DEVELOPMENT OF A NEW SEEDER FOR RESTORING DESERT AND SEMI-DESERT AREAS IN UZBEKISTAN

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ABSTRACT
This study developed and evaluated a specialized seeder for restoring degraded desert and semi-desert pastures in Uzbekistan through mechanized sowing of native drought-resistant plants. Saxaul (Haloxylon spp.), cherkez (Salsola spp.), and izen (Kochia prostrata) were selected because of their adaptation to arid conditions and their potential to stabilize sandy soils and improve pasture productivity. Laboratory and field investigations assessed seed quality, seed-flow behavior, and the operational performance of an experimental seeder equipped with cone-shaped seed-mixture loosening elements. Seed purity ranged from 20% to 25%, and germination capacity ranged from 40% to 45%. Experimental results showed that increasing the operating parameter of the cone-shaped working element increased the quantity of sown seeds while maintaining a relatively low number of wingless seeds. The loosening mechanism reduced seed bridging and clogging, supported continuous seed flow, and improved the uniformity and stability of seed distribution compared with manual sowing. Field trials conducted in 2025 confirmed the practical suitability of the seeder for sandy and degraded pasture soils. The developed technology offers a technically effective approach for pasture restoration, soil stabilization, and improved establishment of desert forage vegetation.

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Introduction

Arid natural pastures, covering millions of hectares and primarily reserved for livestock grazing, contain extensive areas of degradation in almost all regions (Arshad et al., 2022). Approximately 40% of desert pastures have been affected by degradation of varying degrees, resulting in a 20–30% decline in their average productivity (Abd Elsalam & Bahobail, 2016). In the Republic of Uzbekistan, approximately 8.0 million hectares of degraded pastures require improvement (Table 1). Arid and semi-arid regions cover approximately 66.7 million km² worldwide and are home to nearly 2 billion people (Arshad et al., 2022). According to the United Nations (UN), drylands account for approximately 30% of the Earth's land surface across more than 100 countries, and nearly 2 billion people currently live in these areas (Arshad et al., 2022). Considering the current rate of desertification, if the scenario proposed by the UN materializes, by 2025, one in every five people worldwide could be living in territories affected by severe land degradation (Arshad et al., 2022). More than 2 billion hectares of productive land have already been degraded, and an additional 12 million hectares are degraded annually (Anttila et al., 2011). There is a close relationship

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between the spatial structure of vegetation and the desertification processes associated with intensive livestock grazing on natural pastures (N. Z. Shamsutdinov et al., 2021). Degradation occurs particularly rapidly and reaches severe levels in pastures used for grazing throughout the year (Shamsutdinova & Shamsutdinov, 2021). Uncontrolled livestock grazing and overgrazing are among the major causes of degradation of pasture vegetation, soil degradation, and the formation and accumulation of wind-blown sand deposits (N. Shamsutdinov et al., 2020). Pasture ecosystems are particularly vulnerable during the dry season, when vegetation cover and soil moisture are significantly reduced (Farmonov et al., 2022). Under conditions of severe and prolonged drought, the processes of land degradation and desertification may develop rapidly, leading to a substantial reduction in vegetation productivity, soil stability, and the ecological resilience of natural pasture ecosystems (Karimova et al., 2012). Therefore, the restoration and sustainable management of degraded arid and semi-arid pastures require scientifically based technologies and effective mechanized methods for establishing native drought-resistant vegetation (Farmonov et al., 2020a).

Table 1

Level of Pasture Degradation Across Regions of the Republic of Uzbekistan

Republic of Uzbekistan	**The area of degraded grasslands, mil. ha**	**Degradation size, %**
Karakalpakstan	1.50	43.4
Navoi	4.10	43.8
Bukhara	1.2	37.6
Surkhandarya	0.20	41.2
Samarkand	0.12	23.6
Kashkadarya	0.18	24.5
Jizzakh	0.17	25.4
Total	7.47	40

At present, extensive degraded areas are found across almost all natural pasturelands of the Republic of Uzbekistan, with their total area reaching approximately 8 million hectares. The distribution and extent of these degraded areas vary among regions. Approximately 40% of desert pastures have undergone degradation of varying degrees, resulting in a 20–30% decline in their average productivity (Table 1). These figures clearly demonstrate that the primary task for ensuring the sustainable development of livestock production and, in particular, pastoral livestock farming in arid regions is the development of effective technologies and technical means for restoring degraded pastures and increasing their productivity (Urinova et al., 2023). At the same time, protecting arid pastures from further degradation is equally important as improving their productivity. Therefore, sustainable pasture management should focus not only on restoring degraded lands but also on preventing further deterioration of vegetation and soil resources. The implementation of scientifically based technologies and appropriate mechanized technical means for the establishment of native drought-resistant vegetation can contribute significantly to the restoration of degraded pastures, stabilization of sandy soils, prevention of desertification, and improvement of the forage base for livestock production in arid regions.

Method

The study was conducted to develop and evaluate a mechanized technology for improving degraded desert and semi-desert territories of the Republic of Uzbekistan through the establishment of native drought-resistant vegetation. The research methodology was based on field observations, laboratory studies, experimental evaluation of seed quality, and field testing of a newly developed desert seeder. The study area included degraded natural pastures and sandy soils characteristic of the arid and semi-arid

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regions of Uzbekistan (Farmonov et al., 2022). The selection of plant species was based on their natural distribution, adaptation to severe arid conditions, resistance to drought, and potential for restoring degraded pasture ecosystems. The principal plant species selected for the study were saxaul (*Haloxylon spp.*), cherkez (*Salsola spp.*), and izen (*Kochia prostrata*), which are considered promising native desert and semi-desert plants for improving the vegetation cover of degraded lands.

Seed Materials and Quality Assessment

Before sowing, the main physical and biological quality characteristics of the seed material were determined. Particular attention was given to seed purity and germination capacity, since these parameters directly affect the efficiency of mechanized sowing and subsequent plant establishment (Farmonov et al., 2020a). The seed purity of the prepared seed material ranged from 20 to 25%, while germination capacity was determined to be 40–45%.

Seeder Design and Development

A new experimental prototype of a desert seeder was developed for mechanized sowing of saxaul and izen seeds. The design of the seeder was developed taking into account the specific physical and mechanical properties of desert plant seeds, their low flowability, and the technological requirements for sowing on sandy soils (Mirzaev et al., 2021). The seeding system was designed to provide continuous movement, uniform distribution, and controlled placement of seed material while reducing the probability of seed bridging, clogging, and irregular seed flow.

Patented Technology and Experimental Procedures

The proposed seeding technology and the construction of the seeding equipment were developed on the basis of experimental and theoretical studies and are protected by patents of the Republic of Uzbekistan (No. FAP 2670 and No. FAP 3044). Laboratory and field experiments were conducted to assess the operational performance of the seeder and the quality of the sowing process under natural soil and climatic conditions.

Field Trials and Data Analysis

During the field trials, the seeder was evaluated according to the uniformity of seed distribution, stability of the seeding process, and suitability for operation on sandy and degraded pasture soils. The obtained experimental data were analyzed to determine the effectiveness of the proposed technology for restoring degraded desert and semi-desert territories (Farmonov et al., 2020a). The results were used to assess the potential of mechanized sowing of native drought-resistant plants as a practical method for improving pasture vegetation, stabilizing sandy soils, reducing degradation, and increasing the ecological sustainability and productivity of arid pasture ecosystems.

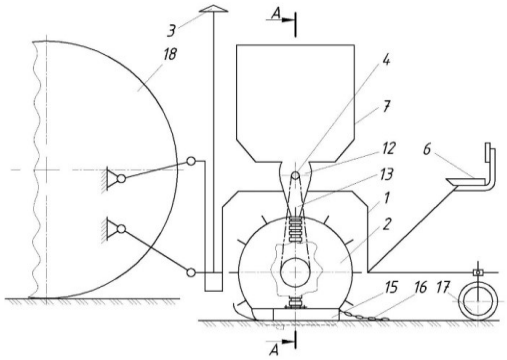
Results

The proposed seeder for sowing the seed heap of desert forage plants (izen) operates as follows (Farmonov et al., 2022). Before starting operation, hopper 7 is filled with the seed mixture. As the seeder, aggregated with a tractor, moves across the field, the ground wheels 2 transmit motion to the left 4 and right 5 horizontal drive shafts. The rotating left 4 and right 5 horizontal shafts, in turn, transmit rotational motion to the seed-mixture loosening devices mounted on bearings 8 in the lower sections of hopper 7. The left horizontal shaft 4 transmits rotation to the two left shafts 9 of the seed-mixture loosening devices, while the right horizontal shaft 5 transmits rotation to the two right shafts 9 of the seed-mixture loosening devices (Fig. 1). The arrangement of the side walls of the quadrangular hopper at an angle of 90° relative to the seed-mixture loosening devices significantly reduces friction between the seed mixture and the walls of hopper 7. This configuration ensures smooth movement of the seed mixture from the upper part toward the lower part of the hopper and onto the surfaces of the conical fingers 10 of the seed-mixture loosening devices (Fig. 2).

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Figure 1

Schematic Diagram of the Proposed Unit for Sowing a Seed Heap of Desert Forage Plants (Izen)

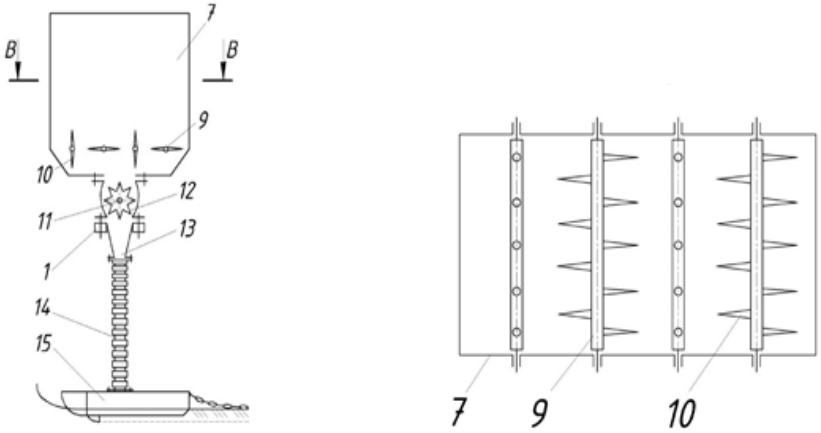


Note. 1 = frame; 2 = support wheels; 3 = marker; 4–5 = left and right horizontal shafts; 6 = seat; 7 = hopper; 8 = bearing; 9 = seed-mixture softeners; 10 = cone-shaped fingers; 11 = drum distributor; 12–13 = seeding apparatus; 14 = seed tube; 15 = coulter; 16 = hedder; 17 = compacting roller; 18 = tractor chassis.

The seeds remain above the surfaces of the fingers 10 of the seed-mixture loosening devices 9 until the fingers are set into motion. The conical fingers 10 prevent the seeds from falling abruptly onto the surfaces of the triangular grooves 12 of the distributing drum 11. As a result, the formation of a seed arch above the grooves is prevented (Fig. 2). The rotation of the seed-mixture loosening devices continuously disturbs and loosens the seed material, thereby maintaining its mobility within the lower part of the hopper. The conical fingers provide a gradual transition of the seed mixture toward the triangular grooves of the distributing drum, preventing localized accumulation and blockage of the seed material.

Figure 2

Seeding Section of the Seed Harrow for Sowing Izen



Note. 1 = frame; 7 = hopper; 9 = seed-mixture softeners; 10 = cone-shaped fingers; 11 = drum distributor; 12 = triangular chute; 13 = seed guide; 14 = seed tube; 15 = coulter.

This operating principle improves the continuity and stability of seed flow and contributes to a more uniform distribution of the seed mixture during the sowing process. Thus, the proposed design makes it possible to maintain a stable flow of the non-free-flowing seed mixture, reduce the risk of bridging and clogging in the hopper, and ensure reliable feeding of the seed material to the distributing drum. This is particularly important for the mechanized sowing of izen seeds, which are characterized by specific physical and mechanical properties and require specialized technological conditions for effective and uniform sowing.

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Figure 3

Laboratory Bench Used for the Experiments



The following data for the proposed device were determined under laboratory conditions using a DT-2236 B electronic tachometer. The calculated values are presented in Figure 5. Field trials of the seeder were conducted in 2025 at the testing grounds of BMKB-Agromash Joint-Stock Company, located in the Farish district of the Jizzakh region, and also in the Urtachirchik district of the Tashkent region that same year. The seeder is coupled to wheeled tractors of class 0.9–1.4 (T-40, MTZ-80/82) (Fig. 4).

Figure 4

General View of the Experimental Prototype of the Machine

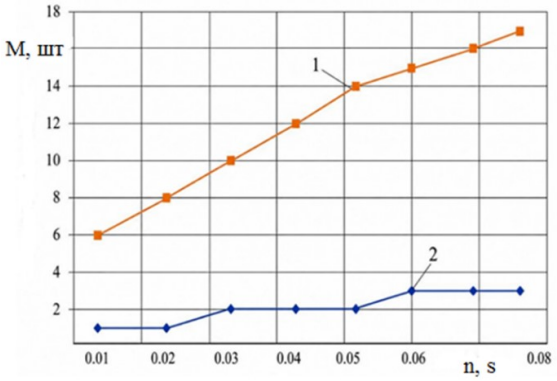


As shown in the figure, with an increase in the rotation parameter from 0.01 to 0.075 s, the quantity of sown seeds increases steadily from approximately 6 to 17 seeds. The most pronounced increase is observed over the range of 0.01–0.05 s, where the number of sown seeds rises from 6 to 14. With a further increase in the parameter, the number of seeds continues to increase, reaching approximately 17 seeds at 0.075 s. In contrast, the number of wingless seeds remains relatively low and stable. At the initial values of the parameter (0.01–0.02 s), approximately 1 wingless seed is observed. At 0.03–0.05 s, this value increases to approximately 2 seeds, and at 0.06–0.075 s it reaches approximately 3 seeds. The obtained relationship indicates that increasing the operating parameter of the cone-shaped working element promotes more intensive loosening and movement of the seed mixture, thereby increasing the amount of seed supplied to the distributing mechanism. At the same time, the relatively small increase in the number of wingless seeds indicates that the working element provides effective separation and controlled movement of the seed mixture. Thus, the results confirm the ability of the proposed cone-shaped working element to ensure a stable and continuous supply of seed material and improve the reliability of the sowing process.

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Figure 5

Dependence of Seed-Heap Quantity on the Number of Revolutions of the Cone-Shaped Working Element



Note. 1 = sown seeds; 2 = wingless seeds.

In general, the graph confirms the direct dependence of the number of seeds on the number of revolutions and allows us to determine the rational range of operation of the device, which ensures high productivity while maintaining the quality of seeding.

Discussion

The experimental results demonstrate that the proposed planter provides a more uniform and stable sowing process within the established agrotechnical requirements compared with manual sowing (Farmonov et al., 2020a; Farmonov et al., 2020b; Farmonov et al., 2022; Mirzaev et al., 2021). The separation of seeds at a fixed rate and their subsequent placement into the furrow formed in the cultivated sandy soil contributed to a more consistent distribution of seeds along the sowing row. This is particularly important for desert forage plants such as izen, whose seeds are characterized by small size and specific physical and mechanical properties that can complicate their uniform metering and distribution. The observed improvement in sowing uniformity can be attributed to the operating principle of the developed planter. The seed mixture is continuously loosened and directed toward the seed-metering and distributing element, which reduces the probability of seed bridging, clogging, and irregular discharge. In contrast, manual sowing is strongly dependent on the operator and may result in fluctuations in the amount of seed deposited along the row. Such fluctuations can lead to both excessive concentration and insufficient density of plants, which negatively affects the uniformity of plant establishment. The results are especially relevant for sowing on sandy soils after plowing and cultivation by machine-tractor aggregates. Under these conditions, maintaining a stable seed flow and placing seeds uniformly in the prepared furrow are essential for obtaining an even plant stand. The proposed planter combines mechanized seed metering with continuous seed-flow regulation, thereby reducing the influence of human factors and improving the stability of the technological process.

The higher efficiency and productivity observed for the developed planter indicate that its application can reduce the labor requirements associated with manual sowing while simultaneously improving the quality of seed distribution. The obtained results therefore confirm the suitability of the proposed design for mechanized sowing of desert forage plant seeds under sandy-soil conditions. Moreover, the improved uniformity of seed placement may contribute to more consistent emergence and establishment of plants, which is important for the restoration and productive use of degraded desert and pasture lands. Overall, the experimental findings confirm that the developed planter is capable of providing a stable and technologically controlled sowing process within the required range of sowing quality. Its advantages over manual sowing are associated primarily with improved seed distribution uniformity, reduced dependence on operator performance, and higher operational efficiency. These findings support the practical application of the proposed planter for establishing desert forage vegetation in sandy areas.

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Conclusion and Implications

The experimental results confirm the effectiveness of the developed planter for sowing desert forage plant seeds under sandy-soil conditions. The proposed design ensures a stable and uniform supply of seeds within the required sowing rate and improves the distribution of seeds along the prepared furrow compared with manual sowing. The use of the cone-shaped working element in the seed hopper contributes to continuous loosening of the seed mixture and prevents the formation of bridges and blockages, thereby maintaining a stable seed flow to the seed-metering and distributing mechanism. The developed planter demonstrated higher sowing efficiency and productivity, while reducing the dependence of sowing quality on operator performance. The obtained results indicate that mechanized sowing provides more consistent seed placement and a more stable sowing process than the manual method. This is particularly important for small and lightweight seeds of desert forage plants, for which achieving a uniform sowing rate is technically difficult. The practical implication of the study is that the proposed planter can be used for establishing and restoring desert forage vegetation in sandy and degraded areas. More uniform seed distribution can contribute to a more even plant stand and improve the efficiency of seed utilization. Consequently, the developed technology has potential for application in pasture restoration, prevention of land degradation, and improvement of the productivity of desert grazing areas. From a technological perspective, the results demonstrate that incorporating a cone-shaped seed-mixture loosening element into the hopper is an effective approach to improving the reliability of seed metering for non-free-flowing desert plant seeds. The developed solution can serve as a basis for further improvement of seeders intended for sowing small, irregularly flowing seeds under difficult soil and environmental conditions. In conclusion, the developed planter provides a technically effective alternative to manual sowing by combining improved seed-flow stability, more uniform seed distribution, and higher operational efficiency. Further research should focus on long-term field trials under different soil moisture conditions, operating speeds, and sowing rates, as well as on evaluating seedling emergence, plant survival, and the economic efficiency of large-scale application.

Declarations

Acknowledgments: Not applicable.

Authors' contributions: Erkin Farmonov contributed to the conceptualization of the study, development of the experimental methodology, design and development of the proposed planter, performance of the experiments, analysis and interpretation of the experimental results, and preparation of the manuscript. Shakhnoza Mirzaeva contributed to the development of the research methodology, organization and supervision of the experimental studies, analysis and interpretation of the obtained results, critical revision of the manuscript, and coordination of the manuscript preparation and submission. Both authors read and approved the final version of the manuscript. Nodira Xodjaqulova contributed to the development of the research methodology, organization and supervision of the experimental studies.

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