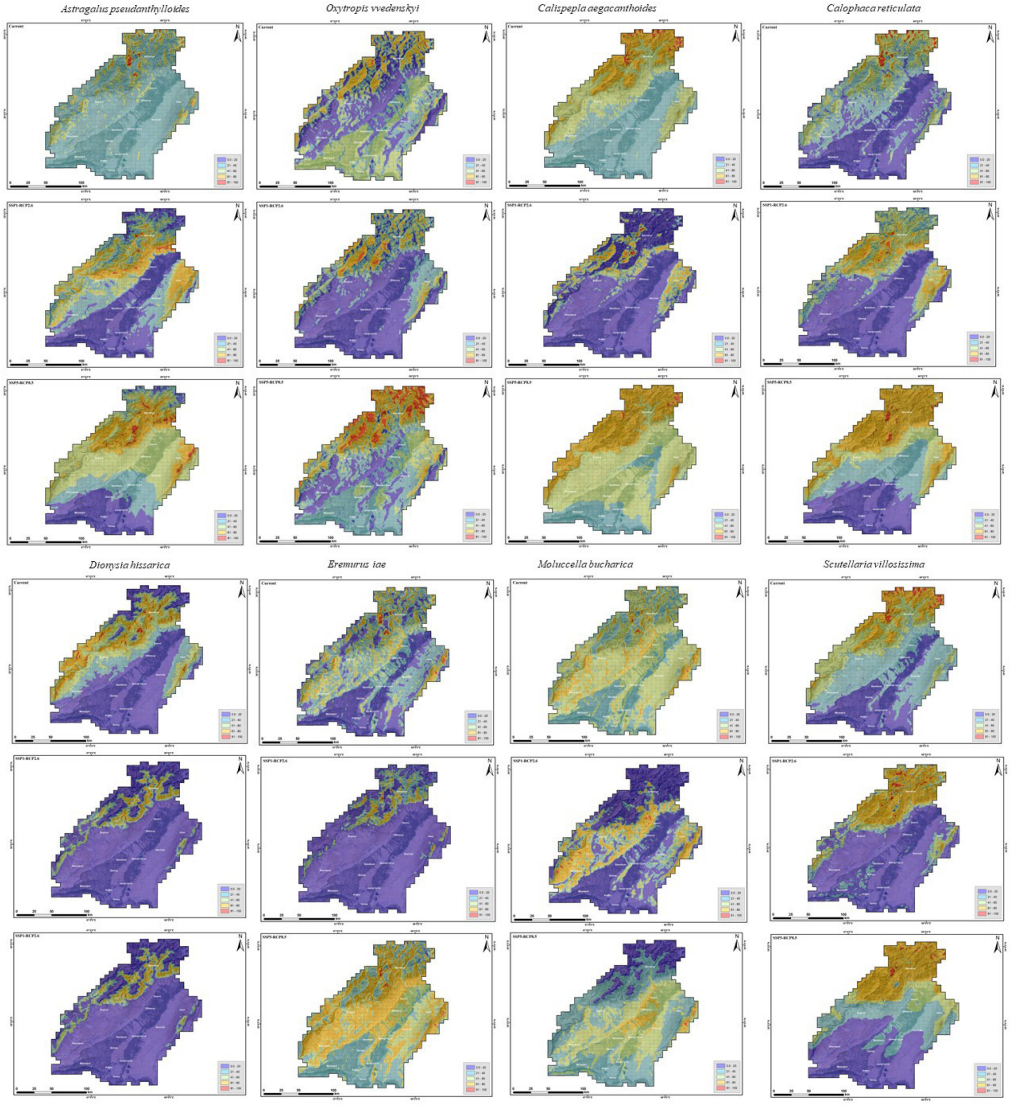
4-jadval

Turlarning o‘sishi uchun optimal sharoit mavjud indekslar

№	Turlar	Joriy davr	SSP1-RCP2.6	SSP5-RCP8.5
1	*Astragalus pseudanthylloides*	26	39	71
2	*Calispepla aegacanthoides*	43	29	23
3	*Calophaca reticulata*	56	30	29
4	*Dionysia hissarica*	61	13	24
5	*Eremurus jae*	38	9	18
6	*Moluccella bucharica*	13	20	9

7	*Oxytropis vvedenskyi*	17	26	142
8	*Scutellaria villosissima*	45	29	27

Joriy davrga nisbatan iqlim ssenariylari ta'sirida *Astragalus pseudanthylloides* (105 > 151 > 261 km.kv), *Oxytropis vvedenskyi* (39 > 114 > 1094 km.kv) potensial tarqalishi mumkin bo'lgan maydonlarning ko'lami va indekslar soni ortadi. Tarqalish areali qisqaradigan turlar potensial tarqalishini SSP1-RCP2.6 va SSP5-RCP8.5 iqlim simulyatsiyalari ostida uch xil namoyon etdi. Birinchi har ikki ssenariy bo'yicha ham areali qisqaradigan turlar *Calispepla aegacanthoides* (194 > 77 > 72 km.kv), *Scutellaria villosissima* (279 > 194 > 176 km.kv), ikkinchi *Moluccella bucharica* (24 < 57 > 23 km.kv) potensial tarqalishi SSP1-RCP2.6 bo'yicha kengayib, SSP5-RCP8.5 ta'sirida kamayadi, uchinchi optimistik emissiya simulyatsiyalarida qisqarib, pessimistik emissiyada ortadigan *Calophaca reticulata* (199 > 83 < 84 km.kv), *Dionysia hissarica* (139 > 21 < 48 km.kv *Eremurus iae* (38 > 9 < 18 km.kv) turlar. *Calophaca reticulata*, *Dionysia hissarica*, *Eremurus iae* uchun +1.0 °C ko'tarilishi salbiy, +1.7 °C ortishi ijobiy ta'sir etadi. *Moluccella bucharica* tarqalishi uchun haroratning +1.0 °C ko'tarilishi ijobiy, +1.7 °C esa noijobiy muhit yaratadi.



1-rasm. MaxEnt tomonidan bashorat qilingan turlarning o'sishi uchun optimal sharoit mavjud hududlar.

XULOSA

Yillik o‘rtacha haroratning ko‘tarilishi ta’sirida turlarning potensial tarqalishida ikki xil o‘zgarish yuz beradi.

1. Hozirgi davrga nisbatan iqlim ssenariylari doirasida potensial tarqalishi mumkin bo‘lgan maydonlari ortib boradigan turlar (25%).

2. Global iqlim o‘zgarishi natijasida tarqalish areali qisqarib borishi kutilayotgan turlar (75%).

Iqlim o‘zgarishi *Calispepla aegacanthoides, Scutellaria villosissima* uchun juda salbiy ta’sirga ega bo‘lib, mavjud o‘rtacha haroratning har qanday darajada ortishi ushbu turlarning potensial tarqalishida qisqarishlar yuz berishiga olib keladi.

ASSESSMENT OF THE IMPACT OF GLOBAL CLIMATE CHANGE ON RARE AND ENDEMIC SPECIES OF SOUTH UZBEKISTAN MOUNTAIN FLORA

Feruz, I. Akbarov[1], Komiljon, Sh. Tojibaev[1]

Ilmiy xabarnoma. Seriya: Biologik tadqiqotlar – Scientific Bulletin. Series: Biological Research. 2023. 4(72). 106-111.

[1]Institute of Botany of the Academy of Sciences of the Republic Of Uzbekistan, Tashkent, 100125, str. Durmon yuli, 32 (Uzbekistan). E-mail: botany@academy.uz

Keywords: MaxEnt, RCP, WorldClim, эндем, ареал, temperature, SSP1-RCP2.6, SSP5-RCP8.5

In the article, the influence of climate change on rare and endemic species of south Uzbekistan mountain flora was evaluated, and bioclimatic models of the species were created. The SSP1-RCP2.6 (medium) and SSP5-RCP8.5 (high) emission climate scenarios were used to assess the vulnerability of species to climate change. According to the results of the study, the species were divided into two groups. 1. Species (Astragalus pseudanthylloides, Oxytropis vvedenskyi) whose areas of potential distribution are increasing under the influence of climate scenarios compared to the current period. 2. Species whose distribution area is expected to decrease as a result of global climate change (Calispepla aegacanthoides, Scutellaria villosissima, Moluccella bucharica, Calophaca reticulata, Dionysia hissarica, Eremurus iae).

Species with a shrinking range showed three different potential distributions under the SSP1-RCP2.6 and SSP5-RCP8.5 climate simulations. The first are the species whose range will decrease under both scenarios: Calispepla aegacanthoides (194 > 77 > 72 km2), Scutellaria villosissima (279 > 194 > 176 km2), the second is Moluccella bucharica (24 < 57 > 23 km sq), which will expand under SSP1-RCP2.6 and decrease under SSP5-RCP8.5, and the third are species that decrease in optimistic emission simulations and increase in pesimistic emission simulations, such as Calophaca reticulata (199 > 83 < 84 km sq), Dionysia hissarica (139 > 21 < 48 km sq), and Eremurus iae (38 > 9 < 18 km sq).

References:

1. Brun, P., Zimmermann, N.E., Hari, C., Pellissier, L., Karger, D.N. (preprint). (2022). Global climate-related predictors at kilometre resolution for the past and future. *Earth System Science Data*. Vol. 14. Issue 12. Pp. 5573-5603.

2. Brun P., Zimmermann N.E., Hari Ch., Pellissier L., Karger D.N. (2022). CHELSA-BIOCLIM+ A novel set of global climate-related predictors at kilometre-resolution. *EnviDat* [data set]

3. Cruz-Cárdenas G. et al. (2014). Potential species distribution modeling and the use of principal component analysis as predictor variables. *Revista Mexicana de Biodiversidad*. 1(85). Pp. 189-199.

4. Eyring, V. et al. (2016). Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design 12 and organization. *Geoscientific Model Development*, 9(5). Pp. 1937-1958,

5. Fick, S.E., Hijmans, R.J. (2017). WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. *International journal of climatology*. 12 (37). Pp. 4302-4315

6. Fischer, G., Nachtergaele F., Prieler S., van Velthuizen H.T., Verelst L., Wiberg D. (2008). *Global Agro-ecological Zones Assessment for Agriculture (GAEZ 2008)*. IIASA, Laxenburg, Austria and FAO, Rome, Italy.

7. Gottfried, M., et al. (2012). Continent-wide response of mountain vegetation to climate change. *Nature climate change*. 2(2). Pp. 111-115.

8. Hengl, T., et al. (2017). SoilGrids250m: Global gridded soil information based on machine learning. *PLoS one*. 2(12). Pp. e0169748.

9. Islam, Kamrul, Md Farhadur Rahman, Kazi Nazrul Islam, Tapan Kumar Nath, and Mohammed Jashimuddin. (2020). Modeling spatiotemporal distribution of Dipterocarpus turbinatus Gaertn. F in Bangladesh under climate change scenarios. *Journal of Sustainable Forestry*. 3(39). Pp. 221-241.

10. Leao, T.C.C., et al. (2014). Predicting extinction risk of Brazilian Atlantic Forest angiosperms. *Conservation Biology*. 5(28). Pp. 1349-1359.

11. Lee, June-Yi, et al. (2021). Future global climate: scenario-based projections and near-term information. *IPCC Assessment Reports*. Pp. 1-195.

12. O'Neill, B.C. et al. (2016). The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6. *Geoscientific Model Development*, 9(9). Pp. 3461–3482.

13. Phillips, S.J., Anderson, R.P., Schapire, R.E. (2006). Maximum entropy modeling of species geographic distributions. *Ecological modelling*. 3-4(190). Pp. 231-259.

14. Pickering, C., Hill, W., Green, K. (2008). Vascular plant diversity and climate change in the alpine zone of the Snowy Mountains, Australia. *Biodiversity and Conservation*. 7(17). Pp. 1627-1644.

15. Rafuse, D.J. (2021). A Maxent Predictive Model for Hunter-Gatherer Sites in the Southern Pampas, Argentina. *Open Quaternary*. 7. Pp. 1-21.

16. Taylor-Rodríguez, D., et al. (2017). Joint species distribution modeling: dimension reduction using Dirichlet processes. *Bayesian Analysis*. 4(12). Pp. 939-967.

17. Wayne, G.P. (2014). Representative Concentration Pathways. *Skeptical science*. Pp. 1-24. https://skepticalscience.com/docs/RCP_Guide.pdf

18. When, S., Lundemo, S., Holten, J.I. (2014). Alpine vegetation along multiple environmental gradients and possible consequences of climate change. *Alpine Botany*. 2(124). Pp. 155-164.

19. Wei, B., et al. (2018). Predicting the current and future cultivation regions of Carthamus tinctorius L. using MaxEnt model under climate change in China. *Global Ecology and Conservation*. 16. Pp. e00477

20. Akbarov, F.I., Tojibayev, K.Sh. (2022). Surxondaryo viloyati florasi ayrim endem turlarning bioiqlimiy modelini yaratish [Creation of a bioclimatic model of some endemic species of flora of the Surkhandarya region]. *Scientific Bulletin of NamSU*. 4. Pp. 127-133.

21. Olonova, M.V., Gudkova, P.D., Shomurodov, X.F., Adilov, B.A., Raximova, N.K, Xabibullayev, B.Sh., Polvonov, F.I. (2021). *Turlarning bioiqlim modelini yaratish: amaliy ishlar uchun topshiriq va ularning bajarilishiga oid metodik ko'rsatma* [Creation of a bioclimatic model of a species: tasks for practical work and guidelines for their implementation]. Tashkent: Institute of Botany.

Mualliflar haqida ma'lumot:

AKBAROV Feruz Iqbolovich – O'zR FA Botanika instituti O'zbekiston florasi laboratoriyasi kichik ilmiy xodimi. E-mail: feruz.akbar@mail.ru

TOJIBAYEV Komiljon Sharobitdinovich – biologiya fanlari doktori, akademik, O'zR FA Botanika instituti direktori. E-mail: ktojibaev@mail.ru