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STUDY OF THE SOURCE MATERIAL OF THE OILSEED FLAX COLLECTION IN THE CONDITIONS OF NORTHERN KAZAKHSTAN

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Annotation

In order to select the source material for breeding to breed a high-yielding variety adapted to the conditions of Northern Kazakhstan, the article presents the results of studying the source material of the collection of oilseed flax. The work was carried out according to generally accepted methods.

The object of the study was collectible samples of oilseed flax of various ecological and geographical origin. Field work was carried out in 2020-2021 at the scientific and field station of the SPCGF named after A. I. Barayev, located in the Akmola region of Northern Kazakhstan. The studies studied the height of the plant, the number of boxes on the plant, the number of seeds in the box, the number of seeds from one plant, the weight of 1000 kernels and yield. The main evaluation measures of oilseed flax were: vegetation period – 3 varieties are allocated here (Kostanaiski yantar– St, Scorpio, Taurus); plant height – 1 variety (Agate); weight of 1000 kernels – Northern (8.0 g) and Sokol (8.1 g) number of boxes and seeds per plant – Nebesny (38 boxes, 225 seeds), Sokol (31 boxes, 143 seeds) and Bison (31 boxes, 140 seeds). Of the studied varieties, the most seeds from one plant had the varieties Sokol (1.18 g), Nebesny (1.74 g) and Northern (1.30 g). Kostanay (13.46 c/ha) and Rucheyok (11.31 c/ha) were the most productive.

Key words: gene pool; breeding; sample; variety; flax; yield; growing season.

Introduction

One of the largest branches of the agricultural sector of Kazakhstan is crop production, which provides

about 60% of gross agricultural output.

Oilseed flax *(Linumusitatissimum L.)* is a family of *Linaceae*, includes 13 genera and 300 species, the genus *Linum*. This is a valuable technical oilseed crop of versatile use [1]. The seeds of varieties of this crop contain more than 50% of high-quality drying oil and up to 23% protein [2]. Linseed oil has good drying properties with the formation of a strong and resistant film. Paints and varnishes obtained on linen drying oil are the standard of durability and reliability. Linseed oil is used in printing, textile, leather and footwear, food, medical, perfumery, electrical engineering and other industries [3,4]. Linseed oil is widely used in the manufacture of glue, linoleum, waterproof fabrics, in painting [5]. Linseed oil also has unique dietary and medicinal properties [6]. Cake and meal are high-protein feeds [7]. Flax straw is used for the production of fibers, paper, and building materials.

High drought resistance, short growing season, adaptability, high yield and economy are distinctive valuable biological and economic qualities of flax [8]. The introduction of oilseed flax, as an important source of edible oil and high-quality protein, is becoming relevant [9].

Flax is an important and economically profitable crop in Kazakhstan. In 2021, 1,496 thousand hectares of oilseed flax were sown in the Republic of Kazakhstan, more than 800.0 thousand tons of flax oilseeds were obtained, with an average yield of 8.5 c/ha. The production of oil, cake and meal has a steady tendency to increase all over the world. Currently, as of 2022, 13 varieties of oilseed flax are included in the State Register of Breeding Achievements approved for Use in the Republic of Kazakhstan, of which all 5 varieties of domestic breeding [10].

Currently, the structure of acreage in the Akmola region is dominated by varieties of foreign breeding, which in the sharply continental conditions of Northern Kazakhstan do not fully realize their potential. In this connection, there is a need to create new, highly productive, high-quality seeds, competitive varieties of oilseed flax, with high resistance to abiotic and biotic environmental factors.

Materials and methods

The material for the study was a collection of oilseed flax of various ecological and geographical origin. 17 varieties of foreign and Kazakh breeding were studied, which were divided into 5 groups according to their origin: Canada: Scorpion, Taurus; USA: Antores, Bison; France: Agate, Libra, Crocus; Russia: Isilkulsky, Severny, Rucheek, Ulan, Sokol, Nebesny, Zheltyi and Legur; Kazakhstan: Kostanayski Yantar, Kostanay. The Kostanayski yantar variety, zoned in the Akmola region, North Kazakhstan, was used as a standard. Sowing and evaluation of the collection nursery was carried out according to the “Methodological guidelines for studying the flax collection” developed by the All-Russian Institute of Plant Growing named after N.I. Vavilov [11] and “Methods of state variety testing of agricultural crops” (2011). Scientific surveys in 2020–2021 were carried out on the experimental field of the

"Scientific and Production Center of Grain Farming named after A.I. Barayev" LLP, represented by ordinary southern chernozems, according to the fallow predecessor.

Research methods – field and laboratory experiments. The preparation of the field and the laying of field experiments was carried out according to the recommendations of "SPC GF named after A.I. Barayev" LLP [12,13].

Field work was carried out at the optimal time on May 20-22. The seeding rate of oilseed flax in our region is 5.5 million germinating seeds per hectare or 550 pcs. per square meter, before sowing, the germination rate was determined by the laboratory method according to GOST 12038. The sowing of the collection nursery was carried out by the SSFC-7 breeding seeder. Immediately after sowing oilseed flax, the plots were rolled with ring-spur rollers.

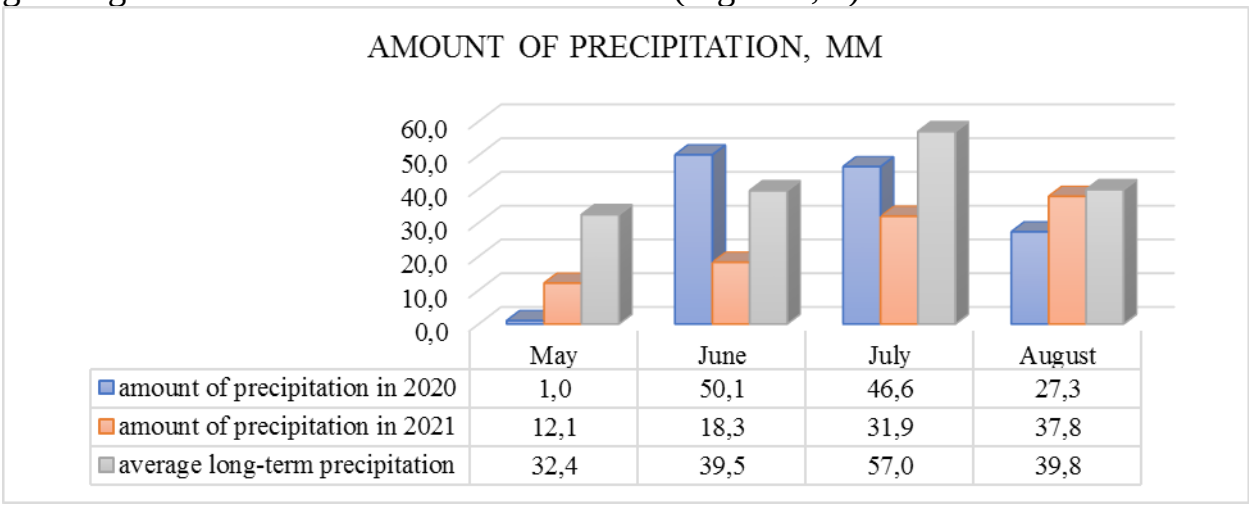
Prior to the start of harvesting, to determine the structure, sheaf samples were selected, according to the most typical plants for this sample, signs and properties were taken into account.

During the period of reaching full maturation of the samples, i.e. physiological ripeness, the Wintersteiger Classic combine harvester was cleaned directly. Seeds, if necessary, were dried, the weight from the plot was determined, based on the yield in hundredweight per hectare. The weight of 1000 kernels was determined according to GOST 12042.

The experimental data were processed by the method of single-factor analysis of variance, integral evaluation using the AGROS 2.11 software package and according to B. A. Dospekhov [14].

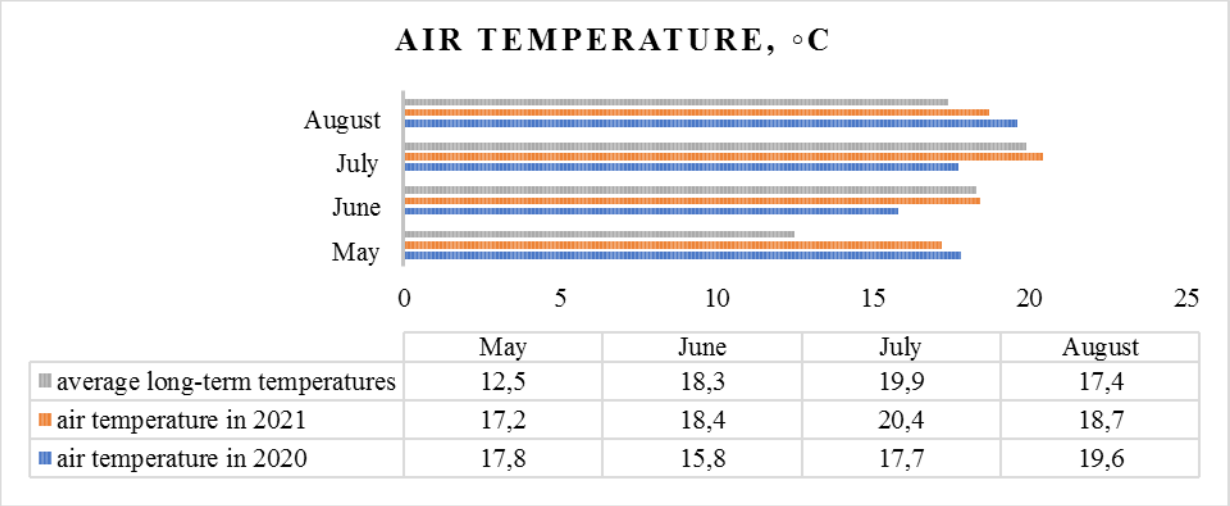
Results

During the years of the experiment, the analysis of meteorological conditions showed that the air temperature and precipitation of the growing season of 2020 and 2021 differed significantly from the average annual data. The temperature regime and the amount of precipitation varied throughout the growing season (Figure 1, 2).



	May	June	July	August
amount of precipitation in 2020	1,0	50,1	46,6	27,3
amount of precipitation in 2021	12,1	18,3	31,9	37,8
average long-term precipitation	32,4	39,5	57,0	39,8

Figure 1- Average long-term precipitation and precipitation for the growing season 2020 - 2021. (Shortandinskaya AMS)



	May	June	July	August
average long-term temperatures	12,5	18,3	19,9	17,4
air temperature in 2021	17,2	18,4	20,4	18,7
air temperature in 2020	17,8	15,8	17,7	19,6

Figure 2 - Air temperature for the growing season 2020- 2021 and average long-term temperatures (Shortandinskaya AMS).

The amount of precipitation during all periods of the growing season was significantly lower than normal. The period of the experiments was characterized as arid, but the different 8distribution of precipitation over the phases of vegetation had an impact on the formation of seed yields of collection samples of oilseed flax. To form a high yield, it is important to get full-fledged seedlings. Weather conditions influenced field germination in flax varieties (Table 1).

Table 1 – Field germination and plant density for harvesting oilseed flax varieties

Sample name	Field germination, %		Plant density for harvesting, pcs/m^2			
	R*/x**	V,%***	total		efficiency	
			R / x	V,%	x/R	V,%
Kostanaisky yantar, St	61-40 51	29,40	290-220 255	19,41	253 286-220	18,45
Kostanaisky	50-35 43	24,96	235-193 214	13,88	214 234-193	13,58
Severny	51-47 49	5,77	245-259 252	3,93	245 241-248	2,02
Agata	61-27 44	54,64	285-149 217	44,32	214 279-149	42,96
Libra	40-28 34	24,96	195-154 175	16,61	172 190-154	14,80
Scorpion	42-29 36	25,89	200-160 180	15,71	176 192-160	12,86
Taurus	49-82 66	35,63	230-245 237	4,47	313 225-400	39,60
Krokus	43-59 51	22,18	200-325 263	33,67	256 193-319	34,80
Antores	53-74 64	23,38	245-407 326	35,14	320 239-400	35,63
Bison	44-71 58	33,20	205-391 298	44,13	286 200-371	42,35
Isilkulski	42-30 36	23,57	200-165 183	13,56	182 198-165	12,86

Sokol	55-26 41	50,63	260-143 202	41,06	200 256-143	40,05
Nebesnyi	40-23 32	38,16	190-127 159	28,11	157 186-127	26,66
Legur	41-41 41	0,00	195-226 211	10,41	207 194-220	8,88
Ulan	42-23 33	41,24	195-127 161	29,18	160 192-127	28,82
Rucheek	49-45 47	45,87	230-248 239	5,33	235 234-235	0,30
Zheltyi	40-28 34	24,96	190-154 172	14,80	172 189-154	14,43

Notice R*- range of variability; x** -average; V***- coefficient of variation

A small but stable germination was observed over the years in the varieties of the Russian breeding Legur (V - 0.0%) and Severny (V – 5.77%). The varieties Sokol (Russia) distinguished themselves by the greatest variability in the field germination index- V – 50.63% and Agata V – 54.64%.

By the time of harvesting, the density of oilseed flax plants was, on average, 232 pcs/m^2, of which 221 pcs/m^2 were productive. The varieties Severny and Rucheek had the least variability on this basis.

Discussions

Selection and improvement of plant types adapted to the conditions of the region is one of the main tasks of breeding. When creating new varieties, it is necessary to take into account the abiotic conditions of the zone for which they are created. Based on this, it is necessary to produce sources of economically valuable traits to attract them to the process of crossing [15, 16, 17].

The growing season of the collection samples of oilseed flax in 2020-2021 was characterized by considerable diversity and varied within 109-136 days. In the standard variety Kostanaisky yantar, on average, over the years of research, the duration of the growing season was 114 days (Table 2).

Table 2–Growing season of oilseed flax

Sample name	Interphase period, days					
	average for 2020-2021				From germination to full ripeness	
	shoots – herringbone	herringbone – flowering	flowering – yellow ripeness	yellow - full ripeness	R*/X**	V***, %
Kostanaisky yantar - St	16	19	47	32	114-114 / 114	0,00
Kostanaisky	17	23	43	34	116-117 / 116	0,61
Severny	17	25	42	34	116-117 / 116	0,61
Agata	18	28	43	35	127-119 / 123	4,60
Libra	18	25	45	37	129-119 / 124	5,70

Scorpion	17	24	39	35	119-110 / 115	5,56
Taurus	18	23	39	35	119-109 / 114	6,20
Krokus	16	24	43	35	119-117 / 118	1,20
Antores	17	27	39	35	119-115 / 117	2,42
Bison	17	25	42	35	118-119 / 119	0,60
Isilkulsky	17	24	43	35	119-116 / 118	1,81
Sokol	17	24	42	36	121-115 / 118	3,60
Nebesnyi	18	21	49	41	136-122 / 129	7,67
Legur	17	23	41	35	119-113 / 116	3,66
Ulan	16	20	48	35	119-118 / 119	0,60
Rucheek	16	18	48	35	118-115 / 117	1,82
Zheltyi	17	25	41	36	121-117 / 119	2,38

Notice R*- range of variability; x** -average; V***- coefficient of variation

The duration of the growing season in the studied collection samples of flax depended on the genotype of the variety, and also differed by year. It was shortest in 2021, due to a higher amount of active temperatures compared to 2020. On average, the value of this indicator in 2021 was 116 days, which is less than in 2020, by 5 days. The smallest vegetation period in an average of two years was observed in Scorpion (114 days) and Taurus (115 days) samples. These genotypes can be used as sources of early maturity. On average, over the years of research, the growing season of all studied samples was 118 days.

Strict requirements are imposed on modern flax varieties. They must have a certain set of valuable traits, most of which are inherited polygenically; many of them consist of several indicators that are in direct or feedback with each other [18].

The main morphological indicators of plants and varieties of oilseed flax are: the height of the plants, the number of branches of the first order, the weight of 1000 kernels and the plant as a whole (Table 3).

Table 3 – Morphological indicators of plants of oilseed flax varieties on average for 2020-2021.

Sample name	Plant height, cm	Branches of the 1st order, pcs.	Plant weight, g	Weight of 1000 kernels, g
Kostnayski yantar, st	39	2	2,23	6,2
Kostnayski	39	2	1,95	5,5
Severnyi	38	3	2,97	8,0
Agata	47	3	1,79	4,4
Libra	42	3	2,44	4,9
Scorpion	40	3	1,96	5,9
Taurus	41	2	2,02	6,3
Krokus	37	2	1,56	6,2
Antores	42	2	2,18	7,0
Bison	44	2	1,97	5,9
Isilkulsky	42	2	1,93	6,9
Sokol	45	3	3,09	8,1
Nebesnyi	39	3	3,77	7,7
Legur	40	2	1,91	6,9
Ulan	36	3	2,04	6,9

Rucheek	37	2	1,75	6,6
Zheltyi	38	2	1,47	6,7

When choosing a variety of oilseed flax, much attention is paid to its manufacturability. On average, the height of plants over the years of research ranged from 36 (Ulan) to 47 (Agata) cm.

In the dry period of 2020-2021, oilseed flax plants formed, on average, 2-3 branches of the first order. In this regard, the weight of seeds from the plant, on average, was 2.18 g. The heaviest weight of kernels from one plant was possessed by the varieties Nebesnyi (3.77 g) and Sokol (3.09 g), the smallest weight of seeds from one plant was observed in the Zheltyi variety (1.47 g).

The consequence of varietal characteristics and the result of the impact on the plant of the totality of all environmental factors is the weight of 1000 seeds. When analyzing this indicator, it was found that the weight of 1000 seeds on average over the years of the study varied between 4.4 - 8.1 g. The largest weight of 1000 seeds was the Severnyi variety – 8.0 g. and the Sokol -8.1 g.

The productivity of the crop depends on the elements of the crop structure, the contribution of which to the final yield is due to the influence of genotype and environmental factors [19]. Our research has allowed us to establish that the seed productivity of flax plants is closely related to the meteorological conditions of the growing season and the varietal characteristics of the studied samples (Table – 4).

Table 4 – Productivity of oilseed flax plant varieties

Sample name	Quantity per plant, pcs.				Weight of seeds per plant, g	
	capsules		seeds			
	R* / x**	V***,%	R / x	V,%	R / x	V,%
Kostanayski yantar, st	21-30 26	24,96	118-151 135	17,35	0,72-0,91 0,82	16,48
Kostanayski	25-29 27	10,48	147-108 128	21,63	0,75-0,73 0,74	1,91
Severnyi	26-30 28	10,10	125-195 160	30,94	0,95-1,64 1,30	37,68
Agata	9-33 21	80,81	60-194 127	74,61	0,22-1,01 0,62	90,83
Libra	14-39 27	66,71	58-136 97	56,86	0,26-1,44 0,85	98,14
Scorpion	16-33 25	49,06	83-193 138	56,36	0,50-1,08 0,79	51,91
Taurus	17-41 29	58,52	83-207 145	60,47	0,45-1,47 0,96	75,13
Krokus	14-35 25	60,61	66-178 122	64,91	0,40-1,11 0,76	66,50
Antores	13-37 25	67,88	87-197 142	54,78	0,60-1,52 1,06	61,37
Bison	19-42 31	53,32	103-176 140	37,00	0,65-1,00 0,83	30,00

Isilkulskyi	18-24 21	20,20	95-139 117	26,59	0,60-1,03 0,82	37,31
Sokol	22-40 31	41,06	105-181 143	37,58	0,82-1,53 1,18	42,73
Nebesnyi	21-54 38	62,23	116-334 225	68,51	0,86-2,62 1,74	71,52
Legur	20-26 23	18,45	109-87 98	15,87	0,65-0,68 0,67	3,19
Ulan	15-31 23	49,49	97-133 115	22,14	0,70-0,89 0,80	16,90
Rucheek	13-31 22	57,85	81-175 128	51,93	0,50-1,20 0,85	58,23
Zheltyi	13-17 15	18,86	79-76 78	2,74	0,49-0,55 0,52	8,16

Notice x* -среднее; R**- range of variability; V***- coefficient of variation

The number of capsules per plant varied greatly over the years, the coefficient of variation ranged from 10.48% (Kostanayski) to 80.81% (Agata). The smallest average number of capsules per plant was observed on average in the Zheltyi variety (15 pcs.), the largest in the Nebesnyi variety (38 pcs.). According to this indicator, the standard was exceeded by Kostanayski, Severny, Libra, Taurus, Bison, Sokol, Nebesnyi. The largest number of seeds from one plant was distinguished by the Nebesny variety -225 pcs. By the weight of seeds from one plant, on average for two years, Sokol (1.74 g), Antores (1.06 g) and Severny (1.30 g). On this basis, the greatest differences were observed in the varieties Libra and Agata. The coefficient of variation on this basis in these varieties was 98.14 and 90.83%, respectively.

The yield of flax was different over the years. In 2020, under adverse weather conditions, it was at the level of 2.53-9.0.1 c/ha. The best yield was in 2021, when the best options reached yields of 15.22...19.22 c/ha (Table 5).

Table 5 – Seed yield of oilseed flax varieties

Variety	Yield, c/ha			Yield deviation from the standard, +/-, c/ha	coefficient of variation V, %
	2020	2021	average		
Kostanayski yantar, st.	9,04	12,42	10,73	0,00	22,27
Kostanayski	7,69	19,22	13,46	2,73	60,59
Severny	6,52	13,06	9,79	-0,94	47,24
Agata	3,48	9,17	6,33	-4,41	63,61
Libra	2,53	6,28	4,41	-6,33	60,20
Scorpion	7,27	13,72	10,50	-0,23	43,46
Taurus	6,04	11,94	8,99	-1,74	46,41
Krokus	5,09	15,22	10,16	-0,57	70,54
Antores	4,28	14,00	9,14	-1,59	75,20
Bison	3,66	13,22	8,44	-2,29	80,09

Isilkulski	6,10	10,89	8,50	-2,24	39,87
Sokol	5,77	8,28	7,03	-3,71	25,26
Nebesny	5,45	6,89	6,17	-4,56	16,50
Legur	4,09	11,67	7,88	-2,85	68,02
Ulan	5,79	9,00	7,40	-3,34	30,69
Rucheek	9,01	13,61	11,31	0,58	28,76
Zhelty	4,90	7,44	6,17	-4,56	29,11
$НСР_{05}$	0,82	2,10	-	-	-
Average and arithmetic mean	5,67 ±0,45	11,80 ±0,80	8,80 ±0,60	-	-
Coefficient of variation V, %	32,3	28,69	25,89	-	-

The yield of oilseed flax seeds on average for 2020-2021 is 8.80 ± 0.60 c/ha. The highest yield of seeds in an average of 2 years was noted in the Kostanayski variety, it significantly exceeded the standard Kostanayski yantar variety by 2.73 c /ha, while the variation over the years of this variety was V - 60.59%. Also, the standard, on average for two years, exceeded by 0.58 c/ha the Rucheek variety (V – 28.76%).

The lowest coefficient of variation in yield was observed in the Nebesny variety. The yield of this variety was not high (5.45 – 6.89 c/ha), but stable, which can be explained by its greater ability to adapt to the action of abiotic stresses.

Conclusions

In the conditions of Northern Kazakhstan, valuable forms have been identified according to the main economically valuable characteristics. The length of the growing season at the level of the standard Kostanayski amber variety was noted in the samples – Scorpion (114 days) and Taurus (115 days). By the total length of the stem, such genotypes as Agata, Bison and Sokol exceeded the standard Kostanayski yantar by more than 10%. The Kostanayski (Kazakhstan) and Rucheek (Russia) varieties exceeded the standard for the yield of oilseeds, the excess was 2.73 and 0.58 c/ha, respectively. Varieties Severny and Sokol stood out by the weight of 1000 seeds, exceeding the standard variety by 29%.

Considering the important role of oilseed flax in providing the population with valuable vegetable protein and oil, as well as its high export potential: it is necessary to further expand the acreage of flax to increase gross collections. The use of the selected genotypes of oilseed flax in breeding programs will ensure the stability and further increase in the yield of flax products. The gene pool of oilseed flax is of scientific interest for fundamental theoretical research and practical significance for the region.

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СОЛТҮСТІК КАЗАҚСТАН ЖАҒДАЙЫНДАҒЫ МАЙ ЗЫҒЫР ЖИНАУЫНЫҢ БАСТАПҚЫ МАТЕРИАЛЫН ЗЕРТТЕУ

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Түйін

Мақалада Солтүстік Қазақстан жағдайына бейімделген өнімділігі жоғары сортты өсіруге арналған бастапқы материалды таңдау мақсатында майлы зығыр коллекциясының бастапқы материалын зерттеу нәтижелері берілген. Жұмыс жалпы қабылданған әдістер бойынша жүргізілді.
Зерттеу нысаны әртүрлі экологиялық-географиялық шығу тегі май зығырының коллекциялық үлгілері болды. 2020-2021 жылдары дала жұмыстары жүргізілді атындағы астық шаруашылығы ғылыми-өндірістік орталығының ғылыми дала станциясында. А.И.Бараев, Солтүстік Қазақстанның Ақмола облысында орналасқан. Зерттеулер өсімдіктердің биіктігін, бір өсімдіктегі қозалардың санын, бір бүршіктегі тұқымдардың санын, бір өсімдікке шаққандағы тұқымдардың санын, 1000 дәннің салмағын және өнімділігін қарастырды. Майлы зығырды бағалаудың негізгі критерийлері мыналар болды: вегетациялық кезең – мұнда 3 сорт (Костанайский янтарь – St, Scorpio, Taurus) ерекшеленді; өсімдік биіктігі - 1 сорт (Агата); 1000 тұқымның салмағы - Северный (8,0 г) және Сокол (8,1 г) бір өсімдіктегі қораптар мен тұқымдар саны - Небесный (38 қорап, 225 тұқым), Сокол (31 қорап, 143 тұқым) және Бизон (31 қорап, 140 тұқым). Зерттелген сорттардың ішінде Сокол (1,18 г), Небесный (1,74 г) және Северный (1,30 г) сорттары бір өсімдіктен ең көп тұқым массасына ие болды. Ең жоғары өнімділікпен Костанайский (13,46 ц/га) және Ручеёк (11,31 ц/га) ерекшеленді.

Кілт сөздер: генофонд; таңдау; үлгі; баға; зығыр; өткізіп жібер; вегетациялық кезең.

ИЗУЧЕНИЕ ИСХОДНОГО МАТЕРИАЛА КОЛЛЕКЦИИ ЛЬНА МАСЛИЧНОГО В УСЛОВИЯХ СЕВЕРНОГО КАЗАХСТАНА

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Анотация
с целью отбора исходного материала для селекции по выведению высокоурожайного сорта адаптированного к условиям Северного Казахстана,

в статье представлены результаты изучения исходного материала коллекции льна масличного. Работы выполнялись по общепринятым методикам.
Объектом исследования служили коллекционные образцы льна масличного разного эколого-географического происхождения. Полевые работы проведены в 2020-2021 гг. на научно-полевом стационаре НПЦЗХ им. А. И. Бараева, расположенном в Акмолинской области Северного Казахстана. В исследованиях изучали высоту растения, количество коробочек на растении, количество семян в коробочке, количество семян с одного растения, массу 1000 семян и урожайность. Основными мерами оценки льна масличного являлись: вегетационный период – здесь выделены 3 сорта (Костанайский янтарь – St, Scorpio, Taurus); высота растения – 1 сорт (Агата); масса 1000 семян – Северный (8,0 г) и Сокол (8,1 г) количество коробочек и семян на одном растении – Небесный (38 коробочек, 225 семян), Сокол (31 коробочка, 143 семени) и Бизон (31 коробочка, 140 семян). Из изученных сортов наибольшую массу семян с одного растения имели сорта Сокол (1,18 г), Небесный (1,74 г) и Северный (1,30 г). Наибольшей урожайностью отличились Костанайский (13,46 ц/га) и Ручеёк (11,31 ц/га).

Ключевые слова: генофонд; селекция; образец; сорт; лён; урожайность; вегетационный период.