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Creation of forest stands with the use of water-retaining polymeric nano-substances (hydrogels) on the drained bottom of the Aral sea

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Abstract. The Aral problem is of a planetary nature and its solution is possible only through large-scale forest reclamation. Every year, up to 150 million tons of salt, dust and sand rise into the air from the entire dried bottom located on the territory of Uzbekistan and Kazakhstan with an area of about 6 million hectares, which rise high into the sky, where they mix with clouds and are carried away to a distance of up to 1000 km. This is the tragedy of the century and it can be solved only by creating forest plantations. The studies were carried out on the sandy loamy plain of the former Rybatsky Bay of the dried bottom of the Aral Sea. In order to increase the germination of seeds of desert plants by increasing soil moisture, work was carried out on an area of 2 hectares. On the dry bottom of the Aral Sea, forest cultivation is difficult due to low rainfall and hot weather. This problem can be solved by introducing water-retaining polymeric nanosubstances into the soil. During the period of shoots in the places where nanosubstances were introduced, soil moisture increased by 1.5-2.2% compared to the control, and the survival rate of seedlings increased by 1.6-3.3%. When studying the effect of nanosubstances on a different range of desert plants, it was revealed that the number of seedlings of saxaul per 100 linear meters was more by 19.1 pcs, cherkez by 17.7 pcs, kandym by 7.5 pcs, Izen by 8.6, chogon by 12.3 and teresken by 13.6 pcs of plants than on control. In the experiment, the survival rate of saxaul and teresken was higher by 28%, and by autumn the mortality of saxaul was 3% and teresken 4%, and in the control, respectively, the mortality was 20 and 9%. The advantage is retained by the water-retaining polymeric nanosubstance produced in Perm. Therefore, in order to obtain abundant seedling shoots from seeds and increase the survival rate of seedlings in the extreme conditions of the dried bottom of the Aral Sea, it is advisable to use polymeric water-retaining nanosubstances.

1 Introduction

The problem of saving water all over the world, including in the Republic of Uzbekistan, is one of the most stable, because our state is located in the arid zone, where desert territories occupy 70% [7]. An area of 3.2 million hectares on the territory of the Republic of Uzbekistan

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is occupied by the dried bottom of the Aral Sea. Water saving is especially relevant in the agriculture of the Republic of Karakalpakstan and on the drained bottom of the Aral Sea. The main source of soil moisture loss on the dried bottom is its evaporation from the upper horizons due to heating under the influence of solar radiation and drying by dry winds. If we take into account the fact that the annual amount of precipitation on the dried bottom is no more than 90 mm, then it is clear that the above factors lead to the complete drying of the soil [8].

To solve the main environmental problem of Uzbekistan, it was necessary to carry out large-scale forest reclamation work on the dried bottom of the Aral Sea in order to create protective forest plantations to fix the easily deflating surface of the former bottom. However, we encountered difficulties, consisting in insufficient amount of moisture in the soil, and therefore the introduction of polymeric water-retaining nanosubstances (hydrogels) into the soil contributed to a significant improvement in the hydrological properties of the soil. The use of hydrogels reduces the evaporation of moisture, does not allow it to flow into the underlying layers of the soil, and contributes to the preservation of productive moisture in the root layer throughout the growing season. The study of the effect of hydrogels from different manufacturers allows us to more deeply understand its effectiveness in maintaining moisture in the soil, the effect on the seeds germination and the survival rate of seedlings of desert plants [9, 11, 12].

We set a goal - to develop an agricultural technology for the use of water-retaining polymeric nanosubstances to increase the survival rate of seedlings and the appearance of abundant seedling shoots in the extreme arid conditions of the dried bottom of the Aral Sea, which will allow retaining moisture in the soil for a long period and increase the survival rate of seedlings of desert plants by 10-25%.

2 Materials and methods

Research area. The studies were carried out on the sandy loamy plain of the former Rybatsky Bay of the dried bottom of the Aral Sea covered with sea shells. The sandy loam is located at a depth of up to 35 cm, and below it is underlain by loam, and then brown viscous clay mixed with loose sand. The natural and climatic conditions of the study area are typical for most of the dried bottom. The main factors determining the habitat of vegetation types on the dried bottom of the Aral Sea are soil salinity, the depth of mineralized groundwater and the composition of bottom sediments. The projective vegetation cover does not exceed 30%.

The dried bottom of the Aral Sea occupies the extreme northern position in the continental subtropical climate zone. The location of the territory in the depths of the mainland at a great distance from the oceans determines the aridity and continentality of the climate [1, 2]. The main features of the climate are an abundance of heat, moisture deficiency, long hot dry summers and relatively frosty winters, often repeated strong winds causing salt-dust storms, and significant evapotranspiration [5, 10].

The objects of research are the drained bottom of the Aral Sea, where seedlings of saxaul, cherkez, kandym, izen, chogon and teresken were planted, as well as seeds of these species were sown. When carrying out forest reclamation work, polymeric moisture-retaining nanosubstances from four manufacturers were used: BYM 5110 NIPI New Technologies, Perm, Russian Federation TSRICHT, Tashkent, Uzbekistan; "ZEBA" UPLLIMITED Gujarat India; "Polysorb-1" JSC, Kopeysk, Russian Federation. The experiment was laid on an area of 2 hectares. First, this area was cleared of vegetation, planned and fenced with tamarix branches, protecting it from wild animals.

Research methodology. Before the experiment was started, a geobotanical description of the research area was carried out according to the generally accepted methodology in forest reclamation: the relief, the type of bottom sediments, the species composition of plants and their projective cover, and the degree of natural self-overgrowing were described. The main elements of forest growing conditions that determine the possibility of using water-retaining nanosubstances on the dried bottom of the Aral Sea are not so much the climate as the topography and thickness of sand, the depth of groundwater, moisture reserves in the upper horizons, as well as the nature and degree of salinity along the profile [13]. Some differences in the climate of the plots could only determine the range of plants and the timing of the work, as well as the rate of application of water-retaining nanosubstances. Soil conditions were characterized by describing soil sections with a depth of at least 100 cm. Soil samples were taken from each genetic horizon for subsequent determination of the granulometric and chemical composition. Soil moisture was determined by the air-thermostatic method. Soil samples were taken using a soil drill along genetic horizons. Since the main goal was to determine the effectiveness of a water-retaining polymeric nanosubstance (hydrogel), the hydrogel was applied both in dry powder form and in liquid form in 4-fold repetition during sowing seeds and planting seedlings [15, 17, 18].

When sowing, the hydrogel was applied in two ways - the seeds were soaked in the hydrogel, mixed and then sown in the prepared soil. The second method was that the seeds were sown dry in the soil, and the hydrogel in liquid form was applied from above in the form of irrigation [6].

When planting seedlings, the hydrogel, both in dry and liquid form, was introduced into the planting hole, thoroughly mixed with the soil, after which the seedlings were planted.

During the entire growing season, biometric measurements of established seedlings were carried out and a record was kept of shoots from sown seeds.

The criteria for the effectiveness of a water-retaining polymer nanosubstance from different manufacturers are an increase in soil moisture throughout the growing season, a high survival rate of seedlings, and a large number of seedlings from sown seeds [19, 20].

3 Results and its discussion

Growing forest plantations on the dried bottom of the Aral Sea is associated with arid climate and lack of moisture in the soil. Therefore, it is so important to find substances whose introduction into the soil will increase its moisture content. Such a substance is a polymeric moisture-retaining nanosubstance, which is a network of cross-linked hydrophilic polymer chains. It can also be in the form of a colloidal gel, in which water is the dispersion medium [3]. A three-dimensional solid is obtained as a result of the fact that the hydrophilic polymer chains are held together by cross-links. The crosslinks that bind the polymers of nanosubstances fall into two main categories: physical and chemical. Physical cross-links consist of hydrogen bonds, hydrophobic interactions, and chain entanglements (among other things). Due to their inherent cross-linking, the structural integrity of the nanosubstance network does not dissolve due to the high concentration of water. Nanosubstances are highly absorbent (they can contain over 90% water) natural or synthetic polymer networks [14, 16].

We introduced water-retaining nanosubstances from different manufacturers during the sowing of seeds and when planting seedlings. One of the ways to sow the seeds was that before they were sown, the seeds were soaked in the nanosubstance, thoroughly mixed, and the sowing was carried out together with the water-retaining nanosubstance, i.e. in the liquid state [4].

The second method consisted in sowing the seeds of desert plants into the prepared grooves 2-3 cm deep, after which a layer of liquid hydrogel was applied on top. Seedlings were counted twice: in June and September. The obtained material was statistically processed and tabulated; at the same time, the soil moisture was studied in order to identify the effect of the nanosubstance on the moisture reserves in it throughout the growing season: April 6, May 6, June 18, and September 6. When creating forest plantations by sowing seeds, soil moisture in the horizon of 0-10 cm is important, i.e. in the seed horizon. It was revealed that the highest soil moisture during the sowing period was when using the nanosubstance of the brand "Polysorb" from Kopeysk and it was 3.2%, while in the control soil moisture was significantly lower and amounted to 1.3%. In the summer period, the advantage is retained by the nanosubstance produced in Perm and amounts to 1.7%, while in the control only 0.15%. The advantage of this nanosubstance is also preserved in September, and here the soil moisture content is 1.8%, while in the control it is 0.05%.

Table 1. Soil moisture (%) in experiments using hydrogel in the horizon 0-10 and 10-40 cm when sowing seeds (2022)

Hydrogel and its manufacturer	April 6		May 6		June 18		September 6	
	0-10 см	10-40 см	0-10 см	10-40 см	0-10 см	10-40 см	0-10 см	10-40 см
Perm	1.4	5.5	3.1	5.05	1.7	4.9	1.8	4.3
TSRICHTc.Tashkent	0.05	1.4	2.1	4.3	0.4	2.1	0.05	0.7
«ZEBA» India	1.5	6.0	2.5	7.5	0.65	2.9	0.3	1.9
"Polysorb", Kopeysk	3.2	7.9	2.2	4.8	0.7	3.1	0.7	2.1
Control	1.3	2.0	0.85	2.3	0.15	1.3	0.05	0.16

Table 2. Soil moisture (%) in experiments using hydrogel in the horizon 0-10 and 10-40 cm when planting seedlings (2022)

Hydrogel and its manufacturer	April 6		May 6		June 18		September 6	
	0-10 см	10-40 см	0-10 см	10-40 см	0-10 см	10-40 см	0-10 см	10-40 см
Perm	2.1	4.0	4.5	11.3	1.7	5.7	1.4	3.9
TSRICHT c.Tashkent	1.4	3.3	0.3	2.5	0	1.1	0	1.1
«ZEBA» India	2.4	4.3	2.8	5.5	0.2	2.6	0.3	1.5
"Polysorb", Kopeysk	1.7	3.2	1.8	4.8	0.6	3.8	0.9	2.1
Control	1.3	2.5	1.2	1.9	0.05	0.7	0	0.75

During the period of planting saxaul and teresken seedlings, we introduced moistened hydrogel from different manufacturers and it was important to have high soil moisture in the horizon where the root system of seedlings is located, i.e. in the horizon of 10-40 cm. In May, in the horizon of 10-40 cm, the soil moisture content when the nanosubstance produced in Perm was introduced was 11.3%, and only 1.9% in the control, while in June this nanosubstance also has an advantage and here the moisture content was 5.7%, and in the control 0.7% (Table 2).

Table 3. The number of seedlings of desert plants that appeared (pieces / 1 linear meter) in experiments using nanosubstances from different manufacturers

Hydrogel	Tree-shrub by species					
	saxaul	Cherkez	Kandym	Izen	Chogon	Teresken
	June 20, 2022					
c. Perm	25.0±1.24	21.5±0.82	21.4±0.53	14.7±0.68	20.3±0.54	20.2±0.68

c. Kopeysk	20.8±0.81	17.0±1.34	14.0±0.98	11.2±0.72	18.1±0.55	15.5±1.12
«ZEBA»India	17.8±1.39	17.7±1.11	12.6±1.28	11.8±0.29	9.9±0.37	10.0±0.65
TSRICHT c. Tashkent	9.5±0.87	10.9±0.86	7.4±0.86	8.2±0.92	7.9±0.88	8.2±0.70
Control	5.9±0.75	3.8±0.67	3.9±0.50	6.1±0.76	8.0±0.78	6.6±0.77
September 23, 2022						
c. Perm	20.4±0.76	17.2±0.64	15.6±0.98	12.1±0.45	14.3±0.76	14.5±0.98
c. Kopeysk	16.1±0.71	12.5±0.72	9.7±0.26	8.3±0.34	12.3±0.58	11.2±0.84
«ZEBA» India	12.4±0.65	12.6±0.97	8.7±0.63	9.4±0.56	6.7±0.91	7.6±0.79
TSRICHT c. Tashkent	6.7±0.28	6.1±0.42	5.2±0.67	6.3±0.14	5.3±0.56	6.2±0.37
Control	3.2±0.16	2.4±0.12	2.6±0.23	4.1±0.17	3.5±0.19	3.7±-.17

The data of the experimental material showed that the largest number of seedlings was detected when a nanosubstance produced in Perm was introduced, where the number of seedlings of saxaul compared to the control was 19.1 plants per 1linear meter, cherkez by 17.7 pieces, kandym by 17.5. Izeni by 8.6 pieces., chogon by 12.3 and teresken by 13.6 plants more than in the control. The second place is occupied by the nanosubstance produced by Kopeysk, the third by ZEBA India, and the nanosubstance produced by TSRICHT in Tashkent, where the number of seedlings was 7.4 - 10.9, was less effective. (Table 3).

A second evaluation of the preserved seedlings was carried out on September 23. It was very important to find out what effect the nanosubstance from different manufacturers has on plants during the hot season? Does it contribute to the preservation of plants at high air temperatures and is there a death of plants during this period of the year.

On September 23, when using a nanosubstance produced in Perm, there were 20.4 saxaul per 1 linear meter, which is 4.6 plants less than it was on June 20, cherkez by 4.3 plants, kandym by 5.8 plants, izen by 2.6 plants, chogon by 6.0 and teresken 5.7 plants less. In the control, where the nanosubstance was not used, the number of plants was very small, which cannot form the basis of future plantations. Moisture-retaining nanomaterial from other manufacturers also had a positive effect on the seeds germination, the survival of seedlings and their safety. The advantage is retained by the nanosubstance produced in Perm, here the soil moisture was significantly higher than in the control, which contributed to better seed germination and seedling survival.

No one had experience in studying the effect of nanosubstance on the survival rate of seedlings of tree and shrub species in Uzbekistan, especially desert plants in the extreme climatic conditions of the dried bottom of the Aral Sea. Therefore, it was important to study the effect of nanosubstances from different manufacturers on the survival rate of seedlings. 100 saxaul plants and 100 teresken plants were planted in clean rows per 100 running meter. A liquid nanosubstance was introduced into the planting holes at the rate of 5 grams per one, where it was thoroughly mixed with the soil.

Table 4. Seedling survival rate (pieces/100 linear meter) when using a water-retaining nanosubstance from different manufacturers

Hydrogel	Date of determination of survival			
	June 20		September 23	
	saxaul	teresken	saxaul	teresken
c.Perm	92±2.12	84±3.21	89±3.56	80±3.56
c.Kopeysk	86±3.45	81±3.48	82±3.42	76±3.45
«ZEBA» India	81±3.36	73±2.73	76±2.78	65±2.98
TSRICHT c.Tashkent	80±2.78	68±3.12	71±3.10	60±2.39
Control	64±2.29	56±2.45	44±2.20	47±1.57

The experimental material showed that the survival rate of seedlings is influenced by a polymeric moisture-retaining nanosubstance. However, not all nanosubstances have the same effect on plants and this depends on the manufacturer. So, when using a nano-substance produced in Perm, the data on the of survival assessment, carried out on June 20, showed that out of 100 planted plants, 92 saxaul plants and 84 teresken plants took root, and a second assessment conducted on September 23 showed that 89 saxaul and 80 teresken plants remained, i.e. the mortality was 3 and 4 plants (Table 4). When using the nanosubstance "Polysorb" 1 from Kopeysk in June, 86 and 81 plants took root in saxaul and teresken, by September 82 and 76 plants survived, and when using "ZEBA" UPLLIMITED Gujarat India, 81 and 73 plants, respectively, took root, and by September they survived 76 and 65 plants. In the control, where nanosubstances were not used, the survival rate of saxaul plants was 64 and teresken 56 plants, and by September, 44 and 47 plants remained, respectively (Table 4). If we compare the survival rate of plants according to the options for the use of nanosubstances from different manufacturers to the control where nanosubstances were not used, it was revealed that the mortality of saxaul and teresken in the experiment with the use of nanosubstances produced in Perm is 28 and 28 plants, and by September 23, 45 and 33 plants have fallen off . The obtained experimental material allows us to determine the advantage of the nanosubstance produced in Perm.

Table 5. Significance of differences in the survival rate of seedlings (pieces /100 linear meter) when using water-retaining polymeric nanosubstances from different manufacturers

Hydrogel	Date of determination of survival			
	June 20		September 23	
	saxaul	teresken	saxaul	teresken
c.Perm	9.0	7.0	10.7	8.5
c.Kopeysk	5.3	5.9	9.3	7.6
«ZEBA» India	4.2	4.6	9.1	5.3
TSRICHT c.Tashkent	4.4	3.1	7.1	4.6

Experimental studies have shown that the survival rate of seedlings with the introduction of moisture-retaining nanosubstances from different manufacturers into the planting hole contributed to a better survival rate of these seedlings and the differences are significant compared to the control (Table 5). Therefore, the introduction of water-retaining nanosubstances when sowing seeds and planting seedlings makes it possible to obtain a significantly larger number of seedlings and significantly increase the survival rate of seedlings.

4 Conclusions

Studies have shown that all water-retaining nanosubstances, regardless of the manufacturer, have a positive effect on the retention of moisture in the soil. It was revealed that the highest soil moisture in the spring was when using the nanosubstance of the brand "Polysorb" from Kopeysk and it was 3.2%, while in the control it was 1.3%. In summer, when the temperature on the soil surface was more than 50º C, the advantage was retained by the nanosubstance produced in Perm, where soil moisture was 1.7%, and only 0.15% in the control. The advantage of this nanosubstance is also retained in September, when soil moisture was 1.8%, and only 0.05% in the control.

The increase in soil moisture when the nanosubstance is applied compared to the control has a positive effect on the number of seedlings that appeared from the seeds of desert plants. The experiment showed that the largest number of seedlings was revealed when a nanosubstance produced in Perm was introduced, where the number of seedlings of saxaul compared to the control is 19.1 plants per 1 linear meter, cherkez - 17.7 pcs, kandym - 17.5, izen - 8.6 pcs, chogon - 12.3 and teresken by 13.6 plants more than in the control. Nanosubstances from other manufacturers also have a positive effect on the number of shoots that have appeared, but it is less significant.

The survival rate of seedlings depends on the manufacturer of water-retaining nanosubstances. When using a nanosubstance produced in Perm, the data on the survival assessment, carried out on June 20, showed that out of 100 planted plants, 92 plants of saxaul and 84 plants of teresken took root, and a second assessment conducted on September 23 showed that 89 saxaul and 80 plants of teresken remained, that is the mortality was 3 and 4 plants. In the control, the survival rate of saxaul was 64 and teresken 56, until September, respectively, 44 and 47 plants survived, the mortality was 20 and 9 plants.

Summarizing the above, we can conclude that the use of water-retaining polymeric nanosubstances can significantly increase the number of seedlings that have appeared from seeds and increase the survival rate of seedlings. In addition, it should be noted that the introduction of a nanosubstance into the soil increases the survival of plants and they more easily tolerate the summer heat, which reduces the number of fallen plants.

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