RESULTS OF THE INVESTIGATION OF BLACK SAXAUL (HALOXYLON AMMODENDRON) SEED GERMINATION

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Abstract. *The article describes the formation of an unfavorable environmental situation resulting from the decline in the water level of the Aral Sea, the expansion of saline land areas, and the increasing negative impact of toxic salts on plant population dynamics. In addition, within the framework of Project No. Al-9424114992, the results of studies on improving the germination of black saxaul seeds are presented. The seeds, both winged and de-winged forms, were treated using humimax, bentonite, and clay (pakhsa wall soil) as substrate components.*

Keywords*: halofit, 12^{00}–13^{00} hours, pipette, 20–25 ml of water, noted in option 5 10%.*

Introduction

Over the past 50 years, the decline in the water level of the Aral Sea and the resulting unfavorable environmental conditions in the region have led to a reduction in the quality of many economically important agricultural crops. Within the forest fund areas, increasing soil salinization, declining soil fertility, expansion of saline lands, and the accumulation of toxic salts have negatively affected plant species populations. Afforestation is considered one of the primary approaches to mitigating this environmental problem.

Forests protect soil from erosion, provide habitats for numerous animal species, and influence the global climate. Every year, millions of hectares of forests are lost worldwide. Some countries attempt to compensate for these losses through reforestation and forest restoration programs [4]. Currently, stabilization of biodiversity in the Aral Sea region can largely be supported through the establishment of green cover using seeds of naturally growing halophytic plant species adapted to local conditions.

The Development Strategy of the Republic of Uzbekistan for 2022–2026 (New Uzbekistan Development Strategy) defines key priorities, including environmental protection, improvement of ecological conditions in cities and districts, and the implementation of the nationwide "Green Space" initiative. Within this framework, it is planned to establish an additional 500,000 hectares of green areas on the dried seabed of the Aral Sea and increase the total green coverage to 2.5 million hectares, or 78% of the territory, by the end of 2026.

Accordingly, within the framework of Project No. Al-9424114992 entitled "Development of Modern Technologies for Establishing Green Cover on the Dried Seabed of the Aral Sea and Cultivation of Desert and Pasture Forage Plants," our research investigated the germination performance of black saxaul seeds under laboratory conditions based on the biological characteristics of halophytic plant species.

During the study, the germination of both winged and de-winged black saxaul seeds was evaluated following treatment with humimax, bentonite, and clay (pakhsa wall soil). The following results were obtained. On December 20, 2025, between 12:00 and 13:00, seed samples were collected for laboratory germination experiments. Humimax, bentonite, and clay soil were primarily used in the germination process. Humimax is an organo-mineral nutrient suitable for various plant species and consists of humic acids prepared from peat and sapropel extracts (sediment from irrigation canals and drainage ditches), plant organic matter, and phytohormones.

Bentonite clay mainly consists of minerals belonging to the montmorillonite group and is sometimes referred to as “stone soap.” In addition to montmorillonite, bentonite may contain hydromica, kaolinite, palygorskite, zeolites, and other minerals. Bentonite is formed through the diagenetic transformation of volcanic tuffs and ash in aqueous environments, primarily marine basins (see diagenesis) [5].

Due to its layered crystalline structure and high water absorption capacity, bentonite swells significantly upon contact with water. To conduct experiments aimed at improving seed germination using mineral nutrient elements, the following materials were prepared: humimax, bentonite, clay soil, Petri dishes, filter paper, tweezers, pipettes for watering, and other necessary laboratory equipment. All containers were washed and dried prior to use.

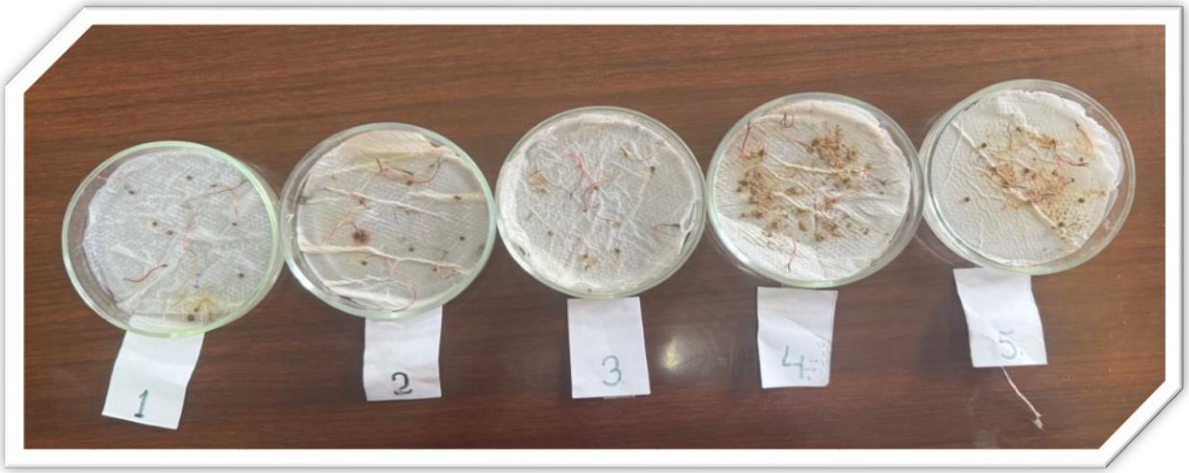


Figure 1. Experimental procedure for evaluating the germination of de-winged seeds

It is well known that seed germination depends on appropriate indoor lighting conditions. In accordance with lighting requirements, the standardization and hygienic assessment of natural illumination were based on two principal methods: the light-technical (instrumental) method and the geometric (calculation-based) method. The primary indicator of the light-technical method is the Daylight Factor (DF), which is determined using the following formula:

$DF = (E_1 / E_2) \times 100\%$

where E_1 represents the illuminance level inside the room, and E_2 represents the illuminance level outside the building. The normative values of the Daylight Factor are established according to the functional purpose of the room and the type of activity carried out within it. These standards comply with SanPiN 2.2.1/2.1.1.1278-03, “Hygienic Requirements for Natural, Artificial, and Combined Lighting in Residential and Public Buildings” (2003) [Methods for Assessing Lighting in Indoor Environments, https://ru.wikipedia.org/wiki].

On December 22, 2025, ten seeds from each treatment variant were placed in Petri dishes and moistened with 20–25 ml of water using a pipette. The germination indicators of the de-winged seeds are presented in Table 1.

Table 1. Germination Performance of De-winged Seeds Under Experimental Conditions

№	Treatment Variant	Dates and Number of Germinated Seeds									Total Germination (%)
		21.12	22.12	23.12	24.12	25.12	26.12	27.12	28.12	29.12	
1	Control	1	3	3	0	0	0	0	0	0	70%
2	Humimax	2	3	3	2	0	0	0	0	0	100%
3	Humimax + Bentonite	1	3	2	0	0	0	0	0	0	60%
4	Humimax + Clay Soil (Pakhsa)	0	1	1	1	1	0	0	0	0	40%
5	Humimax + Bentonite + Clay Soil	0	1	1	1	1	0	0	0	0	40%

Due to the relatively low room temperature (18–22 °C), a slight delay in seed germination was observed.



Figure 1. Process of Studying the Germination of Non-De-winged
(Winged) Seeds

Germination indicators may vary depending on temperature conditions; therefore, the number of germinated seeds was recorded daily. Germination of winged seeds was delayed by 4–5 days compared to de-winged seeds.

The germination performance of non-de-winged (winged) seeds is presented in Table 2.

Table 2.
Germination Performance of Winged (Non-De-winged) Seeds Under Experimental Conditions

№	Treatment Variant	Dates and Number of Germinated Seeds									Total Germination (%)
		21.12	22.12	23.12	24.12	25.12	26.12	27.12	28.12	29.12	
1	Control	0	0	0	0	3	0	0	1	0	40%
2	Humimax	0	0	0	0	4	0	0	2	0	60%
3	Humimax + Bentonite	0	0	0	0	2	0	0	0	0	20%
4	Humimax + Clay Soil (Pakhsa)	0	0	0	0	2	0	0	0	0	20%
5	Humimax + Bentonite + Clay Soil	0	0	0	0	1	0	0	0	0	10%

The highest germination rate was observed in the Humimax treatment (60%), while the lowest result (10%) was recorded in Treatment 5. The timing and duration of seed germination were influenced by ambient temperature conditions. Morphological assessment of seedlings obtained from black saxaul (*Haloxylon aphyllum*) seeds showed that the average total seedling length reached 50 mm, while the mean root length was 25 mm.

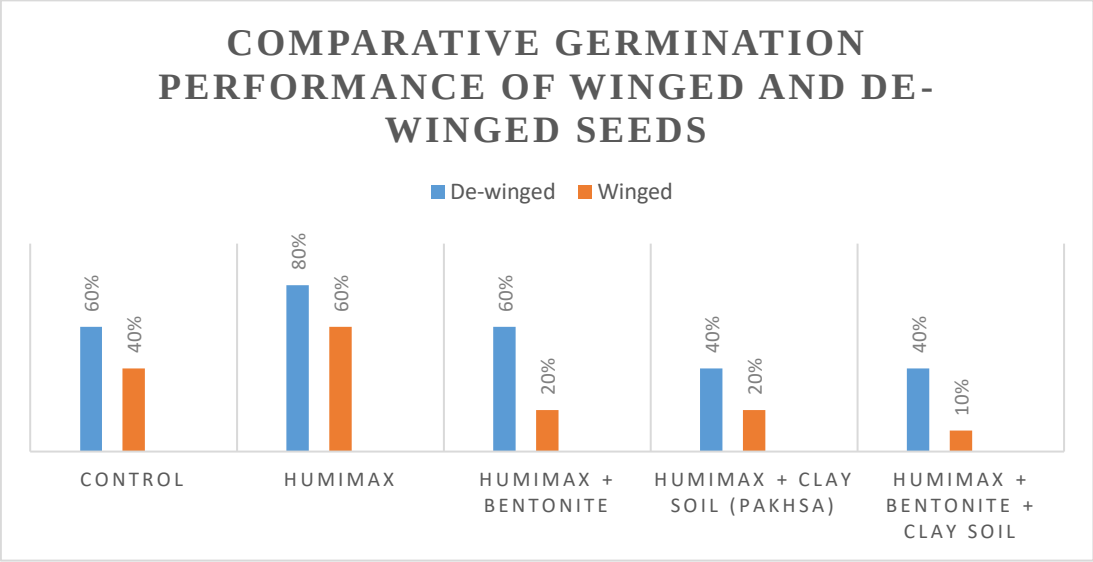


Figure 3. Effect of mineral nutrient elements on seed germination

These biometric indicators reflect satisfactory early growth under laboratory conditions and indicate adequate nutrient and moisture supply during the germination phase.

Results and Discussion (Enhanced Version)

Long-term studies conducted between 2006 and 2021 also investigated pre-sowing treatment methods, including seed wing removal and seed coating technologies [1–3]. Comparative analysis demonstrated that mechanical removal of seed wings ensures more uniform

water absorption and improves contact between the seed surface and the substrate, thereby positively influencing germination dynamics. In our preliminary studies, treatment with Humimax resulted in germination rates ranging from 60% to 80% within 24 hours.

Among all treatment variants, the highest germination rate was observed in de-winged seeds treated with Humimax. Under field conditions, seeds treated with substrate-based variants (254,600 seeds in total) demonstrated germination rates ranging from 15% to 47%, while by September these rates decreased to 1%–4.5%. These results may be explained by the presence of humic acids and biologically active substances in Humimax. These compounds activate metabolic processes, stimulate enzymatic reactions, and promote faster radicle emergence. In contrast, untreated and mixed-substrate variants exhibited comparatively lower germination percentages.

Conclusion

It should be emphasized that seed germination was strongly influenced by ambient temperature conditions. The relatively low room temperature during the experimental period caused a slight delay in the onset of germination. Germination activity gradually declined and ceased on December 29, indicating the temperature-dependent nature of physiological processes in saxaul seeds. Overall, the application of Humimax as an organo-mineral nutrient significantly enhanced the germination efficiency of black saxaul seeds. The obtained results provide a practical basis for improving large-scale afforestation and green cover establishment on the dried seabed of the Aral Sea.

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