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Development of a Model, Selection and Evaluation of the Source Material for the Plant Breeding of Alfalfa Varieties with Increased Seed Productivity

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Abstract: The article presents the results of laboratory and field experiments on the source material of alfalfa in the conditions of Northern Kazakhstan. The purpose of the present research was to study and evaluate the selective value of alfalfa variety populations, as well as to isolate a new source material for creating alfalfa varieties with high seed yields. The experiments were conducted in 2018-2020 in the Kokshetau Experimental Production Farm LLP (Changing village, Zerendinsky District, Akmola Region), located in the steppe zone of Northern Kazakhstan. As a result of research on alfalfa culture, the study of morphological and economically valuable features of an extensive gene pool, the trends in the plant breeding development and production requests, an improved model of a new type of alfalfa varieties with high seed yield was compiled. The following main parameters of the model are experimentally justified: Seed yield, the duration of the blossom time, the shape of the bush, resistance to pests (Tychicus-seed weevil), overgrowth, bushiness, shedding (flowers, beans), bean setting capacity and self-fertility, which predetermine the high seed productivity of plants. According to the results of the experiments, promising samples were identified based on the severity of individual traits and their combination for inclusion in the plant breeding program of hybridization and polycross.

Keywords: Source Material, Breeding Nursery, Selection, Seed Productivity, Polycross Method

Introduction

Due to the high protein content in seeds and leaves, legumes are the main cultivated plants used as animal feed. They have a unique ability among plants to bind with soil bacteria of the genus Rhizobium to form nitrogen-fixing nodules, thereby limiting the need for exogenous nitrates (Iantcheva *et al*., 2009).

The transition to more sustainable systems of crop production and animal husbandry involves the wider cultivation of perennial forage legumes. Alfalfa (*Medicago sativa* subsp. *Sativa*) is the main perennial legume in most regions with a moderate climate, especially where farming systems rely heavily on forage conservation (Annicchiarico *et al*., 2015).

It is almost impossible to choose a high-protein feed crop equivalent to alfalfa, rich in vitamins, mineral salts and trace elements, capable of repeatedly intensively growing after mowing and grazing by animals. Therefore, farms engaged in animal husbandry build effective feed production on the cultivation of alfalfa and using it to produce different types of products (Gorlov *et al*., 2014).

Alfalfa is an important source of feed for livestock all over the world due to its wide adaptability, high yield, good quality and resistance to frequent mowing. It can be used for pastures, hay, silage and soil improvement (Goplen *et al*., 1982; Coburn, 1908). Around the world, alfalfa is grown on about 30 million hectares (Yuegao and Cash, 2009).

The powerful root system of alfalfa is deeply located and contributes to the enrichment of the soil with humus, improving the soil structure, increasing its fertility, water and air permeability, creating water-tight aggregates and improving the pore volume. For three years of cultivation, alfalfa leaves organic matter equivalent to 60 tons of manure per hectare, increasing the humus content by 8-10% (Dyukova, 2013). Alfalfa is considered a good fore crop for many crops since it activates polyphenol oxidase in the soil – an enzyme that participates in the synthesis of humus. Biological nitrogen is hundreds of times cheaper than technical nitrogen, while the use of nitrogen in high doses is considered very costly and environmentally unsafe (Bzheumykhov *et al*., 2007).

Alfalfa is the main high-protein forage crop for field and meadow forage production. Crop breeders have created several highly productive varieties by feed weight (Kokshe, Semirechenskaya Local, Khanshaim, Chaglinskaya 14, Chaglinskaya 17, Shortandinskaya 2, Karagandinskaya 1, Flora 4, Raykhan, Nurilya, in memory to Khasenov, etc.). However, these varieties are not widely distributed due to low and unstable seed productivity. They are characterized by weak bushiness and heat tolerance, during the period of drought, not only leaves fall off but also flowers and beans. These varieties, selected for the productivity of the vegetative mass as main economic use, have poorly developed reproductive abilities. Developing a powerfully developed ground forage mass, they tend to have a prolonged flowering period, in conditions of a lack of natural pollinators, which is typical for the region under consideration with a greater share of plowed agricultural land. Flowers and beans fall off, show a tendency to overgrow. Practically from the 3rd year, it is impossible to obtain an economically suitable crop of seeds (Tarkovsky, 1974; Sagalbekov, 1994; Meirman *et al*., 2012). Therefore, the task was set to create a new type of alfalfa varieties that would combine high feed productivity with stable seed yield. As a rule, these traits have a negative correlation.

Goncharova (1999) wrote that in plant breeding practice, the material entering the selection study is called the source, meaning both collection forms and varieties (samples), involved for plant breeding. This also usually includes selection forms obtained by any method (hybridization, mutagenesis, etc.). The source and selection material are not identical concepts. The source material is what comes for study, i.e., varieties from the VNIIR collection, varieties and forms of other scientific institutions, including varieties (forms) of in-house plant breeding, as well as local and wild-growing samples. The selection material includes samples that are received by breeding nurseries. The source and breeding material have their roles in the breeding process scheme (Goncharova, 1999).

The source material, as is known, predetermines the success of plant breeding. Therefore, its correct choice and use in selecting breeding are of paramount importance. The founder of the doctrine of the source material, N.I. Vavilov wrote in his work "Plant Breeding as a Science": "The doctrine of the source material, the origin of cultivated plants should be put as the basis of selection". The author pointed that “while in the sections of botany, the issues of the source material are considered as general, in the doctrine of selection, they acquire significance, concreteness and special meaning" (Vavilov, 1967).

Updating the genetic material by attracting new initial forms is the basis for the plant breeding of any agricultural crop. For the effective creation of new competitive varieties, it is necessary to have a genetically diverse and comprehensively studied source material, which forms the basis of plant breeding improvement (Ponomareva *et al*., 2018).

One of the most important indicators of the value of the alfalfa variety is the high seed productivity, without which it is impossible to further expand the sown areas. It is known from plant breeding and production practice that the productivity of feed mass and seeds in alfalfa is correlated inversely. Nevertheless, the populations obtained in recent years in the Kokshetau Experimental Production Farm LLP (Changing village) are distinguished not only by the high productivity of the feed mass but also by the tendency to increase the reproductive ability.

Currently, the selection of alfalfa or the creation of the source material remains the basis of successful selective breeding (Novoselova, 1982).

Alfalfa is a complex object for selective breeding. This is a self-incompatible cross-pollinated crop. Its yield is difficult to control. The populations of this culture are a mixture of highly heterozygous genotypes. This makes it necessary to develop new and to improve already employed methods and techniques of selective breeding of alfalfa (Goncharov and Lubenets 1985).

Analysis of special scientific literature and a patent search revealed that in Kazakhstan, alfalfa culture as a forage plant is focused on obtaining the maximum yield of vegetative mass. Therefore, existing varieties are selected for the productivity of green mass and hay and do not provide reliable stable seed yield. They have a long flowering period and are prone to the shedding of flowers, beans and seeds, as well as unevenly ripen, they proliferate at an excess of moisture, are damaged by diseases and pests. It is necessary to create varieties with increased seed productivity.

In agricultural production, the yield of alfalfa seeds is very low, it does not exceed 50-60 kg/ha, although the biological potential of varieties reaches 500-900 kg/ha.

The success of the cultivation of any agricultural crop is predetermined by the choice of the variety, most adapted to local conditions and highly productive, primarily in terms of seed productivity for further reproduction and distribution. With an equal yield of feed mass, alfalfa varieties with a more stable and high seed yield are preferential.

Currently, increasing seed productivity is an extremely important and challenging issue that is being solved by breeding new varieties.

The purpose of the present research is to study and evaluate the breeding value of alfalfa variety populations, as well as to isolate a new source material for creating alfalfa varieties with high seed yields.

Materials and Methods

Selective breeding was carried out in 2018-2020 at the experimental field of Kokshetau Experimental Production Farm LLP (Changing village, Zerendinsky District, Akmola region), located in the steppe zone of Northern Kazakhstan (Fig. 1). Spring sowing in breeding nurseries was carried out in May. Nurseries were laid coverless by hand on a complete fallow in the spring season. The soil was represented by ordinary medium-humus chernozem with a depth of the humus horizon of 25-27 cm and average humus content of 4.01%.

The sowing methods in the collection nursery, the CHP nursery and the OEN nursery were square-nest (70 x 70 cm). In the control nursery for seeds – wide-row (row spacing 70 cm). Each number in the nursery occupied 5 m^2 in six repetitions. The standard was sown every 10 numbers.

Plant care was carried out both manually and in a mechanized way.

The selected numbers were cleaned manually. The threshing of the selected sheaves was carried out on laboratory threshing machines.

During the growing season of plants, two field and one laboratory removing of the worst were carried out. Records, observations and analyses in nurseries were carried out according to generally accepted methods of working with perennial grasses.

The zoned variety of alfalfa of the Kokshe local selection was adopted as the standard.

To evaluate the studied forms, the following records and observations were carried out in nurseries:

- Phenological phases of development were noted; seedlings, regrowth's (in spring and after mowing), budding, flowering and maturation
- The plant height was measured on the 20th day after regrowth, before mowing and in the phase of full ripeness of the seeds
- The yield of the green mass was taken into account by direct weighing of plants from the plot, grass mowing was carried out in the budding phase, i.e., the beginning of flowering
- Hay yield was carried out according to the methodology of the State Commission for Variety Testing of crops (MAF, 1971)
- To determine the leafiness before taking into account the harvest, disassembly was carried out into fractions, leaves and stems were weighed and leafiness (leaf yield) was determined in %

$$\frac{m\,of\ leaves \times 100\%}{m\,of\ leaves \times 100\%};$$

- Structural analysis was carried out before mowing, analyzing a sample weighing 0.5-1 kg
- Accounting of seed productivity was carried out by direct weighing from the plot after drying and threshing

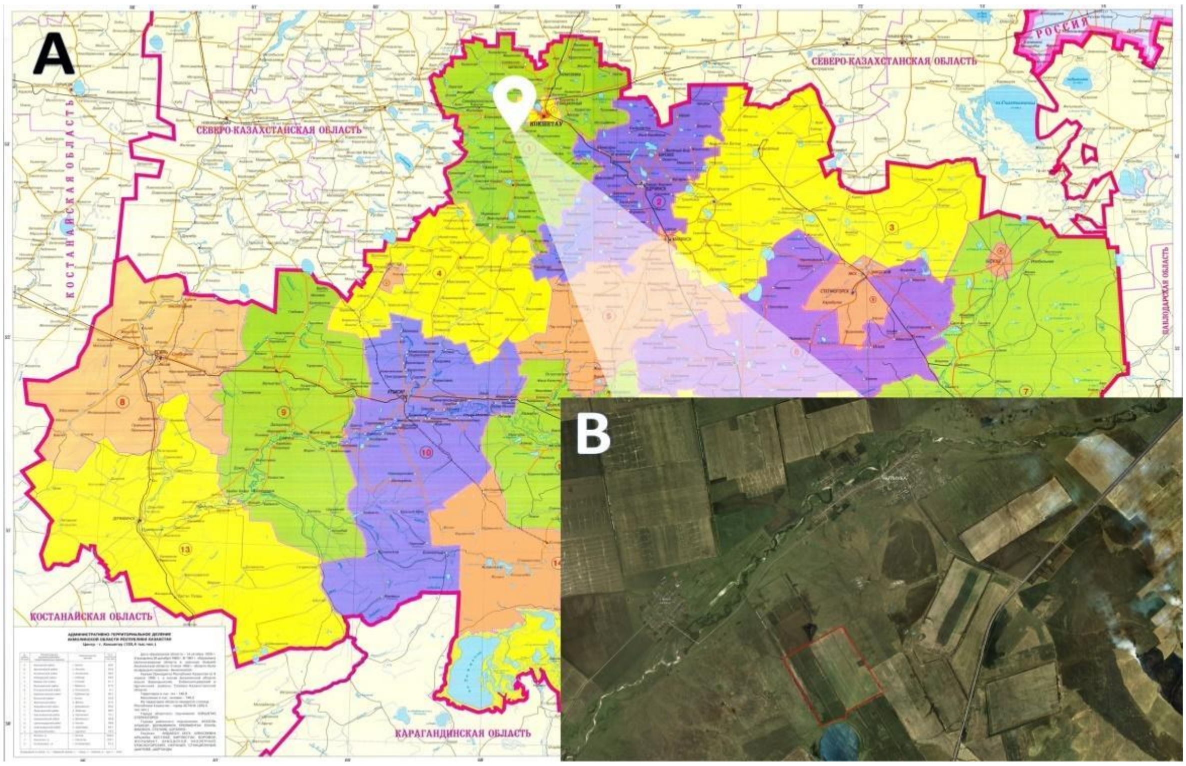

Fig. 1: Local map; A – Kazakhstan, B – experimental field of kokshetau experimental production farm LLP

Visual assessment on a 5-point scale was carried out according to the following criteria:

- The general development and density of the herbage was carried out in the spring and autumn before leaving for winter
- Winter hardiness was determined by counting plants in autumn and spring or visually on a 5-point scale
- Drought resistance was determined during the period of the maximum manifestation of drought as a percentage of green leaves or in scores
- Resistance to diseases and pests was determined in scores during the manifestation of the disease
- The content of protein and fiber in the plant mass was determined according to the generally accepted method
- The nitrogen content was determined by the Kjeldahl method with the conversion of the total nitrogen content into crude protein, using a coefficient of 6.27;
- The crude fiber was determined by Henneberg and Stohmann

The scheme of the breeding process, the laying of nurseries, evaluation, hybridization, selection and variety testing were carried out based on the methodological guidelines for the study of the collection of perennial forage grasses of Herbarium of VIR (N.I. Vavilov All-Russian Institute of Plant Genetic Resources) (MAF, 1979), based on the selection of perennial grasses of VIC (visual and measurement control) (MAF, 1985a), the Sib NIA of Feed (Siberian Scientific Research Institute of Feed) (MAF, 1985b) and the methodology of the state variety testing of crops (MAF, 1974).

Mathematical processing of the research results was performed on a PC using standard software. Statistical processing of the results, in particular, variance and correlation analysis, was carried out according to B.A. Dospekhov (1985).

Results

Research on the culture of alfalfa, study of morphological and agronomic traits of its vast gene pool, amounting to 2-2.5 thousand collectible and selected numbers, development trends in the selective breeding and the needs of production allowed the creation of a new type model of alfalfa varietal population with high seed yield (Table 1).

A further, more detailed analysis of low seed productivity shows that the main limiting feature is the weak setting capacity of beans, which does not exceed 5-7% in the context of a shortage of natural pollinators (Table 2).

The decomposition of the composition of populations of 100 plants of each variety showed that it is possible to identify and select the necessary biotypes with an increased degree of self-pollination (Table 3).

The most promising in terms of seed productivity were biotypes with 25% of self-pollination from the composition of population varieties of North Kazakhstan 8–5 plants and new complex hybrid synthetic populations of SGP-09-10-7–13 plants, SGP-02-21-9–12 plants and SGP-04-09-3–14 plants (Table 3). These elite plants will be the progenitors of the future new variety of alfalfa with increased seed productivity.

Results, Obtained in a Collection Nursery

The nursery of the source material was sown periodically as new incoming varieties from other research institutes and expeditions engaged in the collection of wild forms. Since 2018, the collection nursery has been laid three times: 46 Samples were laid in 2018, 46–in 2019 and 46–in 2020.

Promising samples were identified according to the severity of individual traits and their combination for inclusion in the selective breeding program of hybridization and polycross (Table 4).

In terms of the winter hardiness (overwintering 91-100%), Kokshe, Flora 6, Karabalyk Pearl, Nurilya, Uralochka and Omsk 7 were selected.

In terms of the drought resistance (during the drought period, the proportion of green leaves amounted to 85-91%), Lazur Naya, Nurilya, Baralfa, Sarga, Hanshaiym, as well as varieties (K-6940 from India and K-41422 from Turkey), Flora 6, Rayhan and Raduga were selected.

In terms of the resistance to various diseases – K-502 from the USA, K-930 from Canada, K-42340 from Italy, K-39112 from Sweden, as well as Rambler, Bokkara, Baralho, Koko ray, Lucius and Lazur Naya were selected.

In terms of the vegetative mass structure (leafiness, plant height, bushiness), Flora 6, Nurilya, Rayhan, Karabalyk Pearl and Omsk 7, as well as K-45589 from the Russian Federation, K-41121 from Portugal and K-43833, Viola and Lucia from Denmark were selected (Table 5).

In terms of the seed productivity structure, flowering vigor, resistance to proliferation and setting capacity of beans–the Rambler, Nurilya, Sarga, Uralochka, Flora 6, Lazurnaya, Starbuck, Karabakh Pearl, Raduga, Rayhan, as well as K-3793 from England and K-2192 from Australia were selected (Table 6).

In total, 18 varieties and samples were selected for further selective breeding.

The Polycross Nursery (PN) for limited-free pollination includes promising biotypes from the varieties Kokshe, Omsk 7, Nurilya, in Memory to Khasenov, Rambler, Rayhan, Flora 4, Tulun Hybrid, Zheltogibridnaua (Yellow Hybrid) 55, Oranzhevaya 115 (Orange), Kapchagay 80, Zhainak 96, Raduga and Aisulu.

A total of 24 SGPs were tested annually (2018-2020).

As a result of re-pollination, 124 polycross hybrids were isolated according to the combination of selected traits in compliance with the model of future varieties.

A new cycle of the nursery containing 12 numbers has been laid for these purposes in 2020.

In the offspring evaluation nursery, using the polycross method with a staggered arrangement of parent forms and hybrids, the total combinational ability of 124 polycross offspring was evaluated in 2018-2020 and 65–in 2020. The evaluation was carried out for the entire complex of biological properties and economically valuable traits.

In 2020, a new cycle of the offspring evaluation nursery consisting of 65 polycross hybrids was laid.

A preliminary test for 12 CHPs was carried out annually (for sowings of 2018 and 2019) and a new cycle (2020).

The main features of CHP are presented in Table 7 and 8.

In the nursery of 2018, CHP-9, CHP-11 and CHP-12 were identified as the most promising crops. According to the testing results and evaluation in the nursery of 2018 sowing year, the following complex hybrid populations were identified as the most promising for inclusion in the crop variety testing: CHP-2–drought tolerance, CHP-6–disease resistance, CHP-10–productivity of green mass and CHP-12 – overwintering.

The CHP of 2020 sowing year will be evaluated in 2021-2022.

Besides, 37 varieties of 2018 sowing year and 39 varieties of 2019 sowing year were subjected to the lesser crop variety testing in the Control Nursery (CN). Besides, a new CN cycle was laid in the amount of 36 numbers of 2020 sowing year.

In terms of the yield of green mass, hay and seeds, 10 varieties were allocated in the CN of 2018 sowing year and 8-of 2019 sowing year (Table 9).The characteristics of the combined features of promising numbers allocated in the CN for inclusion in the competitive variety trial showed that they were distinguished by high winter hardiness (5 scores), drought resistance (5 scores), disease resistance (4 scores), leafiness (2-3%), as well as were taller (11-20 cm) while vegetation was at the standard level (Table 10). Another good distinguishing feature of the new varieties is that almost all 12 numbers surpass the control variety in seed productivity. They will be included in the competitive variety trial of 2020 sowing year.

Table 1: The approximate model of alfalfa varieties for selecting source material with sustainable seed productivity

Indicator variety	Recognized variety	New
Seed yield, c/ha	0.6-1.0	1.6-3.3
Duration of the flowering period, days	44-56	31-38
The shape of the bush bush	Sprawling bush	Upright
Pest resistance (Tychicus-seed weevil), scores	2-3	5
Proliferation, scores	4-5	0-1
Bushiness, pcs. of stems	13-26	33-41
Shedding ability (flowers, beans), scores	4-5	0-2
Setting capacity of beans, %	5-7	31-53
Self-fertility, %	1-6	10-13

Table 2: The setting capacity of beans of various varieties and samples of alfalfa, 2018-2020

No	Grade, Number	Setting capacity of beans, %
1	Kokshe (standard)	5.7
2	Omsk 7	6.4
3	Nurilya	15.5
4	Rambler	6.1
5	Karabalyk Pearl	5.5
6	Bokkara	7.3
7	Serpovidnaya (sickle-shaped)	4.4
8	Baralfa	8.3
9	Lazurnaya (Azure)	9.2
10	Viola	9.5
11	Raykhan	5.5
12	Yaroslavna	10.4
13	Starbak	7.6
14	Flora 6	9.1
15	Uralochka	8.1
16	Sarga	7.2
17	Lucia	7.5
18	Hanshaiym	7.4
19	SGP-02-21-9	24.4
20	SGP-04-09-3	28.1
21	SGP-09-10-7	29.4

Table 3: Decomposition of the population composition of various alfalfa varieties by self-fertility (2018-2020), plant units

Variety, Population	Self-fertility, %					
	5	10	15	20	25	30
Kokshe	36	2	-	-	-	-
Omsk 7	32	11	2	-	-	-
Lazurnaya	34	4	-	-	-	-
Karabalyk Pearl	31	-	-	-	-	-
Rayhan	38	7	1	-	-	-
Yaroslavna	41	12	7	-	-	-
Nurilya	43	24	11	3	-	-
Flora 6	48	26	12	5	-	-
Sarga	44	23	11	3	-	-
North Kazakhstan 8	31	30	27	7	5	-
Hanshaiym	23	27	29	9	7	4
SGP-02-21-9	21	22	23	14	12	8
SGP-04-09-3	20	21	22	17	14	6
SGP-09-10-7	20	11	20	15	13	7

Table 4: Promising varieties and samples according to individual traits

№	Variety, sample	Winter hardiness, s, %	Drought resistance, e, %	Resistance to a complex of diseases, score
1	Kokshe	91	82	3
2	Flora 6	93	85	4
3	Karabalyk Pearl	92	83	4
4	Nurilya	93	87	4
5	Uralochka	95	84	4
6	Omsk 7	94	82	3
7	Lazurnaya	84	89	5
8	Baralfa	80	85	5
9	Sarga	81	85	4
10	Hanshaiym	85	90	4
11	K – 6940	79	85	3
12	K – 41422	77	85	3
13	Rayhan	84	90	4
14	Raduga	82	91	4
15	Lucia	83	80	5
16	Rambler	89	78	5
17	K – 502	82	80	5
18	K – 930	82	80	5
19	K – 42340	80	75	5
20	K – 39112	82	77	5
21	Bokkara	84	80	5
22	Kokoray	80	80	5

Table 5: Promising varieties and samples according to the structure of the vegetative mass

№	Variety, sample	Leafiness, %	Plant height, cm	Bushiness, pcs/stems
1	Kokshe (standard)	48	76	41
2	Flora 6	49	79	46
3	Nurilya	49	78	46
4	Rayhan	49	78	45
5	Karabalyk Pearl	50	79	45
6	Omsk 7	51	77	44
7	K – 45589	52	75	43
8	K – 41121	50	77	45
9	K – 43833	51	75	44
10	Viola	49	78	46
11	Lucia	50	75	44

Table 6: Promising varieties and samples for the main elements of the structure of seed productivity

№	Variety, sample	Seed productivity, g/m^2	Flowering duration, days	Growth resistance, score	Bean set, %
1	Kokshe	1.1	45	3	5.7
2	Flora 6	1.5	42	4	9.1
3	Karabalyk Pearl	1.7	42	4	5.5
4	Nurilya	1.9	40	5	15.5
5	Uralochka	1.6	42	4	8.1
6	Lazurnaya	1.8	40	5	9.2
7	Sarga	1.7	42	4	7.2
8	Rayhan	1.2	41	4	5.5
9	Raduga	1.5	40	4	5.4
10	Rambler	1.3	43	4	6.1
11	Starbak	1.9	40	4	7.6
12	K – 3793	1.0	43	3	5.3
13	K – 2192	1.1	44	3	5.4

Table 7: Characteristics of complex-hybrid alfalfa populations by a set of features

CHP	Winter hardiness %	Drought resistance, % of green leaves	Disease resistance, scores	Vegetation period, days		Productivity, g/m^2	
				Green mass	Seeds	Green mass	Seeds
Kokshe (standard)	87	67	3.0	57	97	450	1.1
CHP-1-18*	97	83	3.7	58	99	540	2.4
CHP-2-18	98	86	4.0	58	96	680	2.8
CHP-3-18	94	92	4.5	61	100	670	3.0
CHP-4-18	91	86	4.3	57	98	580	2.4
CHP-5-18	98	85	4.7	59	99	660	4.4
CHP-6-18	95	88	4.3	58	100	590	2.8
CHP-7-18	100	92	4.7	60	99	630	3.2
CHP-8-18	97	87	4.0	58	98	570	2.4
CHP-9-18	100	94	4.7	59	101	705	3.5
CHP-10-18	96	89	4.3	60	97	585	3.8
CHP-11-18	91	91	4.5	61	100	715	3.7
CHP-12-18	97	91	4.7	59	98	730	3.6

Note: CHP-1-18* – complex-hybrid population, 1 – population number, 18 – the year of sowing

Table 8: Characteristics of complex-hybrid alfalfa populations by a set of features (CHP of the 2019 sowing year, accounting for 2020)

CHP	Winter-hardiness %	Drought resistance, % of green leaves	Disease resistance, scores	Vegetation period, days		Productivity, g/m^2	
				Green mass	Seeds	Green mass	Seeds
Kokshe (standard)	85	73	3.0	57	98	467	1.5
CHP-1-19	92	84	3.7	57	97	608	2.4
CHP-2-19	95	96*	3.8	58	100	747	3.8
CHP-3-19	90	87	3.7	57	98	597	2.4
CHP-4-19	85	77	3.4	58	97	588	2.3
CHP-5-19	90	91	4.0	59	99	742	3.4
CHP-6-19	90	92	4.7	58	99	790	3.7
CHP-7-19	90	86	4.5	56	97	780	3.8
CHP-8-19	95	88	4.0	55	96	601	2.3
CHP-9-19	90	86	4.1	56	97	670	2.7
CHP-10-19	100	91	4.7	56	101	805	3.9
CHP-11-19	95	87	4.3	57	99	657	3.0
CHP-12-19	100	90	4.7	58	100	785	3.7

Note: * – features for which samples were selected

Table 9: The yield of feed mass and seeds of alfalfa varieties in CN

Variety, Number	Green mass c/ha	Average error +,-	Hay (std. error)	Average error c/ha	Seeds +,-	Average error (std. error)	c/ha	+,-	(std. error)
2018 sowing year, accounting for 2019									
Kokshe (standard)	61	-	0.15	14.2	-	0.10	0.6	-	0.11
CHP-4-11-15-2**	81	+20	0.10	25.1	+10.9	0.08	1.1	+0.5	0.09
CHP-10-11-14-5	80	+19	0.07	24.8	+10.6	0.19	1.4	+0.8	0.14
CHP-9-11-6-6	89	+28	0.12	27.1	+19.9	0.14	1.2	+0.6	0.17
CHP-5-11-11-1	94	+33	0.12	28.9	+14.7	0.12	1.4	+0.8	0.13
CHP-4-11-10-8	96	+35	0.14	29.5	+15.3	0.11	1.3	+0.7	0.18
CHP-9-11-17-2	99	+38	0.10	31.1	+16.9	0.22	1.5	+0.9	0.06
CHP-5-11-12-7	107	+46	0.06	34.2	+20.0	0.11	1.7	+1.1	0.21
HCP_{05}	8.7				4.2			0.23	
2019 sowing year, accounting for 2020									
2018 sowing year, accounting for 2019	97	-	0.12	19.4	-	0.09	0.9	-	0.17
CHP-4-11-15-2**	119	+22	0.09	24.7	+5.3	0.12	1.3	+0.4	0.12
CHP-10-11-14-5	120	+23	0.07	25.2	+5.8	0.18	1.5	+0.6	0.14
CHP-9-11-6-6	129	+32	0.11	28.8	+9.4	0.06	1.9	+1.0	0.10
CHP-5-11-11-1	133	+36	0.19	30.0	+10.6	0.21	1.6	+0.7	0.15
CHP-4-11-10-8	135	+38	0.20	32.5	+13.1	0.07	1.5	+0.6	0.11
CHP-9-11-17-2	148	+57	0.07	32.9	+13.5	0.12	2.2	+1.3	0.17
CHP-5-11-12-7	159	+62	0.14	34.6	+14.8	0.10	2.4	+1.5	0.11
HCP_{05}	9.5				5.2			0.25	

Note: CHP-4-11-15-2**, where CHP is a complex hybrid population, 4 is the number of the biomechanical mixture, 11 is the year of seed production, 15 is the number of the plot, 2 is the number of selection

Table 10: Characteristics of promising alfalfa varieties in the CN by a set of features

Variety, number	Winter hardiness, scores	Drought resistance, scores	Disease resistance, score	Leafiness, %	Plant height , cm	Vegetation period, days
	2018 sowing year, accounting for 2019					
Kokshe (standard)	4	4	3	45	67	59
CHP-9-06-6-6	5	5	4	46	78	61
CHP-5-06-11-1	5	5	4	46	79	62
CHP-4-06-10-8	5	5	4	47	84	60
CHP-9-06-17-2	5	5	4	46	86	59
	2019 sowing year, accounting for 2020					
Kokshe (standard)	4	4	3	43	54	57
CHP-9-06-6-6	5	5	4	44	68	57
CHP-5-06-11-1	5	5	4	45	59	58
CHP-4-06-10-8	5	5	4	46	64	59
CHP-9-06-17-2	5	5	4	46	66	59

Discussion

Increasing seed yield is critical to the commercial development of alfalfa varieties. Differences in alfalfa seed production are a result of the crop's genetic potential and environmental factors such as insect attractants (Sreedhara *et al*., 2012).

The shape of the bush is a constitutional feature of selection or marker, based on external morphological features. The bush shape should be upright. The shape of the bush affects the generative structure of the seeds.

All alfalfa species freely interbreed with each other within the tetraploid set of chromosomes. Under these conditions, developing reproductive organs and forming seeds depends on the plant's ability to self-pollinate. In terms of its biological characteristics, alfalfa belongs to the facultative cross-species type and, based on this hypothesis, the composition of the population of various varieties was decomposed into biotypes according to self-fertility with complete individual isolation of individual plants.

The existing varieties of alfalfa by their genetic nature represent a population containing different types of biotypes and eco-elements in their composition. In our studies, biotypes were selected according to self-fertility, pod set and seed productivity.

In the nursery of Complex Hybrid Populations (CHP), the populations are formed into a biomechanical mixture, as the final stage of selection before variety testing. A complex hybrid population of biotypes with a high overall combinational ability and bio-morphologically corresponding to the model in terms of both the duration of the vegetation and a combination of valuable economic characteristics form the basis of the variety of populations (Table 7).

To establish the degree of evenness of biotypes, a statistical analysis was carried out on seed productivity, the average value of the standard deviation (std. deviation) and the average error (std. error) does not exceed the allowable norm (5%) (ANOVA).

Conclusion

Thus, based on the study of the biological features of plant growth and development, the influence of environmental factors that reduce potential seed productivity, an improved model of a variety with increased seed productivity has been developed and tested. The following main parameters of the model are experimentally justified: Seed yield, the duration of the flowering period, the shape of the bush, resistance to pests (Tychicus-seed weevil), proliferation, bushiness, shedding (flowers, beans), setting capacity of beans and self-fertility, which determine the high seed productivity of plants.

Based on the conducted experiments, promising samples were identified according to the severity of individual traits and their combination for inclusion in the selective breeding program of hybridization and polycross.

In total, 18 varieties and samples were allocated for further selective breeding.

A total of 24 biotypes were tested annually (2018-2020).

In consequence of re-pollination, 124 polycross hybrids were isolated in terms of the combination of selected traits according to the model of future varieties.

In terms of the yield of green mass, hay and seeds, 10 varieties were allocated in the CN of 2018 sowing year and 8 varieties–in the CN of 2019 sowing year.

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Author's Contributions

All authors equally contributed in this work.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

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