World Journal of Environmental Biosciences
Available Online at: **www.environmentaljournals.org**

Volume 15, Issue 2: 1-7

https://doi.org/10.51847/B8l2ELUev7

ISSN 2277- 8047

Agro-Biological Evaluation of Wheatgrass Genotypes For Breeding in Arid Conditions

Serik Abayev[1], Azamat Khidirov[1], Galym Shegebaev[2], Nurlybek Kaskabaev[2], Mukhtar Ashirbekov[3]*

[1]Kazakh Research Institute of Agriculture and Plant Growing, Almalybak, Almaty region, Kazakhstan.
[2]Forage Crops Laboratory, Kazakh Research Institute of Agriculture and Plant Growing, Almalybak, Almaty region, Kazakhstan.
[3]Seed Production Laboratory, Kazakh Research Institute of Agriculture and Plant Growing, Almalybak, Almaty region, Kazakhstan.

ABSTRACT

Wheatgrass (Agropyron spp.) is recognized for its exceptional drought resistance and longevity, making it a critical genetic resource for climate-resilient agriculture. This study aimed to assess the species diversity, ecological distribution, and breeding potential of wheatgrass in Kazakhstan and to characterize its germplasm for future selection programs. Field expeditions were conducted across diverse agroecological zones in Kazakhstan to collect and document over 1,500 Agropyron samples. Morphological traits, productivity indicators, drought and salinity tolerance, and ploidy levels were evaluated using classical botanical methods, cytogenetic analysis, and comparative field trials at experimental stations. Kazakhstan's wheatgrass gene pool includes diverse species such as A. cristatum, A. pectiniforme, A. desertorum, and A. sibiricum. Promising samples were identified for key agronomic traits: early ripening (8–10 days earlier than standard), high biomass yield (13–28% above standard), seed productivity (up to 34.7 g/m²), and strong drought and salinity tolerance. Significant correlations were observed between plant height, root length, and green mass yield (r = 0.826, p < 0.05). Polyploid variation (2n=14, 28, 42) was confirmed across different ecotypes, supporting targeted breeding strategies. The results highlight Kazakhstan's strategic role in the conservation and utilization of wheatgrass genetic resources. Identified accessions provide a valuable foundation for breeding forage crops adapted to arid conditions. Continued exploration and genotypic/phenotypic characterization will support ecological restoration and improve feed security in dryland agriculture.

Keywords: *Wheatgrass, Genetic resources, Drought resistance, Kazakhstan, Perennial grasses, Arid climate adaptation*

Corresponding author: Mukhtar Ashirbekov
e-mail ✉ m.ashirbekov@mymail.academy
Received: 16 January 2026
Accepted: 03 April 2026

INTRODUCTION

The consequences of climate change involving primarily an increase in average temperature and weather instability impact agricultural development. In these conditions, farmers are forced to change the structure of crops by reducing hydrophilic crops and increasing the share of drought-resistant plants adapted to adverse environmental conditions (Alavi *et al*., 2024; Fischer *et al*., 2024; Muthanandam *et al*., 2024; Raju, 2024; Umarova *et al*., 2024; Abdelrahman & Saad, 2025; Damaševičius *et al*., 2025; Herrera *et al*., 2025; Jun *et al*., 2025; Morales *et al*., 2025; Tabynbayeva *et al*., 2025; Shaimerdenova *et al*., 2026).
For Kazakhstan, the importance of perennial grasses, such as wheatgrass, alfalfa, sainfoin, melilot, awnless brome, prostrate summer cypress, sheep fescue, Russian wildrye, and other arid plants from the natural flora, is increasing. They are characterized by a high degree of drought resistance and the physiological ability to transition into anabiosis during periods of acute shortage of soil moisture. In Eurasia, 15 species are widespread in the wild, and four grow in Kazakhstan: Agropyron pectiniforme Roem et Schul., and Agropyron cristatum subsp. pectinatum (Bieb) Tzvel., Agropyron cristatum, Agropyron desertorum (Fisch) Schult., Agropyron sibiricum (Wild) P.B. Agrost.
The wheatgrass in West Kazakhstan, due to the strong vital energy generated in the process of survival and formation of the species in the dry-steppe region, shows high competitiveness among other crops in the struggle for growing conditions under various agrophytocenoses (Nokusheva *et al*., 2025). It can also resume vegetation as the soil is saturated with moisture, thereby maintaining its longevity.
Wheatgrass cultivation is technologically simple, and obtaining full-fledged harvests is not difficult. Wheatgrass can be sown in spring and fall. In Kazakhstan, it exhibits high winter hardiness (95-100%).
These factors make wheatgrass an indispensable plant for adapting the agricultural complex to climate change. Studying its specific indicators and features allows one to improve the effectiveness of measures for the rational use of natural resources and the cultivation of sustainable crops.
The purpose of the article was to identify key traits and agronomic values of wheatgrass that are essential for its effective use in future breeding programs

MATERIALS AND METHODS

World Journal of Environmental is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-Non Commercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms. (https://creativecommons.org/licenses/by-nc-sa/4.0/).

This study was carried out from 2020 to 2023 across multiple agroecological zones of Kazakhstan, including the Aktobe, Almaty, West Kazakhstan, Atyrau, Kostanay, and Zhambyl regions. Field expeditions were organized during the vegetation seasons (May to September) to collect and document wild wheatgrass (*Agropyron spp.*) accessions. A total of 1,500 samples were collected using GPS-tagged sampling at natural populations with ecological notes on soil type, precipitation, and associated flora.

Sample collection and passporting

Each accession was passported according to international genebank standards, including species identification, growth form, donor origin, collection site coordinates, phenology stage, and habitat description. Samples were collected in triplicate to ensure representation and were processed and stored at the Kazakh Research Institute of Animal Husbandry and Feed Production.

Field trials and experimental setup

Experimental trials were conducted at four research stations representing steppe, semi-desert, and desert zones. A randomized complete block design (RCBD) with three replications was used. Each plot measured 3 m², and the sowing rate was standardized at 10 kg/ha. Control varieties such as *Aktyubinsky uzkokolosy mestny* and *Karabalyksky 202* were used for benchmarking.

Plots were maintained under rainfed conditions with no irrigation to simulate arid environments. Soil moisture, temperature, and salinity levels were monitored biweekly. Standard agronomic practices were followed, and weed management was conducted manually (Amrani *et al*., 2024; Ernst & Weber, 2024; Feng *et al.*, 2024; Gonzalez *et al*., 2024; Hashem *et al*., 2024; Rexhepi *et al*., 2025; Sato *et al*., 2025; Scott *et al*., 2025; Tanaka *et al*., 2025; Turner *et al*., 2025).

The collected data were systematized to identify biomorphological features and economically valuable traits relevant to wheatgrass breeding:

Plant height, tillering capacity, ear length, and leaf width were measured on 10 randomly selected plants per plot.

Green biomass yield and dry matter yield are determined by harvesting all above-ground biomass at the flowering stage, and drying it at 70°C for 48 hours.

Seed productivity – calculated from harvested seed weight per m².

Foliage percentage – determined as a ratio of leaf to stem biomass.

1,000-seed weight – measured with precision scales on a random seed sample.

Root tip cells from germinated seeds were used to determine chromosome number using the aceto-orcein staining method. Chromosome counts (2n=14, 28, 42) were conducted on at least 10 metaphase cells per accession to assess ploidy levels.

The summarized results enabled a comprehensive agrobiological evaluation of wheatgrass genotypes for use in the forage crop improvement sector.

RESULTS AND DISCUSSION

Based on the results of studying the species diversity of wheatgrass, the wide range of its distribution in Kazakhstan and the world became evident. The study aligns with recent studies focused on harnessing genetic evaluation in optimizing wheatgrass breeding in arid regions such as Kazakhstan (Pototskaya *et al*., 2022; Ainebekova, 2023).

Crested wheatgrass, also known as *A. pectiniforme or A. cristatum subsp*. pectinatum, is ubiquitous in Kazakhstan's northern areas. Its vegetation is limited to mountain rivers, depressions, estuaries, and river floodplains in the semi-desert region to the south. The western regions have the greatest diversity of wild populations. The geographical distribution of wheatgrass in Kazakhstan attests to its resilience and ability to withstand drought. The distribution's uniformity is consistent with recent research by Murzataeva *et al*. (2022) and Loskutova *et al*. (2024). Delimited forms and subcategories of A. pectiniforme and A. cristatum subsp. pectinatum exhibit high levels of variability in morphological, karyological, and other traits.

The stems are 25-75 cm tall and slightly rough under the ears; the lower leaf sheaths are glabrous but less frequently slightly villous. The leaves are slender and linear, folded or flat, 1.5-3mm wide, occasionally wider (5-10mm), smooth from below, and somewhat villous or rough from above. The ears are substantially constricted upwards, oblong, and ovate, but with clearly apparent gaps between the spikelets; they are crested, 1.5-6 cm long, and 1-2 cm wide. The upper flowering glume is bidental at the top and ciliated along the keels, while the lower flowering glume is bare, 0.5-0.7 cm long, and has a short, rough awn that is 3-4 mm long. The spikelets are green or bluish-green, not compressed to one another, and have three to ten flowers that are completely glabrous, 0.8-1.5 cm long, and uneven.

It has the largest distribution range compared to other species. This species is found in southeastern Spain, eastern France, Italy, northern Africa, the Balkan Peninsula, Iran, Afghanistan, the European part of Russia, the Caucasus, the Crimea, the Trans-Urals, West Siberia, and Central Asian republics (except deserts). In the east, *A. pectiniforme* and *A. cristatum subsp. pectinatum* enter the area of distribution of *A. cristatum*.

A. cristatum (L.) Beav. is distributed in eastern Kazakhstan. The populations are low-productivity but very winter-hardy. The stems are 25-75cm tall, usually slightly villous under the ears, and less often glabrous; the sheaths of the lower leaves are densely villous or glabrous. The leaves are narrow and linear, folded or flat, with slightly wrapped edges, 2-5mm wide, smooth from below, and slightly villous from above. The ears are dense, without noticeable gaps between the spikelets; oblong, ovate, and lobed; usually barely narrowing upwards; 1.5-5cm long and 1-2cm wide; and crested with a finely pubescent axis. The spikelets are gray-green or slightly colored purple, closely pressed together, with 3-10 flowers, villous, and 0.8-1.5cm long. The husk is ovate and lanceolate, 0.3-0.5cm long, with 2-3mm long awns, uneven, and long-toothed along the keel. The lower flowering glume is lanceolate, densely villous (0.5-0.7cm long), with a short rough awn 1.75-2.5mm long. The upper flowering glume is bidental at the top, ciliated or long-ciliated along the keels.

A. cristatum (L.) Beav. has a much smaller distribution area compared to *A. pectiniforme.* It grows in West and East Siberia, the Far East, Central Asia, and Mongolia.

A. sibiricum grows in the sandy steppes of the Aral-Caspian lowland, the Balkhash region, and the Syrdarya region. Outside the Commonwealth of Independent States, it grows in Turkmenistan, Uzbekistan, Karakalpakstan, and Mongolia. When examining the Moyunkum sands, the ubiquity of Siberian wheatgrass was noted. Its quantity differed in different areas and under different conditions.

A. sibiricum stems are 30-80 cm tall, straight or bent at the base, glabrous, and slightly rough under the ears; the sheaths of the lower leaves are glabrous, smooth, or slightly rough; and the leaves are narrowly linear, folded or flat, up to 5 mm wide, smooth from below, and rough from above. The ears are linear, crested, multispiculate, 7-10cm long, and 0.5-1.2cm wide. Spikelets are pale green, with 4-9 flowers, crested, 0.7-1cm long; the husk is ovate and lanceolate, boat-shaped, keeled with obscure lateral veins, pointed or with a short tip up to 1.5mm long, smooth or barely rough at the top of the keel, 0.5-0.7cm long. The husk is uneven and long-ciliated along the keel, the lower flowering glume is not very densely covered with protruding long white hairs and lanceolate; 0.5-0.7cm long, with a short rough tip 3-4mm long, the upper flowering glume is bidental at the top, ciliated along the keels.

It is found in the southern regions of the former Soviet Union: southern Ukraine, Lower Volga, Trans-Volga region, Pre-Caucasus, West Siberia, and Central Asia. It has been spotted in southeastern Mongolia.

A. desertorum is widespread in all regions of the steppe and semi-desert zone of Kazakhstan and occupies significant massifs only in the western part of the country. In this territory, populations have a wide variety of forms and represent the main potential breeding pool. The species grows on clay, gravelly flat soils, fresh lands, and saline complexes (Ivanov, 1980).

The stems at the base are cranked, glabrous, and slightly rough under the spike; the sheaths of the lower leaves are villous with protruding white hairs or glabrous; and the leaves are stiff, bluish-green, folded, narrow (2-3mm wide), glabrous, smooth from below, and rough from above. The ears are short-linear, non-crested, slightly cylindrical with splayed flowers, overlapping spikelets, and a slightly villous awn; the length of the ears is 2.5-7cm long and 0.7-1.2cm wide. The spikelets are pale green, with 5-7 flowers, 0.7-1.2 cm long; the husk is keeled, with a short awn, 2-3mm long, ovate and lanceolate, glabrous and smooth, only rough at the top under the awn along the keel, 0.3-0.4cm long without awns; the lower flowering glume is 0.5-0.6cm long, lanceolate, boat-shaped, glabrous, and smooth, 2-3mm long; the upper flowering glume is pointed, sharp, and bidental at the top, ciliated along the keels; the film is 4mm long.

The species is distributed in the Lower Volga, Lower Don, Trans-Volga region, Pre-Caucasus, West Siberia, the Caucasus, and Central Asia. Unlike the broad-eared wheatgrass, *A. desertorum* moves further into the desert steppes. *A. desertorum* is an important pasture crop as highlighted by the study of Turko *et al*. (2023), who reported on the agroecological aspects of *A. desertorum* and its role in restoring vegetative cover of degraded soil, enhancing soil stability, and subsequently providing high-quality fodder.

Other species of wheatgrass common outside of Kazakhstan, such as *A. tanaiticum Nevski* (growing on the sands along the banks of the Lower Don rivers), *A. cimmericum Nevski* (on the sandy shores and slopes of the Crimea and Kerch Peninsula), and *A. imbricatum Roem et Schult*., can serve as a source of economically valuable traits in the development of genetic breeding research to create new varieties.

The genetic diversity of wheatgrass is determined at the species level and the ecotypic level among species representing complex populations. To involve the most valuable material in breeding, it is necessary to have a wide geographical outlook and use various ecological and geographical groups within the same species. This practice aligns with the studies of Redfearn *et al*. (2020) and Chumakova *et al*. (2024), who elucidated a system of ecologically and phytocenotically differentiated varieties of perennial grasses. Determination of genetic diversity at this level is essential for ecological restoration, optimal conservation of genetic resources, and breeding.

The main distinguishing features of wheatgrass species are the structure and width of the ear. Based on this feature, in agronomic practice, wheatgrass has been conditionally divided into broad-eared and narrow-eared wheatgrass.

From this set of samples and varieties growing in a desert zone with annual precipitation of 160-170mm, fluctuations in some years from 65 to 402.3mm, frosts up to -45°, and dry summers with temperatures reaching +40°, the following promising varieties were identified for breeding:

- by early ripening: samples of *A. cristatum (L.) Beav*. from the Aktobe region ripened 8-10 days earlier than the standard (k-713, 715, 718);
- by the ability to resist dehydration: samples of *A. sibiricum* from the Atyrau region (k-37766) and the Taukum hybrid variety (k-38045);
- by recovery ability: samples *of A. pectiniforme, A. cristatum subsp. pectinatum* (k-706), *A. desertorum* (k-723, 729), and *A. sibiricum* (k-730) from the Aktobe region;
- by height: samples of *A. cristatum subsp. pectinatum* from the West Kazakhstan (k-40680) and Aktobe (k-729) regions. The height of the plants was 68.0-71.0 cm when the standard of the Aktyubinsky uzkokolosy variety reached 60.0 cm;
- by general tilling capacity: samples of A. pectiniforme and *A. cristatum subsp. pectinatum* of the Batyr variety (k-47346) and a sample from Russia (k-28587), which had 171 and 169 stems from one bush, exceeding the standard value of 139 stems;
- by foliage: the maximum foliage was found in the samples of *A. tanaiticum* of the subspecies from Russia (k-44239) and *A. sibiricum* from the Aktobe region (k-730). The foliage of the samples was 39-41%, while that of the standard was 38%;
- by the yield of green mass: samples of *A. desertorum* from West Kazakhstan (k-40680) and Aktobe (k-729) regions, *A. pectiniforme* and *A. cristatum subsp. pectinatum* from the Almaty region (k-710), the hybrid (k-48559) from the USA, *A. pectiniforme* and *A. cristatum subsp. pectinatum* (k-42141) from the Stavropol Territory, *A. pectiniforme* and *A. cristatum subsp. pectinatum* from the Aktobe region, and the Karabalyksky 202 variety from the Kostanay experimental station, which exceeded the standard by 13-28%. The yield of the Aktyubinsky uzkokolosy mestny standard amounted to 459.6 g/m^2;
- by weight of 1,000 seeds: samples of *A. sibiricum* (k-704), *A. pectiniforme,* and *A. cristatum subsp. pectinatum* (k-700, 706, 708, 710, k-37765) from the Aktobe region. The weight of their 1,000 seeds was set at 2.5-2.7 g;

- by ear length: the longest ears from 11.0 to 12.0 cm were observed in samples of *A. sibiricum* from the Aktobe region (k-722), *A. desertorum* (k-40680) from the West Kazakhstan region, and *A. tanaiticum* from Russia (k-44239). The standard has an average ear length of 6.5 cm over 3 years;
- by seed productivity: samples *of A. pectiniforme* and *A. cristatum subsp. pectinatum* (k-44923) from the West Kazakhstan region, *A. pectiniforme* and *A. cristatum subsp. pectinatum* (k-710) from the Almaty region, *A. pectiniforme, A. cristatum subsp. pectinatum* (k-703,706,708), *A. desertorum* (k-724), and *A. sibiricum* (k-723) from the Aktobe region. The seed productivity of samples from 1 m^2 ranged from 28.0 to 34.7 g, while for the standard it was 25.6 g (Erzhanova & Takaeva, 2013).

Wheatgrass in the database of the Kazakh Scientific Research Institute of Animal Husbandry and Feed Production is represented by samples of the following species: *A. fragile*: 161, *A. desertorum*: 277, *A. pectinatum*: 485. *A. imbricatum*: 154, *A. cristatum*: 443 samples. Their phased regeneration is carried out at the Institute for transfer to the centralized storage of doublet samples to the Kazakh Research Institute of Agriculture and Crop Production.

A phylogenetic analysis of *Agropyron* species was carried out. The evolutionary relationships of *Agropyron* species were evaluated by the neighbor-joining method, the phylogenetic tree was built based on the Nei genetic distance. *A. imbricatum* was separated from other species, and the remaining samples were grouped in one cluster. *A. desertorum* turned out to be closer to *A. fragile* than to *A. cristatum* and *A. pectinatum*. *A. cristatum* was the closest of all species to *A. imbricatum* (Ainebekova *et al*., 2023).

Replenishment of the Institute's collection is carried out by collecting wild specimens growing in different parts of Kazakhstan (Ainebekova & Yerzhanova, 2022; Ainebekova *et al*., 2022). There are 1,500 documented samples of wheatgrass according to the main descriptors of the passport part: type of development, type of population, status, donor, country, herbarium, research institute of storage, and storage status. 100 samples of five plant species were studied in more detail: 20 samples of *A. cristatum (L.) Beauv*; 10 samples of *A. desertorum*; 33 samples of *A. cristatum subsp. collectinatum (A. pectiniforme, A. imbricatum, A. dagnae Grossh., A. karataviense Pavel., A. litvinovii Prokud.)*; and 19 samples of *A. imbricatum*. The Aksengersky mestny variety of *A. pectinatum* was taken as the standard, zoned in the research area. Based on the results of experimental studies in the field:

- the wheatgrass variety samples were divided into early-ripening (101-109 days), medium-ripening (110-114 days), and late-ripening (115-121 days) groups according to the duration of the growing season. 19 samples were selected that exceeded the standard in terms of feed mass yield: *A. cristatum* k-439925, D-261, k-440062, k-439924, Krasnokutsky 305, k-439953, D-601, Karabalykskу 202; *A. pectinatum* Synthetic 6, AIC 014, k-531539, AR 132, TK-26864, DJ-4193; *A. fragile* AIC 041, No. 86; *A. imbricatum* k-429771, D-968; and *A. desertorum* k-439970. Based on biomorphological features affecting seed productivity, 25 samples were identified that significantly exceeded the standard;
- the following samples with high foliage were identified: *A. cristatum* k-440062: 57.1%, *A. pectinatum* No.678: 56.5%, A. imbricatum D-11: 56.1% ($p<0.001$), exceeding the foliage index of the standard by 14.7-16.8%. 13 samples exceeded the standard in terms of crude protein content: *A. cristatum* k-439925, k-440062, Krasnokutsky 305, k-439924, Karabalyksky 202, k-440063; *A. pectinatum* Synthetic 6, AIC-014; AIC-017; *A. desertorum* k-439980, k-439970; *A. fragile* No. 86; and *A. imbricatum* D-11;
- based on the analysis of such biochemical characteristics as water, chlorophyll, proline, and malonyldialdehyde (MDA) content in leaves, electrical conductivity of cells, 14 drought-resistant samples were isolated: *A. cristatum* k-439925, Krasnokutsky 305, k-439924; *A. pectinatum* GR-591, AR-132, AIC-007, Synthetic 6; *A. desertorum* k-439970, K-439979, K-439956; *A. imbricatum* D-11, S-261, VIR37496; and *A. fragile* No. 86;
- based on a comparative assessment of potassium and sodium ions in the leaves, four samples were identified that were most resistant to salinization of soils: *A. cristatum* k-439925, *A. pectinatum* GR-591, *A. cristatum* Krasnokutsky 305, and *A. pectinatum* AR-132. The Aksengersky variety served as the standard;
- plant height ($r = 0.577$, $p<0.05$), leaf length (0.544), and number of generative shoots (0.528) had a positive effect on the yield of green mass. Root length and yield of green mass ($r = 0.826$), root length, and plant height (0.713) had a positive relationship.

From the study, we observe that crested wheatgrass *A. cristatum* displays high standards of resistance to drought, soil salinization and produces high foliage. These findings align with the studies of Robins and Jensen (2020), Ünal *et al.* (2022) and Ainebekova (2023). Further research is recommended to understand the molecular mechanism surronding these traits and why they are better expressed in *A. cristatum.*

We were able to identify 135 of the best samples that exceeded the standard in yield of green mass by 11–25%, yield of dry mass by 14–36%, and yield of seeds by 29–93% through a long-term study of 840 samples based on economically valuable characteristics (foliage, tilling capacity, intensity and vigor of growth, and plant height). Ten were chosen for preliminary variety testing, eight for competitive nurseries, and thirty-six breeding samples were chosen from the control species. Following breeding, the production of green mass samples increased by 1.7–24.8 c/ha, dry weight by 1.2–20.4 c/ha, and seeds by 0.2–0.6 c/ha. The planting area of the species it introduced is more than 150tsd ha, and the station's seed-growing areas are 1,000 ha (Didenko *et al*., 2021).

By demonstrating the great diversity and drought-tolerant characteristics of wheatgrass, this study makes a substantial contribution to our understanding of the agrobiological potential of Agropyron species in Kazakhstan. However, studying is not without limitations. A limitation of this study lies in the fact that though the study combined traditional taxonomy and cytogenetics and used a comprehensive survey of more than 1,500 samples, the depth of genotype-level differentiation is limited by the lack of molecular genetic analysis. In order to precisely identify trait-linked alleles, modern breeding is increasingly depending on molecular markers. Incorporating genomic tools would improve marker-assisted selection and accession classification accuracy, particularly for complex traits like salinity resistance and drought tolerance. This aligns with the study of Bajgain *et al.* (2022), who applied genomic models in predicting yield and yield component traits, domestication-related traits, and disease resistance traits in intermediate wheatgrass.

Secondly, the study utilizes phenotypic evaluations carried out in controlled experimental stations, which presents a scenario where environmental interactions in natural settings remain insufficiently investigated. Genotype-by-environment interactions can significantly impact trait expression, especially under variable stress conditions that are common in arid ecosystems (Robins *et al*., 2020). Future research is recommended to study multi-location trials over multiple growing seasons to validate trait stability and adaptability under real-world conditions. Furthermore, the majority of the current work focuses on above-ground traits, with only a brief mention of root system architecture, a crucial component of drought adaptation (in relation to plant height and green mass yield correlations). High-throughput root phenotyping under stress conditions could offer additional insight into drought avoidance mechanisms among various ecotypes (Correia *et al*., 2022).

The institute maintains links with international centers, in particular with the Crop Trust, which deals with biodiversity issues. In 2024, 522 samples from eight species of perennial forage grasses were transferred to the Svalbard Global Seed Vault (SGSV) in Svalbard for the first time on a depository basis, including alfalfa, wheatgrass, sainfoin, melilot, cock's-foot, etc., and 128 wheatgrass samples. The Institute of Genetic Resources of the National Academy of Sciences of Azerbaijan (Baku) was chosen as the first level of deposit storage of these samples, where an appropriate information center was established, and a unified information system with a centralized database on plant genetic resources of Azerbaijan was developed (Bandi *et al*., 2024; Figueroa-Valverde *et al*., 2024; Leadbeatter & Tjaya, 2024; O'Connor *et al*., 2024; Abdullah *et al*., 2025; Gong *et al*., 2025; Loutroukis *et al*., 2025; Tutticci & Marian, 2025). The Institute has experience in transferring seeds from national collections to the SGSV. In conclusion, scaling up breeding efforts and encouraging the sustainable use of Agropyron germplasm in arid-land agriculture will require integrating ecological and economic factors with agro-biological data. Such integrative approaches will strengthen the country's position as a hub for forage crop innovation under climate stress.

CONCLUSION

Establishing a dependable ecological framework for the agricultural landscape, which includes natural and seeded grazing areas and perennial grasses on arable land, is crucial to improving agricultural sustainability in the face of recurrent drought. The growth of perennial grasses, primarily wheatgrass, makes it possible to stabilize the environment and advance the sustainability of agricultural output. Particularly in Kazakhstan's arid regions, cultivating perennial grasses and placing them in zones that meet biological criteria is turning into a successful strategy for resolving a number of environmental issues and increasing the feed base for animal husbandry.

The issue of collecting wheatgrass and other perennial plant gene pools remains relevant in Kazakhstan, where there are approximately 25 million ha of unproductive soils and degraded arable land that requires phytomelioration. According to breeding experience, the primary objective of agricultural research continues to be replenishing existing gene pool collections with fresh samples and studying them to identify origins and providers of commercially valuable plant characteristics. The study revealed that scientific institutions in Kazakhstan are actively working on this wheatgrass mission, and its gene pool is now developing as a result of annual travels to various parts of the nation.

The generalization of the study and breeding of wheatgrass proposed in this work can become the basis for subsequent field experiments on the cultivation of the most economically valuable samples of this crop.

ACKNOWLEDGMENT: The authors would like to express their sincere gratitude to the editor and reviewers for their valuable comments and suggestions, which greatly improved the quality of this manuscript.

FINANCIAL SUPPORT: The study was carried out within the framework of grant funding from the Ministry of Higher Education and Science of the Republic of Kazakhstan, Individual Registration Number (IRN) AR 19676041 "Conservation of genetic resources of forage plants based on expedition fees from the wild flora of Kazakhstan".

CONFLICT OF INTEREST: None

ETHICAL STATEMENT: None

REFERENCES

Abdelrahman, A. S., & Saad, M. K. (2025). Generalized bioimpedance equations underestimate fat-free mass in elite male soccer players: Development and validation of soccer-specific predictive models. *Journal of Medical Sciences: Interdisciplinary Research, 5*(1), 141–152. doi:10.51847/JBloJwTYN0

Abdullah, N. A., Zulkifli, M. I., & Mohamed, A. S. (2025). Refinement of the 8th AJCC staging system for medullary thyroid cancer: Integrating tumor size and lymph node characteristics with SEER and multicenter validation. *Archive International Journal of Cancer and Allied Sciences, 5*(2), 34–43. doi:10.51847/R1sIaONOms

Ainebekova, B. (2023). Genetic analysis and molecular characterization of the wheatgrass (*Agropyron cristatum* L. Gaertn.) in South-East Kazakhstan. *SABRAO Journal of Breeding and Genetics, 55*(4), 1132–1141. doi:10.54910/sabrao2023.55.4.10

Ainebekova, B. A., & Yerzhanova, S. T. (2022). Formation, documentation, and study of wheatgrass genetic resources in Kazakh Research Institute of Animal Husbandry and Forage Production. *Science and the World, 4*(98), 32–36.

Ainebekova, B. A., Yerzhanova, S. T., Seitbattalova, A. I., & Kambarbekova, E. A. (2022). Exploring the *Agropyron* Gaerth. collection according to the main economically valuable and biological characteristics in the conditions of the southeast of Kazakhstan. *3i: Intellect, Idea, Innovation, 3*, 52–62.

Alavi, M., Karimi, R., & Ahmadi, H. (2024). Exploring the color and biofunctional potential of six natural textile dyes: Eucalyptus, weld, madder, annatto, indigo, and woad. *Interdisciplinary Research in Medical Sciences (Special Issue), 4*(1), 96–115. doi:10.51847/lhSoPW78r2

Amrani, F. Z., Benali, Y., & El-Haddad, S. (2024). Anti-inflammatory effects of *Viola odorata* aqueous extract in an ovalbumin-induced murine model of allergic asthma. *Special Journal of Pharmacognosy, Phytochemistry and Biotechnology, 4*, 276–283. doi:10.51847/EHIKDXt2zi

Bajgain, P., Li, C., & Anderson, J. A. (2022). Genome-wide association mapping and genomic prediction for kernel color traits in intermediate wheatgrass (*Thinopyrum intermedium*). *BMC Plant Biology, 22*(1). doi:10.1186/s12870-022-03616-7

Bandi, V., Dey, S. K., & Rao, O. (2024). Factors influencing the physician prescribing behaviour of medicines in developed and developing countries: A systematic review. *Journal of Integrative Nursing and Palliative Care, 5*, 21–34. doi:10.51847/ZS3boQgksO

Chumakova, V. V., Mironova, T. M., Derevyannikova, M. V., Chumakov, M. F., & Sukharev, S. A. (2024). A system of ecologically and phytocenotically differentiated varieties of perennial grasses for central Caucasus conditions. *Lecture Notes in Networks and Systems, 2*, 437–444. doi:10.1007/978-3-031-72556-2_42

Correia, P. M. P., Westergaard, J. C., da Silva, A. B., Roitsch, T., Carmo-Silva, E., & da Silva, J. M. (2022). High-throughput phenotyping of physiological traits for wheat resilience to high temperature and drought stress. *Journal of Experimental Botany, 73*(15), 5235–5251.

Damaševičius, R., Maskeliūnas, R., & Blažauskas, T. (2025). Enhancing virtual medical history taking: Effects of customized guidelines in two serious games for medical education. *Annals of Pharmacy Education, Safety, Public Health and Advocacy, 5*, 39–49. doi:10.51847/kNshKQSf5t

Didenko, I. L., Limanskaya, V. B., Sarsengaliyev, R. S., Shektybaeva, G. H., & Imanbaeva, G. H. (2021). Study of collection of wild wheatgrass dry steppes of West Kazakhstan to identify useful features. *Perm Agrarian Journal, 3*(35), 28–35.

Ernst, P., & Weber, T. (2024). Impact of flexible work arrangements on the engagement levels of younger employees. *Annals of Organizational Culture, Leadership, and External Engagement Journal, 5*, 72–86. doi:10.51847/njhaTa39mx

Erzhanova, S. T., & Takaeva, M. K. (2013). A study of genetic diversity of forage crops in Kazakhstan: Wheatgrass. *Contemporary Problems of Science and Education, 6*.

Feng, L., Wei, G., & Lei, Z. (2024). Pharmacists' contributions to the management of mental health conditions: A comprehensive review. *Annals of Pharmacy Practice and Pharmacotherapy, 4*, 125–139. doi:10.51847/ReKLpACV6c

Figueroa-Valverde, L., Marcela, R., Alvarez-Ramirez, M., Lopez-Ramos, M., Mateu-Armand, V., & Emilio, A. (2024). Statistical data from 1979 to 2022 on prostate cancer in populations of Northern and Central Mexico. *Bulletin of Pioneer Research in Medical and Clinical Sciences, 4*(1), 24–30. doi:10.51847/snclnafVdg

Fischer, L. M., El Sherif, A. K., & Bekele, T. M. (2024). Oral microbial signatures predict susceptibility to SARS-CoV-2 infection. *Journal of Current Research in Oral Surgery, 4*, 140–148. doi:10.51847/NhM1Ql15WT

Gong, J., Chenand, M., & Li, Q. (2025). Understanding what drives nursing undergraduates to pursue postgraduate entrance: Insights from a qualitative study. *Journal of Integrative Nursing and Palliative Care, 6*, 24–33. doi:10.51847/pTPZiCvnCN

Gonzalez, M., Ruiz, J., Torres, L., & Moreno, D. (2024). QSAR-guided identification of novel triazole derivatives as potent α-glucosidase inhibitors with favorable ADMET profiles. *Pharmaceutical Science and Drug Design, 4*, 230–248. doi:10.51847/jluA9dekev

Hashem, W., Mokhtar, M., Rahman, A. A., & Rashad, A. (2024). Adult acute lymphoblastic leukemia: Insights from six years of clinical practice in an Egyptian tertiary care center. *Asian Journal of Current Research in Clinical Cancer, 4*(2), 51–61. doi:10.51847/fFirKGgI3X

Herrera, L., Quintana, P., & León, M. (2025). Exploring the impact of evolving business environments on the trade of medicinal plant products in Tanzania. *Interdisciplinary Research in Medical Sciences (Special Issue), 5*(1), 107–120. doi:10.51847/aD8VupkMwm

Jun, W., Hao, C., & Wei, L. (2025). Evaluating household-based oral health interventions delivered by community health workers under average psychosocial conditions. *Journal of Current Research in Oral Surgery, 5*, 81–91. doi:10.51847/PYzUyKYCSb

Leadbeatter, D., & Tjaya, K. C. (2024). Human rights and bioethical principles in correctional settings: A systematic review of the evidence. *Asian Journal of Ethics in Health and Medicine, 4*, 97–106. doi:10.51847/wSNBedLrGt

Loskutova, G., Alimzhanov, K., Satayeva, Z., Zhaxybayeva, E., & Zhakupov, M. (2024). Study of the chemical composition and feed value of pasture grass. *E3S Web of Conferences, 539*, 02006. doi:10.1051/e3sconf/202453902006

Loutroukis, T., Moore, P. D., & Kuchen, R. (2025). Radial peripapillary capillary alterations in COVID-19: Insights from optical coherence tomography angiography – A systematic review. *Bulletin of Pioneer Research in Medical and Clinical Sciences, 5*(1), 126–136. doi:10.51847/wGIOEpd65q

Morales, V. I., Castillo, J. P., & Vega, D. R. (2025). Temporal variations in risk perception and emotional response of healthcare workers in China during the COVID-19 pandemic. *International Journal of Social Psychological Aspects in Healthcare, 5*, 265–276. doi:10.51847/Tw0PKDaHVI

Murzataeva, T. Sh., Aitymbetova, K. Sh., Sitpayeva, G. T., & Elubaeva, A. S. (2022). Morphobiological characteristics of *Agropyron* Gaertn. species stored in the seed bank of the Institute of Botanics and Phytointroduction of the RK. *News of the National Academy of Sciences of the Republic of Kazakhstan. Series of Biological and Medical, 1*(348), 36–65. doi:10.32014/2022.2519-1629.108

Muthanandam, S., Muthu, J., Babu, B. V., Rajaram, S., & Kengadharan, S. (2024). Raising awareness of oral precancer and cancer among Indian long-distance heavy vehicle drivers: A neglected group. *International Journal of*

Social Psychological Aspects in Healthcare, 4, 20–25. doi:10.51847/2JNlaeP6n5

Nokusheva, Z., Nasiyev, B., Kantarbayeva, E., Zhanatalapov, N., Bekkaliyev, A., Khairush, A., & Okshebayev, A. (2025). Bio-organic fertilizer application for forage quality improvement and rangeland restoration in Northern Kazakhstan's steppe ecosystems. *International Journal of Design and Nature and Ecodynamics, 20*(10), 2363–2373.

O'Connor, D. P., Byrne, S. M., & Evans, L. J. (2024). Pregnancy outcomes and prognosis in young women with hormone receptor-positive breast cancer: A systematic review and meta-analysis. *Archive International Journal of Cancer and Allied Sciences, 4*(1), 81–92. doi:10.51847/09JqoaN4Lx

Pototskaya, I. V., Shamanin, V. P., Aydarov, A. N., & Morgounov, A. I. (2022). The use of wheatgrass (*Thinopyrum intermedium*) in breeding. *Vavilovskii Zhurnal Genetiki i Selektsii*. doi:10.18699/VJGB-22-51

Raju, N. (2024). Exploring healthcare providers' views on cognitive assessment in geriatric care. *Annals of Pharmacy Education, Safety, Public Health and Advocacy, 4*, 29–42. doi:10.51847/OHbxZJ6ejX

Redfearn, D. D., Harmoney, K. R., & Smart, A. J. (2020). Grasses for arid and semiarid areas. In *Forages* (pp. 313–330). Wiley. doi:10.1002/9781119436669.ch17

Rexhepi, D., Krasniqi, A., & Gashi, L. (2025). Elevated baseline NT-proBNP identifies poor prognosis in frail gastroesophageal cancer: GO2 post-hoc analysis. *Asian Journal of Current Research in Clinical Cancer, 5*(2), 150–157. doi:10.51847/QmwOykJ0u1

Robins, J. G., & Jensen, K. B. (2020). Breeding of the crested wheatgrass complex (*Agropyron* spp.) for North American temperate rangeland agriculture and conservation. *Agronomy, 10*(8), 1134. doi:10.3390/agronomy10081134

Robins, J. G., Rigby, C. W., & Jensen, K. B. (2020). Genotype × environment interaction patterns in rangeland variety trials of cool-season grasses in the Western United States. *Agronomy, 10*(5), 623. doi:10.3390/agronomy10050623

Sato, Y., Nakamura, K., Fujimoto, A., & Mori, K. (2025). Green human resource management and organizational commitment: The mediating role of green human capital in Pakistan's dairy sector. *Annals of Organizational Culture, Leadership, and External Engagement Journal, 6*, 186–194. doi:10.51847/Z4eiILxSkS

Scott, O., Miller, W., & White, C. (2025). Potential molecular targets for hypertension in *Allium schoenoprasum* identified through network pharmacology and molecular docking approaches. *Annals of Pharmacy Practice and Pharmacotherapy, 5*, 164–173. doi:10.51847/nKkK01MaCz

Shaimerdenova, A., Abdireimov, S., Ashimkhan, N., Zhumakan, A., Auesbekov, N., Kaisanova, A., Vagapova, A., Stepanova, D., Satvaldiyev, B., Ussarov, U., et al. (2026). Spatial assessment of soil fertility using GIS and remote sensing: A case study of southern Kazakhstan. *SABRAO Journal of Breeding and Genetics, 58*(1), 474–485. doi:10.54910/sabrao2026.58.1.44

Tabynbayeva, L., Bastaubayeva, S., Konusbekov, K., Kantarbayeva, E., & Yerzhebayeva, R. (2025). Ecological and agronomic evaluation of sugar beet hybrids (*Beta vulgaris* L.) in a Northern Kazakhstan agroclimatic zone. *International Journal of Agriculture and Biosciences, 14*(6), 1307–1315.

Tanaka, A., Mori, Y., Sakamoto, H., & Fujii, K. (2025). Larvicidal potential of essential oils from Ethiopian medicinal plants against *Anisakis* L3 larvae: Chemical composition and cytotoxic evaluation. *Special Journal of Pharmacognosy, Phytochemistry and Biotechnology, 5*, 253–262. doi:10.51847/Y2ND34xN4K

Turko, S. Y., Rybashlykova, L. P., & Vlasenko, M. V. (2023). Agroecological aspects of cultivating granary crop for the restoration of degraded lands under arid zone: A review. *Research on Crops, 24*(3), 618–627. doi:10.31830/2348-7542.2023.ROC-947

Turner, O., Grant, H., & Douglas, M. (2025). Hippocampal angiogenesis driven by the SIRT1/FOXO1 pathway contributes to the antidepressant actions of Chaihu Shugan San. *Pharmaceutical Science and Drug Design, 5*, 96–113. doi:10.51847/CV0RYDBQVQ

Tutticci, S., & Marian, M. (2025). Integrating environmental sustainability into clinical decision-making: A systematic review of rationale. *Asian Journal of Ethics in Health and Medicine, 5*, 79–94. doi:10.51847/oGhDOKCuki

Umarova, M. S., Akhyadova, Z. S., Salamanova, T. O., Dzhamaldinova, Z. I., Taysumova, Z. D., Bekmurzaeva, M. R., Tapaeva, M. M., & Ivanushkina, I. M. (2024). Influence of vibrations and other negative physical factors of production on protein metabolism and protein dynamics in the body. *Journal of Medical Sciences: Interdisciplinary Research, 4*(1), 39–44. doi:10.51847/Jk38F1v5XH

Ünal, S., Mutlu, Z., & Efe, B. (2023). Assessment of crested wheatgrass (*Agropyron cristatum* L. Gaertn.) populations for the agro-morphological and the quality traits under semiarid condition. *Romanian Agricultural Research, 40*, 225–238. doi:10.59665/rar4022