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Perspective Technology to Improve Arid Pastures

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Abstract. This article presents the problems of degradation-desertification of astrakhan pasture and hayfields. In these areas, contain all kinds of livestock, as well as diverse fauna. In lean years and degradation, above animals cause large losses.

Degradation, world science and practice recommended to be suspended by improvement, that is, by seeding of zoned fodder plants. Based on literature review, this article presents the features of perspective fodder plants of desert introduced into culture to improve arid pastures.

Uzbekistan contains only Karakul sheep, whose skin is very highly valued on the world market, more than 10 million heads. More than 4.0 hectares are required per sheep per year, and the pasture area is about 20.0 million hectares. To improve which more than 40,000 tons of Kochia seeds are required per year, for which it is necessary to create seed plants nurseries. Therefore, the authors of this research paper had the goal to develop perspective technology for improving arid pastures, with the creation of rational Kochia seed plants.

The results of existing scientific and practical work analyzed and present authors continue to study some indicators of physic-mechanical properties (friction coefficient for various materials) of Kochia seeds.

Existing technologies for improving pastures and hayfields, and creating seed plants were studied. These studies have developed the methodology and effectiveness of furrow sowing of the Kochia seeds, in comparison with surface sowing (control).

The main parameters are theoretically substantiated and experimentally confirmed – diameter and width, as well as the type of the covering roller of experimental seeder (based on grain-grass seeder) for sowing Kochia seeds, simultaneously forming a sowing furrow and seed embedment in them.

Based on the results of laboratory, field and economic tests of experimental desert seeder, optimal seedlings obtained of Kochia seeds and, subsequently, a high yield of fodder and seed mass.

A continuation of the proposed innovative technology for improving arid pastures, hayfields and creation of seed plants are preliminary and further research on control of pests and diseases of desert fodder plants and their seeds by biological methods, and the use of ultraviolet radiation.

Keywords: Sheep breeding, karakul (astrakhan) production, arid, desert, semi-desert, fodder plants, Kochia (Kochia prostrata), sagebrush, saxaul (Haloxylon), furrow sowing.

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I. INTRODUCTION

Sheep and goat breeding (SC – small cattle) is one of the leading livestock industries in the Republic of Uzbekistan [1]–[4]. Sheep breeding is subdivided by breed into meat-wool, fat tail and karakul sheep. The Republic contains more than 20 million small cattle, of which more than half livestock are Karakul sheep [2], [5], [6].

At present, for further development of SC of the Republic, it is necessary to increase the productivity of sheep, improve the breeding qualities of existing sheep breeds, mechanize technological operations, equip farms with latest machinery and equipment, and introduce rational methods for using pasture while preserving pasture cover. Unfortunately, the area of natural pastures and hayfields is decreasing every year. It has been proved by science and practice that it is necessary to increase the productivity, at the same time, nutritional value of pasture and haymaking fodder vegetation, turning natural-arid (desert and semi-desert) pastures and hayfields into cultivated ones [3]–[9].

To increase the productivity and nutrition of fodder vegetation, it is necessary to produce a radical or superficial improvement of pastures. Improvement of pastures and hayfields carried out by sowing or aftersawing of zoned and most perspective fodder plants, such as, for example, Kochia, sagebrush and saxaul [9]–[11].

For this, it is necessary for the Republic at least 40,000 tons of seeds per year. However, due to the lack of cultivated seed nursery-gardens (seed plant), seeds collected from wild plants by enthusiasts and scientific staff. The present research of this article posed the problem of developing an innovative (perspective) technology for creating seed plant for fodder plants to improve desert and semi-desert (arid) pastures and hayfields [1]–[2].

At the beginning of the research, based on a review of literature materials and joint research institutes of astrakhan breeding and desert ecology, soil-climatic characteristics and physic-mechanical properties of soil studied in the field during sowing in territory of Aidarkul in the Jizzakh region. The characteristics and physic-mechanical properties of fodder plant seeds of Kochia, sagebrush and saxaul, agrotechnical requirements for their cultivation were studied.

Based on the above and a review of existing grain grass seeders and devices for sowing seeds of desert fodder plants, technology for sowing seeds of Kochia, sagebrush and saxaul has been developed, the technological scheme and parameters of working bodies for sowing have been substantiated.

II. ORIGINAL BACKGROUNDS TO IMPROVE ARID PASTURES

Features of fodder plants introduced into the culture to improve arid pastures. The rational use of pastures, hayfields and seed production in arid zone should be based on knowledge of biological and morphological characteristics of individual plants and plant sociology, and an important place belongs to the right selection of highly productive fodder plants suitable for improving natural forage lands.

Since 1931, more than 250 species of wild plants tested in arid zone of Central Asia and Kazakhstan. Perspective species characterized by high productivity, drought, and salt tolerance are 25–30 species, such as saxaul, Kochia, sagebrush and others [1], [7], [9]. A common practical application received by Kochia (Fig. 1).

Fig. 1. Kochia (Kochia prostrata) of the second year standing, end of May 2017 (sowing on December 2015)

Kochia is cultivated in southern regions of the Russian Federation, in Central Asia, Kazakhstan and on the vast territory of the Eurasian continent. Kochia ("izen" is the local name) – Kochia prostrata (L.) Schrad, shrub with a height of 35–75 cm and differ in three ecotypes: sand, clay and rock. Kochia is a perennial, drought-tolerant, winter-hardy, high-yielding and highly nutritious fodder plant (according to its nutritional value, it is considered Lucerne arid zone). In 100 kg of dry food in Kochia, 45-60 feed units are contained. The average yield of Kochia in cultural form is 15 quintals/ha. Germination of Kochia seeds, laboratory 5.0–90.0%, and field - 0.05-17.0% [9]–[11].

III. CULTIVATING METHODS OF ARID FODDER PLANTS

In karakul breeding practice, two directions formed for improving natural fodder land - surface (partial) and radical [9]–[11]. Superficial – gives positive results on sandy soils with lighted grass stand. Main on continuous or broadband ploughing used on gray-brown, takyr, meadow, marsh and salt alkaline lands.

When improving the pasture with saxaul and creating a pasture of protective barriers, the strip is laid with a width of a = 25 m, between the sown stripes leave natural pastures with a width of b = 200–250m (Fig. 2).

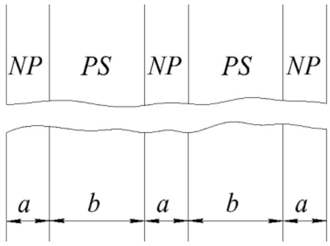

Fig. 2. Placement of natural pastures (a = NP) and improved saxaul pasture protective strips (b = PS)

When creating and improving autumn-winter and summer pastures and hayfields, and laying seed plants, selected area is divided into strips. Width of strips a = 10–30 m or a = 100 m with an inter-strip space of natural pastures of the same width b = 10–30; 100 m or twice as wide as b = (10–30; 100 m) x 2, apart from each other at an arbitrary length (Fig. 3). With all methods of improvement, bands are perpendicular to the direction of prevailing winds. Fodder plants must be cultivated on row spacing of 45, 60, 70, 75, 90, 105, 135 cm (for all types of plants) and 3 m (for saxaul) [10], [11].

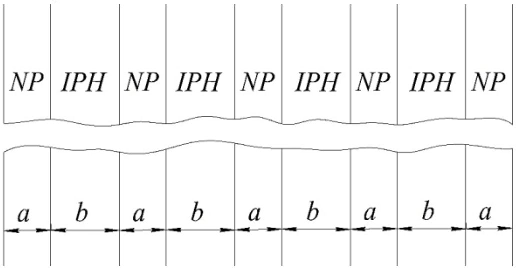

Fig. 3. Placement of natural pastures (a = NP) and improved pastures, hayfields or seed plants (b = IPH)

Crop care is an integral part of the cultivation of pasture plants. On overcrust of soils and with strong clogging seeding are necessary to cultivate in row spacing to a depth of 6.0-10.0 cm.

But, unfortunately, it cannot be used to grow for crops of fodder plants under production conditions due to the fact that until now seeds have been sown in astrakhan farms manually. At best, with existing grain-grass seeders, from which the coverer (working organs) are then removed, so as they do not provide shallow embedding. In addition, seeds mixed with ballast (dry sand, mineral or organic fertilizers). Embed of seeding is done with additional working organs (spike-tooth harrow or roller) or with passage flock of sheep.

IV. AGROTECHNICAL REQUIREMENTS AND PHYSIC-MECHANICAL PROPERTIES OF SEEDS

A. Agrotechnical requirements

A necessary agrotechnical method in agriculture is high quality ploughing and pre-sowing tillage, which is also required when cultivating pasture fodder plants.

When improving pasture and creating seed plants, it is very important to establish the optimal seed rate and apply seeds of the first or second class [10].

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Optimum seed sowing rates at 100% field germination and seed purity, respectively, of saxaul 5.0 kg/ha and Kochia 3.0 kg/ha. Weediness (fruitstalks, seed wings, particles of branches and stems) of seeds can be – saxaul is up to 50.0% and Kochia to 75.0%. The moisture content of seeds should not be higher than 15.0%. Seeds of saxaul and Kochia is necessary planted to a depth of 1.0 cm [10], [11].

A number of domestic and foreign scientists' works indicated that the seeds of arid fodder plants that requiring shallow embedment is necessary to embed with light or sowing spike-tooth harrow, to roll together annuloid or smooth rollers, or just press them into the soil.

B.Physic-mechanical properties of seeds

Physic-mechanical properties of seeds are specific in nature and are determining factor in creation or improvement of any machines, in particular, sowing machines. In our case, we study the physical and mechanical properties of Kochia seeds. Kochia seeds are round-oval or almost round with an annular germ, the diameter and thickness varies between 1.6–4.2 mm and 0.75–2.5 mm, respectively [10]–[13].

Apparent density and weight 1000 pcs Kochia seeds are in the range of 150–220 g/dm^3 and 0.7–2.5 g, respectively, which indicates lightness and their large volume.

The flowability of seeds is characterized by repose angles (α), and are divided into four groups – increased α = 26º, granular α = 27º–40º, lowered α = 42º–50º and non-granular α = 52º–90º. Moreover, characterized by degree of flowability (η), which subdivided into four groups according to the classification: large η = 0.87, medium η = 0.76, small η = 0.51 and non-granular η = 0.33. From this, it can be seen that Kochia seeds in the repose angle are within the range of α = 2º–64º and flowability degree is η = 0.32–0.34. However, it is subdivided according to the classification – non-flowing, which complicate the use of existing sowing devices without additional special devices or equipment [7].

To develop a seeder, it is studied coefficient of sliding friction of Kochia seeds on the surfaces of materials found in development of rubbing surfaces – steel sheets, planed pine boards, rubberized fabric, rubber, cast iron, polyethylene and seeds over seeds at immobility and in motion at moisture content of 12-14% and seed purity 25-100%. The results showed that friction coefficient of Kochia seeds fluctuates, at immobility 0.40–2.2 and in motion 0.31–2.61.

Improvement made in autumn-winter period, at this time of the year wind speed reaches 20 m/s, an average of 5 m/s per year. Hence, it was determined that Kochia seeds are lightweight and aerodynamic properties of seeds are high, in the range 0.50–5.40 m/s.

V. CHARACTERIZATION OF ARID PASTURES AND SOIL BEFORE SOWING

A. Climatic conditions of arid pastures

The Central Asia's arid climate characterized by specific rhythm of natural phenomena and certain level of climatic indicators from northern deserts of our continent.

In deserts and semi-deserts, summers are hot, very dry and long continued; air temperature reaches + 80°, and soil surface + 90°. In summer, the temperature is + 40–45 °C, and in winter, there are – 30° frosts. The soils of the desert zone of Uzbekistan divided into six types: gray-brown (at 0.3–0.6% humus), takyr (less than 1.0%), desert-sand (0.5–0.6%), meadow (1.0–2.0%), sagebrush-ephemeral and marsh (5.0–6.0%) [9].

B. Physic-mechanical properties of arid pasture's soil before sowing

The physic-mechanical properties of soil prepared for sowing were studied in autumn-winter period after main and pre-sowing cultivation of the field in December 2015-2016 on territory of the Karakul farm of M.Akhmedov, Farish district, Jizzakh region. The moisture, hardness, repose angle, static and dynamic coefficients of friction, soil resistance during vertical crushing, soil aggregate composition and strength of soil lumps were studied. The soil characterized by light gray earth, of light and medium mechanical composition with layered structure, without significant salinization of upper layers, with slight plastering and low nutrient content.

Physic-mechanical properties of soil, before sowing studied according to GOST 20915-2011 "Agricultural machinery. Methods for determining test conditions".

The results of studies show that physic-mechanical properties of soil of arid zone, the soil moisture and hardness varies horizontally between 0–5, 5–10, and 10–15 cm, while moisture decreases from 11.5 to 5.2%, and hardness increases from 0.49 to 1.53 MPa. The repose angle of soil is in the range of 6–25°, the friction coefficient of soil at moisture content is of 5.5 to 10.3% about the surface of painted and polished steel, smooth rubber and soil against the soil is at immobility – 1,983–0,342 and in motion – 1,536–0,157. Soil resistance during vertical crushing at horizon of 0–5 cm and moisture content of 6.5–10.3% is in the range of 0.5–2.9 kg/mm^2, which is quite satisfactory for calculating parameters of covering roller. Aggregate composition of soil of the desired fraction of 2.0–5.0 mm can be achieved with any soil moisture content of 6.6–10.7% by mechanical presowing treatment, with tooth harrows with multiple passes of unit. The breaking load increases from 5.0 to 30.0 N and specific strength of lumps decreases from 960 to 14 g/cm^3 with an increase in the volume of lumps between 1.0 cm^3 and 10.0–250.0 cm^3.

VI. PROPOSED METHODS OF PERSPECTIVE TECHNOLOGY FOR SOWING KOCHIA

Studies have established that Kochia seeds are necessary for even distribution of seed material. First sowing on the surface of soil dispersion over width of 100 mm and then to embed them with roller having a rim width of 100 mm, which forms furrow with a width of b=95–100 mm and depth of h=20–30 mm. Embedding of seeds to a depth of 10 mm occurs due to longitudinal deformation of soil, crushing of soil lumps and pressing (indentation) of seeds to the bottom of the furrow (Fig. 4).

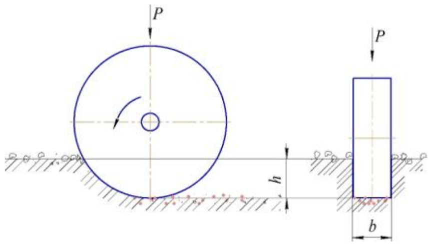

Fig. 4. The technological scheme of seed embedding and formation of sowing furrow

The suggested sowing furrow provides uniform distribution of seeds during sowing, protects them from blowing, and creates favorable conditions due to moisture retention and ingress direct sunlight in the period of emergence and seedlings growth. During the growth of young plants, backfilling by wind of tillering node occurs, which protects them from breaking (Figures 5–9).

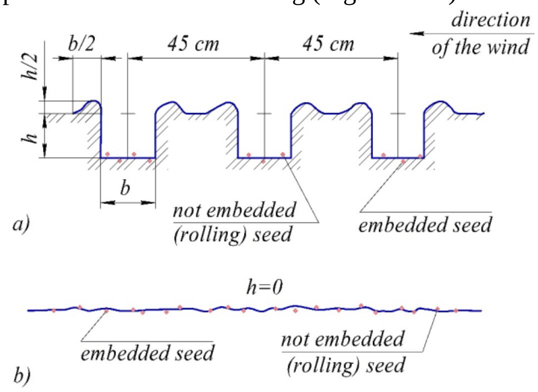

Fig. 5. Scheme (shape) of the sowing furrow with soil huddle (method 1), during sowing; *h* – depth of the furrow, mm; *h*/2 – height of the huddle, depending on half depth of the furrow, mm; *b* – furrow width, mm; *b*/2 – width of the huddle, depending on half the width of the furrow, mm

The Table-I shows profile parameters of experimental furrow with soil rollers (option *a*, method 1) and the control, on the field surface (option *b*, method 1), during the sowing of seeds of desert fodder plants using an example of a Kochia (Fig. 6).

Table-I: Profile parameters of experimental sowing furrow with soil rollers and control on the field surface during sowing of Kochia seeds

a	**1** – h = 20–30	**2** – h = 20–30	**3** – h = 20–30
	b = 45–50	*b* = 95–100	*b* = 145–150
	h/2 = 10–15	*h*/2 = 10–15	*h*/2 = 10–15
	b/2 = 22,5–25	*b*/2 = 47,5–50	*b*/2 = 72,5–75
	4 – *h* = 50–60	**5** – *h*=50–60	**6** – *h*=50–60
	b = 45–50	*b* = 95–100	*b* = 145–150
	h/2 = 25–30	*h*/2=25–30	*h*/2=25–30
	b/2 = 22,5–25	*b*/2=47,5–50	*b*/2=72,5–75
b	the control: *h* = 0; *b* = 0		

The furrow-sowing scheme was laid in two ways. The first – with soil huddle on surface of the furrows, depending on depth and width of furrows width (Fig. 5), second - furrows were without soil huddles (Fig. 6).

The furrows depth in both ways was in two versions 20–30 mm and 50–60 mm. Each depth option was studied with a width of 45–50, 95–100 mm and 145–150 mm. A further increase in width of furrows leads to decrease in protective zone of plants during inter-row processing. Therefore, limited to width of 145-150 mm.

In each variant, the seeding rate of the Kochia was 5 kg/ha and embedding by rolling. A control option was existing seeding technology (seeding rate of 5 kg/ha), that is, sowing seeds on surface and seeding them with harrowing.

The plot of experimental crops and control had a route length of 50 m. Experimental crops laid perpendicular to the prevailing winds.

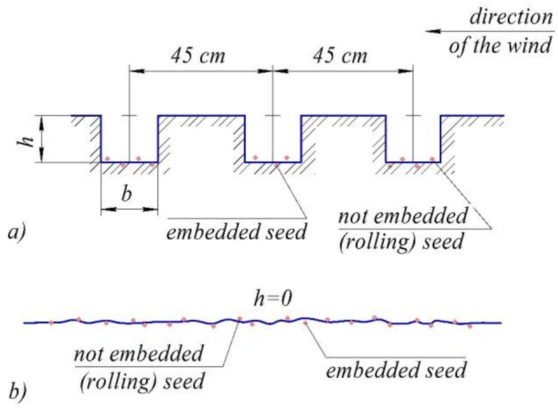

Fig. 6. Scheme (shape) of the sowing furrow without soil huddle (method 2), during sowing; *h* – depth of the furrow, mm; *b* – furrow width, mm.

The Table-II shows profile parameters of experimental furrow without soil rollers (option *a*, method 2) and the control, on the field surface (option *b*, method 2), during the sowing of seeds of desert fodder plants using an example of a Kochia (Fig. 7).

Table-II: Profile parameters of experimental sowing furrow without soil rollers and control on the field surface during the sowing of Kochia seeds

a	**1** – *h* = 20–30	**2** – *h* = 20–30	**3** – h = 20–30
	b = 45–50	b = 95–100	b = 145–150
	4 – h = 50–60	**5** – h = 50–60	**6** – h = 50–60
	b = 45–50	b = 95–100	b = 145–150
b	the control: *h* = 0; *b* = 0		

The results of sowing furrows influence on seedlings and further growth of Kochia plants established by phenological observations according to the generally accepted method [11].

VII. EXPERIMENTAL RESULTS AND DISCUSSION

Phenological observations carried out in 2016-2018 over the 2015 sowing of the Kochia in furrows with and without soil huddles (test variants) and on the field surface (control) showed (Tables III and IV) that the best way to sow seedlings is density of plant standing and growth is furrow without soil huddles 20–30 mm deep and 95–100 mm wide.

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Negative indicators of plantlets, density of standing and growth of Kochia plants in furrow with soil huddles (Fig. 5, Table-III and Fig. 7) are explained by the fact that the soil huddles located on the edge of furrow slide into it from the winds action and precipitation. As a result, seeds backfilled to a greater depth (more than 2.0 cm, by "Agro Technical demands" no more than 1.0 cm) [11]. Further, by the wind, due to the movement of the soil huddles remains, young plants (seedlings) backfill with.

Table-III: Seedlings indicators, density of standing and growth of plants in a furrow with soil huddles (sowing – December 2015)

№	Experiment options (furrow diagram), *h*, *b*, *h*/2, *b*/2 – mm	Plantlets, pcs/ha, May, 2016	Density of standing, pcs/ha			Average plant height, cm			
			November			*May, 2016*	*November*		
			May, 2016	*2017y*	*2018y*		*2016y*	*2017y*	*2018y*
1	*h* = 20–30 *b* = 45–50 *h*/2 = 10–15 *b*/2 = 22,5–25	8400	2350	2900	2600	2,6	24,9	32,1	63,1
2	*h* = 20–30 *b* = 95–100 *h*/2 = 10–15 *b*/2 = 47,5–50	8200	5100	5600	5400	2,3	23,6	31,2	63,2
3	*h* = 20–30 *b* = 145–150 *h*/2 = 10–15 *b*/2 = 72,5–75	8100	5100	4550	3600	2,4	22,8	31,3	62,9
4	*h* = 50–60 *b* = 45–50 *h*/2 = 25–30 *b*/2 = 22,5–25	4100	780	970	880	1,4	21,6	29,5	52,7
5	*h* =50–60 *b*=95–100 *h*/2=25–30 *b*/2=47,5–50	4400	1100	1500	1280	1,9	19,5	28,7	52,4
6	*h*=50–60 *b*=145–150 *h*/2=25–30 *b*/2=72,5–75	4600	1650	1200	1020	1,7	16,8	27,9	51,8
7	*h*=0; *b*=0 (the control)	8060	4500	5100	4750	2,5	26,4	36,1	70,8

Table-IV: Indicators of seedlings, density of standing and growth of plants in a furrow without soil huddles (sowing - December 2015) 2016 November

№	Experiment options (furrow diagram), *h*, *b* – mm	Plantlets, pcs/ha, May, 2016	Density of standing, pcs/ha			Average plant height, cm			
			November			*May, 2016*	*November*		
			2016y	*2017y*	*2018y*		*2016y*	*2017y*	*2018y*
1	*h* = 20–30 *b* = 45–50	11200	9090	9500	8300	3,7	33,5	41,7	73,4
2	*h* = 20–30 *b* = 95–100	16180	14000	15030	15020	4,9	35,6	46,3	74,0
3	*h* = 20–30 *b* = 145–150	16000	13000	13100	10080	4,8	36,3	42,6	73,6
4	*h* = 50–60 *b* = 45–50	9900	8700	8800	8400	3,9	31,7	41,5	73,7
5	*h* =50–60 *b*=95–100	12200	6800	7300	7000	3,7	31,4	37,4	73,5
6	*h*=50–60 *b*=145–150	14300	6200	6100	5800	3,5	31,9	39,8	73,7
7	*h*=0; *b*=0 (the control)	9600	5020	5420	4830	2,8	29,2	34,5	71,0

According to the results of phenological observations (Table-III), it is clear that even when sowing on soil surface (control), the best indicators obtained for seedlings and plant stand density in comparison furrows with soil huddles.

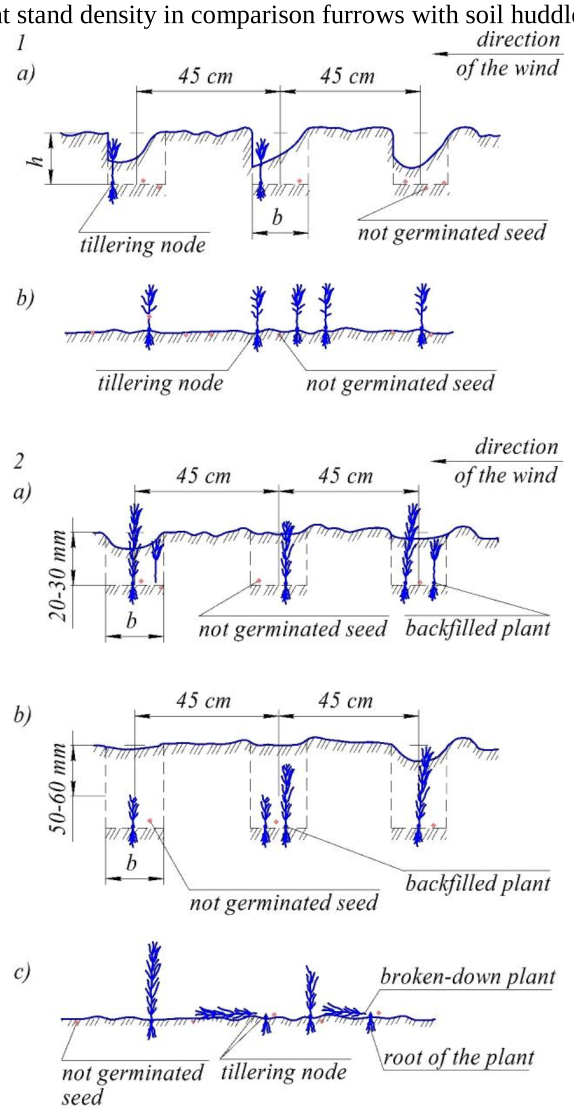

Fig. 7. Scheme (profile) of sawing furrow with soil huddles. *1*) during the plantlets period, May 2016: *a*) sowing in furrow; *b*) seeding on the surface of the field, control. *2*) during vegetation, November 2016y: a) sowing into furrow with a depth of h = 20–30 mm and a width of b= 45–50 mm, 95–100 mm and 145–150 mm; *b*) sowing into furrow with a depth of h = 50–60 mm and a width of b = 45–50 mm, 95–100 mm and 145–150 mm; *c*) seeding on the field surface, control, h = 0; b = 0

Studies have shown that seeding into a furrow without soil huddles with a depth of 20-30 mm and a width of 95-100 mm is the best compared to other options (furrow shapes) and control (Fig. 6, Table-IV and Fig. 8).

When sowing in furrows with depths of 20–30 mm and 50–60 mm, width of 45–50 mm, seeds accumulate, which subsequently inhibit the seedlings of each other in the first year of life. Sowing in furrows with depth of 20–30 mm and 50–60 mm and a width of 145–150 mm showed that plants (plant standing density) die after some time due to their density.

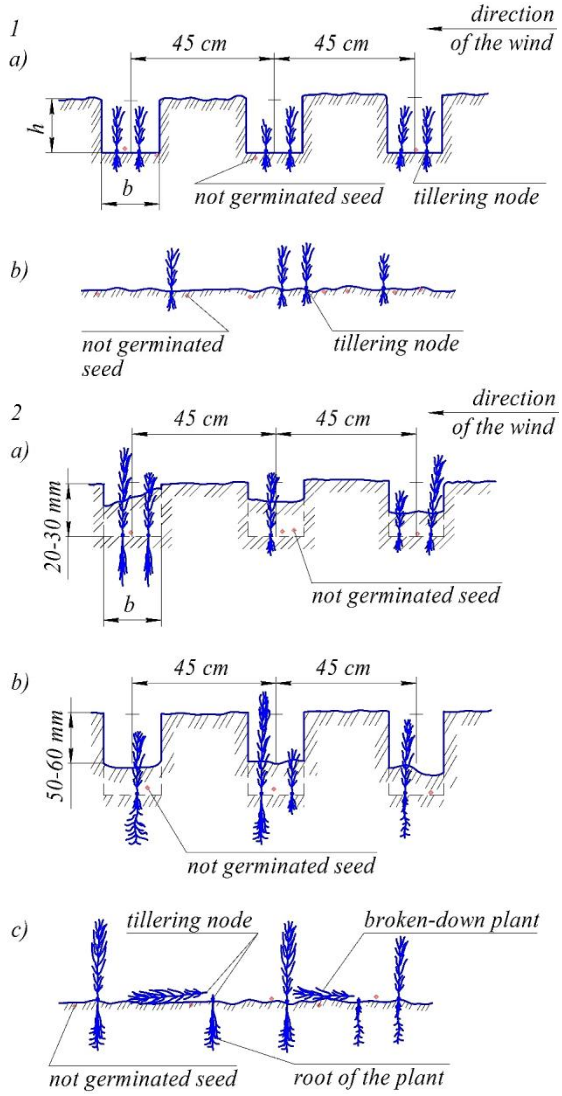

Fig. 8. Scheme (profile) of the sowing furrow without soil huddles. *1*) during the plantlets period, may 2016y: a) sowing in furrow; *b*) seeding on surface of the field, control. *2*) during vegetation, November 2016y: *a*) sowing into furrow with a depth of h = 20–30 mm and a width of b = 45–50 mm, 95–100 mm and 145–150 mm; *b*) sowing into furrow with a depth of h = 50–60 mm and a width of b = 45–50 mm, 95–100 mm and 145–150 mm; *c*) seeding on the field surface, control, h = 0; b= 0

On the control sowing, high indicators were obtained, but during growing period a large number of plants died, due to the fact that the soil under plants dries quickly, in addition, tillering node of most plants is in open state. All this leads to poor growth of plants and their conservation. With an open tillering node, young outgrowths break due to the action of strong winds (15–20 m/s).

Indicators of seedlings, density of standing and growth of Kochia in furrow with a depth of 20–30 mm and width of 95–100 mm were obtained, apparently, positive due to the fact that plantlets across the furrows do not oppress each other. Since their number is smaller compared to the furrow width of 145–150 mm. In addition, there is no crowding of seeds as in variant with a width of 45–50 mm. Further,

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plantlets and young plants in a furrow with depth of 20–30 mm do not completely backfilled, as in a furrow with soil huddles and tillering node of plants is below the horizon, and this contributes to their increased resistance to winds and high temperatures.

Analysis of the research results showed that the most favorable method of sowing is furrow without soil huddles, with flat rectangular bottom of the profile shape for parameters with a depth of 20-30 mm and width of 95-100 mm (Fig. 6). Therefore, more than 16 thousand pcs/ha plantlets were obtained, which by the third year of sustainable survival, more than 15 thousand pcs/ha of plants remained and their average growth reached 74 cm (Tables III and IV), which respond to agrotechnical (10–12 thousand pcs/ha and 50-60 cm) instructions [11].

As a results of literature review, observations of existing technologies and working hypothesis of sowing seeds of desert fodder plants. As well as agronomic studies (the results of the agronomic value of sowing furrow were presented in detail in this article above) carried out by authors (2015–2019y), it was found that they should be sown in prepared furrow with flat rectangular bottom 95–100 mm wide and 20–30 mm deep.

This furrow provides uniform distribution of seeds during sowing, protects them from blowing, and creates favorable conditions due to moisture retention and direct sunlight from the emergence and growth of plantlets. In addition, during growth of young plants there is backfilling with soil moved by the wind of tillering node, which protects them from breaking.

Based on the above results, working hypothesis was put forward that seeds of desert fodder plants need to distribute. Seeds firstly to sow on surface of the soil randomly spread over a width of 100 mm and then embed them with roller to rim width of 100 mm, which forms furrow with width of 95–100 mm and depth of 20–30 mm. Seeding's to a depth of 10 mm occurs due to longitudinal deformation of soil, crushing of soil lumps and pressing of seeds to the bottom of the furrow (Fig. 4).

A review of existing seeder designs and studies showed that their coverer does not provide above technology for sowing and seeds embedding of desert fodder plants.

The objective of theoretical research was to substantiate new technology for seed embedding of desert fodder plants based on the advanced working hypothesis and parameters of covering roller for its implementation (Fig. 4).

The question of dependence of sowing furrows depth and shallow seed embedding on parameters of the roller in literature is not illuminated. However, when considering these issues by analogy, one can use well-known theories of wheels and rollers, which highlighted in the research of V.P.Goryachkina, N.P.Krutikova, G.M.Rudakova, S.S.Sahakyan and many others [14-19].

Some researchers, to determine track depth (in our case, the depth of seed furrow) of wheel and roller offer their own formulas, while assuming that the relationship between specific load and track depth is expressed by power equation:

$$P = ch^{\mu} \tag{1}$$

Taking dependence (1) with an index of μ = 0.5 for ploughed loose soils at depth of the track or roller of 30–40 mm, S.S.Saakyan recommends following equation for determining residual depth of track:

$$h = \frac{1.22Q^{1.1}}{q^{1.1}B^{0.25}D^{0.45}} \tag{2}$$

where: Q – load on the wheel or roller; B – width of the wheel rim or roller; D –diameter of the track or roller; q – the coefficient to characterizing soil resistance to crushing (the coefficient of volumetric crushing of the soil), for ploughed field – 1.5–3.0.

During operation, the wheel and roller form not only truck, but also meet with soil clods and lumps, while rolling, they rise on them, as a result of which the lumps break, crumble or press into soil due to pressure. However, with considerable height of lumps and clods, roller or wheel of small diameter can drag clods or lumps of soil in front of itself. In this regard, there is a violation of the technological process of the wheel or roller, as well as their agricultural indicators. To eliminate this drawback, determine the height of the clod, and lump h_1, S.S. Saakyan presents the following equation:

$$tg(\gamma_1 + \gamma_2) \geq \frac{2\sqrt{h_1 D - h_1^2}}{D - 2h_1} \tag{3}$$

where: γ_1 and γ_2 – angles of friction; h_1 – height of the clods and lumps; D – diameter of the wheel and roller.

From expression (3), knowing angles of friction and diameter of the wheel and roller, it is possible to determine the height of clod through which wheel or roller can pass (roll over) without dragging it in front of itself.

The wheel and roller during operation, as mentioned above, forms track, while breaking, crumbling and pushing soil clods and lumps, and forms soil huddle in front of it. The work of researchers shows that the height of soil huddle, i.e. longitudinal soil deformation, largely depends on diameter of the wheel and roller.

The height of soil huddle at the same depth of truck formation increases with decreasing diameter of the wheel and roller. Therefore, use of small diameter wheels and rollers leads to negative results, unnecessarily increasing traction resistance of the wheel and roller. A high soil huddle is formed in front of heavy wheel and roller of small diameter, and there are cases when wheel and roller drags the soil forward.

To reduce soil huddle (longitudinal deformation of the soil) it is necessary to calculate correctly diameter of the wheel or roller according to the recommended S.S.Saakyan formula:

$$D \geq \frac{2h}{1 - \cos\alpha} \tag{4}$$

By formula (4), you can determine the admissible minimum diameter of the wheel or roller, given values of h and α. At the same time, given depth h of the wheel track or roller, according to the agrotechnical requirement. Wrapping angle α of the wheels' rim or roller with soil, S.S.Sahakyan recommends within 15-20°.

It should be noted that during operation of the wheel and roller, cracks are formed at the bottom of the track, which negatively affect agricultural indicators, and to reduce size of soil cracks, the diameter of the roller and the track depth should be chosen so that angle of the wheel rim and roller is no more than 45°.

To preliminary definition diameter of the covering roller in order to form a sowing rectangular shape of furrow with a depth of 20–30 mm, the interaction of the roller with soil analyzed according to the scheme (Fig. 9) using formula (4), S.S.Sahakyan. From *ΔOCE* we have:

$$\cos\alpha = \frac{OE}{OC} = \frac{R}{OC} \quad (5)$$

Where $OC = OA + AC = R + AC$; α – wrapping angle; R – radius of the roller.

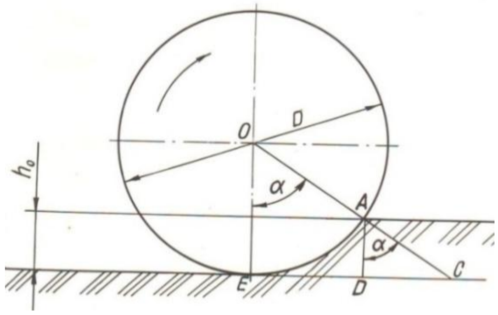

Fig. 9. Interactions of the covering roller with soil

Now we determine the length of *AC*. From Δ*ACD*, we have:

$$\cos\alpha = \frac{AD}{AC} \quad (6)$$

from here:

$$AC = \frac{AD}{\cos\alpha} = \frac{h_o}{\cos\alpha} \quad (7)$$

where h_0 – the depth of furrow.

Having found length of the *AC* (7), we substitute it into formula (6) and determine length of the *OC*:

$$OC = R + \frac{h_o}{\cos\alpha} \quad (8)$$

Having determined length of *OC* (8), we substitute in formula (5), we find wrapping angle of roller:

$$\cos\alpha = R / (R + \frac{h_o}{\cos\alpha}) \quad (9)$$

from here:

$$R\cos\alpha + h_o = R \quad (10)$$

$D\cos\alpha + 2h_0 = D$; $D(1-\cos\alpha) = 2h_0$

Using formula (10), we determine covering roller diameter:

$$D = \frac{2h_o}{1-\cos\alpha} \quad (11)$$

Calculations (Fig. 10) based on the obtained formula (11) show that for the formation depth of the sowing furrow within h = 20–30 mm, roller with a diameter of D = 170–450 mm and wrapping angle α = 15–45° is required.

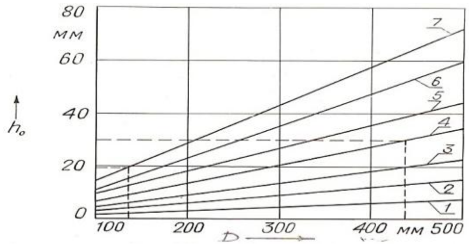

Fig. 10. The depth *h* of seed furrow from diameter *D* of the covering roller and wrapping angle α of the roller rim:

1–α =15º, 3–α =25º, 5–α =35º, 7–α=45º;
2–α =20º, 4–α =30º, 6–α =40º

The task of choosing type of covering roller is to provide the required depth of sowing furrow and seed embedding. Seeds of forage plants in arid zones are sown in autumn-winter period, on covering rollers with metal and rubberized surface, wet soil sticks to it, and this violates technological process of seeds embedding. Based on this, support roller with an atmospheric pressure tire was selected from existing vegetable cultivators. Experimental studies have shown (Fig. 11), for given roller, in this case, covering roller that the surface of this one is not smudged by soil. This is due to the fact that when covering roller presses on soil, tire drowns inward to the rim by a small amount. Further, when the contact point of tire with soil is left behind and contact point rises, the tire, due to its elasticity, returns to its original position. In this regard, having such a property, roller with a tire of atmospheric pressure does not smudged by soil.

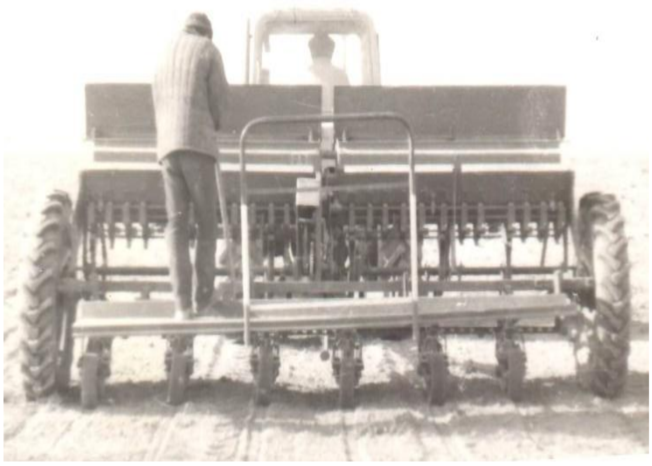

Fig. 11. Converted grain-grass-seeder SZT-3.6 (experimental) on sowing seeds of desert fodder plants (Kochia-"izen")

The use of converted seeder will reduce direct costs and labor costs, respectively, two times and more than 20%. As well as the rate of sowing seeds 2–3 times and get an economic effect without taking into account the yield of at least $150 per hectare and produce inter-row cultivation in comparison with existing technologies for sowing seeds of arid fodder plants (Fig. 12).

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Fig. 12. Crops of third year of standing, Kochia (izen) seeded with experimental seeder (astrakhan farm M.Akhmedov, Farish district of Jizzakh region, June 2019)

Further research to improve arid pastures and seed plants continuing with development of devices and equipment for: - stimulation of seeds with ultraviolet rays before sowing; - biological control of pests and diseases of feed plants [20], [21].

VIII. CONCLUSIONS

1. An analysis of literature review showed that the world problem of arid zones due to non-operational exploitation is subject to severe degradation-desertification.

2. The degradation of desert and semi-desert pastures in Central Asia and Kazakhstan can only be stopped by radical or surface improvement, that is, sowing and aftersawing of desert perspective fodder plants (Kochia, Salsola orientalis, Salsola subaphylla, etc.) and afforestation (saxaul, etc.).

3. Science and practice have proven that furrow seeding is the best way to improve pasture in arid zone. Since with this method the seeds do not volatilize, by gradually mole the soil under plants from year to year, plants become stronger. Furrows trap snow and moisture, which is very important in desert areas.

4. Practice have shown that, when applying to sow grain-grass-seeders for sowing of desert plants seeds, while removing the coverer. In all cases, seed embedding is carried out by harrowing, to rolling together or driving flocks of sheep.

5. Desert fodder plants must be sown on row-spacing of 45, 60, 70, 90 cm and 3 m for saxaul. Seeds embed by rolling into a rectangular furrow with a depth of 20-30 mm and a width of 95-100 mm.

6. These studies have developed the technology of furrow method for sowing desert fodder plants and substantiated its parameters. To implement this technology, technological scheme of seeder, substantiated its operation mode and basic parameters of its coverer.

7. The most suitable for sowing seeds of arid fodder plants is SZT-3.6 trailed converted grain-grass-seeder, which has special coverer developed on the basis of existing agricultural machines.

8. Studies indicate that coil sowing apparatuses of the SZT-3.6 grain-grass-seeder provide sowing of Kochia, saxaul, Salsola orientalis and sagebrush seeds with satisfactory uniformity of sowing, which corresponds to agrotechnical requirements. When Kochia sown with purity in range of 25–100% and germination rate is 10–100%, the unevenness is within the permissible range of 1.2–10.0%.

9. Based on the present research, it is recommended section of the seeders' coverer, which has windproof device from two disks mounted in parallel to each other and covering roller. Covering roller with atmospheric pressure tire with a diameter of 300 mm and a rim width of 100 mm.

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