Prospective resources for flax selection from the national gene fund of plants of Uzbekistan

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Abstract. Flax is one of the oldest oil crops in Central Asia and was cultivated for edible oil 1000 years ago. In 2023, flax was grown on an area of 13,000 ha in the arid regions of the Republic of Uzbekistan, and the average yield was 0.7-0.8 t/ha. The main reason for the low productivity is the lack of high-yielding varieties of flax suitable for the climatic conditions of Uzbekistan. In the climatic conditions of Uzbekistan, 100 flax varieties from the National Gene Bank were studied for morphobiological and economically valuable traits, belonging to more than 30 countries of the world. As a result of the research, 20 flax samples were selected based on the length of the main stem, 11 samples based on resistance to lodging, 10 samples based on early ripening, 17 samples based on the productivity of one plant, and 7 samples based on a set of traits. These samples will subsequently be involved in the breeding process to create new early-ripening, productive varieties with a high oil content in the seeds.

1. Introduction

Flax is an annual herbaceous plant belonging to the Linaceae family. This family unites about 200 species, of which ordinary linen occupies an important place in the industry [1].

In the world (in 58 countries), 2.5-3 million, and 85% of this product belongs to the countries of Canada, Russia, Kazakhstan, China, USA and India [2]. It is observed that the areas where flax is grown are expanding year by year, and this situation is related to its unique healing properties. Flax is widely used in folk medicine as an ointment for the treatment of various diseases, including: scarlet fever, stomach ulcer, kidney, anterosclerosis and burned skin, and at the same time, it is also widely used for weight loss due to the fact that its seeds are rich in biologically active substances. In the industry, high-quality oil and varnish-paint products are also produced from linseed oil [3].

Flax, cultivated worldwide for its versatile fiber and nutritious oil, is categorized into three primary groups: flax-dolgunets, flax-mejeumok, and flax-kudryash [4]. These groups exhibit distinct features such as stem morphology, plant height, pod production, and yields of seeds, oil, and fiber. Furthermore, they display varying degrees of resilience to temperature and humidity, reflecting their adaptability to diverse environmental conditions [5].

The world genetic repository of the Scientific Research Institute of Plant Genetic Resources houses a diverse collection of approximately 300 flax samples sourced from different regions across the globe. Our groundbreaking study represents the inaugural comprehensive analysis of 100 flax varieties within the unique climatic confines of Uzbekistan [6]. Through meticulous examination of their morphobiological and economic attributes, our research seeks to unravel the performance and adaptability of these varieties in Uzbekistan's distinctive environmental milieu, offering valuable insights for optimizing flax cultivation practices in the region [7].

The research aims to identify primary sources for the development of new early-ripening, high-yielding, and high-oil flax varieties suited to Uzbekistan's climate. This involves selecting promising flax lines from a collection of 100 varieties sourced from various geographic locations, including Abyssinia, Argentina, Armenia, and Afghanistan, among others. The study focuses on analyzing morphobiological characteristics, such as plant height, branching pattern, leaf shape, flower color, and seed characteristics [8]. Additionally, the research evaluates early ripening traits, productivity, weight of 1000 seeds, oil content in the seeds, and correlations between these valuable economic traits.

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To achieve these goals, the researchers will conduct field trials and laboratory analyses. Field trials will involve planting the different flax varieties in experimental plots in Uzbekistan and closely monitoring their growth and development throughout the growing season [9]. Laboratory analyses will include measuring the oil content in the seeds, determining the weight of 1000 seeds, and studying the genetic characteristics of the flax varieties [10].
The ultimate goal of the research is to identify the most promising flax varieties that exhibit early ripening, high productivity, and high oil content, and to use these varieties as primary sources in breeding programs to develop new flax varieties that are well-adapted to Uzbekistan's climate and agricultural conditions.

2. Materials and Methods

The research methodology was based on established guidelines for studying oilseed crops, including flax, as outlined in manuals such as the methodical manual for the study of the world collection of oilseed crops from the Vavilov Institute of Plant Industry (VIR) in Leningrad, 1986, and the methodical guide for studying the world collection of oilseeds from the Institute of Plant Sciences in Tashkent, 2010. These manuals provided standardized protocols for evaluating morphological and agronomic traits, seed characteristics, and oil content.
The results of the study were analyzed using correlation analysis, following the methodology. Correlation analysis helps identify relationships between different traits, such as the relationship between plant height and seed weight or between oil content and flowering time. This analysis provides valuable insights into the factors influencing flax productivity and quality.
Statistical analyses of the data were carried out using the MS Excel 2007 software package. This software was used to calculate means, standard deviations, and correlations, as well as to create graphs and charts to visualize the data. The use of statistical analysis software ensures the accuracy and reliability of the results obtained from the study.

3. Results and Discussion

Flax collection samples were sown in 1 m^2 plots in the fall prepared in the second ten days of March, and on March 24-28 the seedlings were fully collected. In the first year, the samples separated by valuable economic signs were planted in the second-third years in 3.5 m2 plots with three times repetition. After every ten samples (1, 11, 21, 31, etc.) in the collection nursery, and after every four samples (1, 5, 10, 15, etc.) in the control nursery, the model variety Baxmal-193 was planted for comparison.
During the growth period, the following development phases were noted: grass germination; honing; flowering i.e. beginning of flowering period (10%), entry into full bloom (75%), end of flowering period (last five % of plants entering flower). Germination status of lawns was evaluated according to a five-point system.
It was observed that the flax samples entered the flowering stage 32-42 days after the emergence of grasses, and in this case, Central Asian (Uzbekistan, Tajikistan, Kazakhstan), Abyssinian, Argentinean varieties in 32-34 days, Afghanistan, Armenia, Georgia, Turkey, Russia, Chinese samples in 36-37 in Denmark, Portugal, Asia Minor, India, China, Morocco, Tunisia, Kalmar (Sweden) and others, it was noted that it reached full flowering stage in 40-42 days.
According to the morphological characteristics, the main characteristics of the flax crop during the period of full flowering are: the color of yellow leaves; character of corollas (curled or smooth); flower state (open or collected); the shape of the flower (wide funnel-shaped, bell-shaped, fluted or star-shaped); plant height; the number of follicles per plant was studied.
2 of the studied linen samples have a dark air color k-205 (Uzbekistan), k-82 (Asia Minor), white color in 5 including: k-158 (Uzbekistan), k-168, k-204 (Russia), k-189 (Denmark) and k-199 (Tajikistan) were samples, and the remaining 93 were found to be light blue in color.

3.1. Main stem length of flax samples

Flax stem height is one of the main economic traits, and fiber can also be produced as a secondary product from oilseed flax. When the flax samples were studied according to the height of the main stem, 69 out of 100 samples were of medium height (42-55 cm), 31 were medium height (56-68 cm), and no short (from 30 cm) or high (from 80 cm) samples were identified.
St. In Bakhmal-193 variety, the height of the main stem is 43 cm. It was found that 2 of the studied samples are lower than the standard (42 cm), 5 are equal, and 93 are relatively high (45-68 cm). The following results were obtained when comparing the height of the plant stem by geographical regions, including: the average length of the stem in the samples of Afghanistan is 46 cm, in the samples of Uzbekistan it is 47 cm, in the samples of Asia Minor, Pamir, Turkey 49 cm, in the samples of India, Armenia 51 cm, Russia, Kalmar, Morocco and Argentina 55 cm in the samples, 55.6 cm in the Danish and Portuguese samples, 56 cm in the Chinese samples, 60 cm in the Abyssinian samples and 62 cm in the Tunisian samples.

26 samples with the highest results compared to the variety, including k-158, k-201, k-254 (Uzbekistan), k-199 (Tajikistan), k-54; k-105, k-230, k-259, k-260 (India), k-22, k-103 (China), k-251 (Argentina), k-214 (Tunisia), k-227 (Armenia) , k-189 (Denmark), k-137, k-168, k-204, k-244, k- 272, k-275, k-276, k-281 (Russia), k-224 (Dagestan) and (Denmark) and in k-2024, k-275, k-281 (Russia) samples, it was found that the length of the main stem was 15-19 cm higher than the standard (Table 1).

Table 1. Valuable farm characteristics of varieties selected from the flax collection according to the length of the main stem

Catalogue	Origin	Main stem length, cm	Number of baskets	Number of seeds in 1 harvest basket, pcs	1 plant productivity, g	Oil content of seeds, %
St. 93	Uzbekistan	43	66	7	2.6	34.6
158	Uzbekistan	62	88	6	3	35
201	Uzbekistan	58	110	6	3.4	36
254	Uzbekistan	62	134	5	3	35
199	Tajikistan	60	34	7	1.4	36
54	India	58	102	5	2.6	34
105	India	60	74	6	2.3	33
230	India	67	100	5	2.5	35
259	India	65	95	5	2.6	34
260	India	62	114	5	2.8	34
22	China	62	105	6	3.6	33
103	China	62	82	6	2.3	34
251	Argentina	58	100	6	3	34
214	Tunisia	62	99	6	3	32
227	Armenia	65	114	5	2.7	35
189	Denmark	63	92	6	3	33
137	Russia	60	87	5	2	32
168	Russia	61	87	5	2.3	33
204	Russia	61	87	5	3	36
244	Russia	64	87	6	2.2	33
272	Russia	62	87	5	2.5	33
275	Russia	60	87	5	3.6	35
276	Russia	62	87	6	2.5	36
281	Russia	62	87	4	3.1	34
224	Dagestan	64	87	5	1.8	34
226	Abyssinia	63	98	5	2.6	33
241	Abyssinia	68	85	5	2.4	32

These samples will serve as a unique primary source for the future creation of universal varieties. These samples will serve as a unique primary source for the future creation of universal varieties.

The number of stems in a plant is one of the important biological characteristics and serves as the main "key" in determining the subspecies of a variety. Out of 100 linen collection samples studied by us, 2 stems were formed in 12 samples, 3 stems in 55 samples, 4 stems in 24 samples, 5 stems in 7 samples, 6 stems in 1 sample, and 7 stems in 1 sample.

Another, very important selection feature of flax is the trait of resistance to lodging of the stem. This sign is very important for quality harvesting of the flax crop without destroying it with the help of machinery.

In the nursery of the flax collection, the evaluation of the varieties and samples for the resistance to dormancy of the stem began during the flowering period, the number of plants that remained dormant was determined on the second day after the rain, and after three days, the regeneration characteristic of the plants was observed, that is, how many plants regained the upright position of the stem. was studied.

Among the 11 plants according to the resistance to falling, k-126 (Uzbekistan), k-23 (Turkey), k-35 (Russia), k-36, k-42 (India), k-59, k-130 (Afghanistan), k-82, k-83 (Asia Minor) and k-102, k-115, (China) samples were selected. In these samples, the percentage of dormant plants after the rain was 19-22%, while this indicator was found to be 50% in the variety Baxmal-193 (Table 2).

Before harvesting, plant height, branching and nodulation uniformity were assessed in each section. The following three conditions during the harvest ripening period: the green ripening period of the harvest baskets; yellow ripening period of harvest baskets; the harvest period was taken into account.

Table 2. Samples of varieties selected for the resistance to lodging of flax plant (2019-2021)

Catalogue	Origin	Plant height, cm	Fallen plants %
Bakmal-193, st	Uzbekistan	43	50
k-126	Uzbekistan	53	22
k-23	Turkey	49	20
k-35	Russia	48	22
k-36	India	45	19
k-42	India	44	20
k-59	Afghanistan	49	20
k-130	Afghanistan	42	20
k-82	Asia	49	19
k-83	Asia	51	20
k-102	China	52	22
k-115	China	48	20

The period of green ripening of harvest baskets (after full germination of flax seeds) was observed in 71-72 days in early varieties, 82-84 in mid-ripening samples, and 87 days in late-ripening samples. The sample was recorded in 1982-1984 in the Bakhmal-193 variety.

The last assessment was that the general condition of the pods during yellowing ripening was evaluated according to the five-point system compared to the model variety, and biometric analysis was carried out on ten plants from each sample (main branch length, number of side branches, number of pods per plant).

3.2. Early ripening feature

The early ripening feature of the variety is also one of the important characteristics in the cultivation of flax. The growth period of the sample Bakhmal-193 variety is 90 days. 82 days after germination, k-21, (Russia), k-10 (Pamir), k-41, k-95 (India) ripened in 85 days, i.e. 5-8 days earlier than the model variety.

From the samples studied in the nursery of the collection K-76, k-77 (Armenia), k-69 (Georgia), k-97 (Ethiopia), k-23 (Turkey), k-82, k-83, k-108 Asia Minor, k-35 (Russia), k-36, k-42, k-121 (India), k- 182 (Portugal) k-55, k-44, k-59, k-130 (Afghanistan) k-195, K-20, K-126 (Uzbekistan) samples ripened in 100-105 days, while all other (70) samples ripened in 90 days almost at the same time as the model variety (Figure 1).

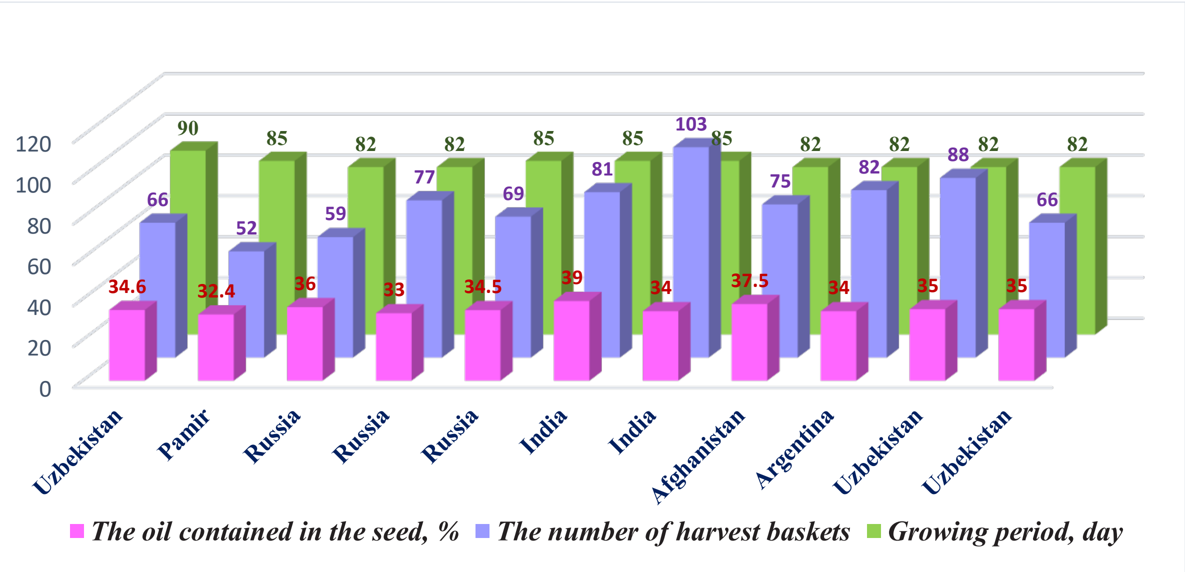

Fig. 1. Samples selected from the world collection of flax according to the characteristics of early ripening

3.3. Productivity per plant

The number of bolls per plant, the number of seeds per boll, and the weight of the seeds are among the main determinants of flax productivity. In flax samples, biometric measurements were made on 10 plants from each section when the seeds were physiologically fully ripe. In this, pods on one plant and the number of seeds in one pod was determined.

The average productivity of one plant is 2.6 grams in the variety "Bakhmal-193", 17 of the studied samples, including: k-3, k-158, k-201, k-205 (Uzbekistan), k-76 (Afghanistan)), k-125 Tajikistan, k-43 (India), k-22 (China), k-251 (Argentina), k- 214 Tunisia), k-189 (Denmark), k-182 (Portugal), k- 111, k-204, k-275, k-281 (Russia) and k-76 (Armenia) samples were selected. In these samples, the average productivity of one plant was 3-3.6 grams, which was 115-138% higher than that of Baxmal-193 variety (Table 3).

Table 3. Selected varieties from the flax collection based on the productivity of one plant

Catalogue	Origin	Productivity of one plant, g	Pods in 1 plant, pcs	The number of seeds in 1 pod, pcs	Productivity, g/m^2	Oil content of seeds, %
St-193	Uzbekistan	2.6	66	7	260	34.6
158	Uzbekistan	3	88	6	300	35
201	Uzbekistan	3.4	110	6	340	36
205	Uzbekistan	3.8	80	5	380	35
3	Uzbekistan	3	85		300	30
125	Tajikistan	3	65	7	300	36.6
43	India	3.3	85	5	330	36
22	China	3.6	105	6	360	33
251	Argentina	3	100	6	300	34
214	Tunisia	3	99	6	300	32
76	Armenia	3.1	77	7	310	35
189	Denmark	3	92	6	300	33
182	Portugal	3.4	99	6	340	32
111	Russia	3.4	123	6	340	34
204	Russia	3	90	6	300	36
275	Russia	3.6	120	5	360	35
281	Russia	3.1	121	4	310	34
189	Denmark	3	92	6	300	33

According to the amount of oil in the seed. While the oil content of flaxseed is influenced to a certain extent by soil and climate conditions, oiliness is a genetic trait (Table 4).
From 100 varieties of flax grown in the climatic conditions of Uzbekistan, belonging to different geographical regions, 13 varieties with high moisture content were selected. The content of oil in the seeds of these selected samples is 37.1-39%, and it was found that the model has 2.3-4.4% higher results than the variety. Based on the analytical selection of these samples, there are opportunities to create new varieties with a high yield and high oil content in a short period of time (2-3 years).

Table 4. Samples of flax varieties selected according to the high content of oil in the seed.

Catalogue	Origin	The amount of oil in the seed,%	Relative to the model, % ±
St-193	Uzbekistan	34,6	0
79	Asia	37	+2,4
82	Asia	37,1	+2,5
87	Asia	38,6	+4
48	Afghanistan	38,1	+4,1
58	Afghanistan	37,5	+2,9
59	Afghanistan	37,3	+2,7
130	Afghanistan	37,3	+2,7
36	India	37,9	+3,3
41	India	39,0	+4,4
42	India	37,9	+3,3
117	India	37,1	+2,5
121	India	37,1	+2,5
124	India	37,1	+2,5

The oil content of seeds in samples k-87 (Asia Minor), k- 48 (Afghanistan) and k-41 (India) with high results was 38.1-39.0%, and 34.6% in the model variety. Flax samples selected according to complex characteristics. k-125

(Pamir), k-158, k-201, k-205 (Uzbekistan), k-182 (Portugal), k-22 (China) and k-204 (Russia) according to complex markings: 7 samples was selected (Table 5).

Table 5. Flax samples selected from the world gene pool of plants according to their complex characteristics

Catalogue	Origin	Plant stem height, cm	The number of pods in 1 plant, pcs	Weight of 1000 seeds, g	1 plant productivity, g	The amount of oil in the seed, %
St-193	Uzbekistan	43	66	5.4	2.6	34.6
k-125	Pamir	47	65	6.3	3	36.6
k-158	Uzbekistan	62	88	5.6	3	35
k-201	Uzbekistan	58	110	5.2	3.4	35
k-205	Uzbekistan	52	80	6	3.8	35
k-182	Portugal	58	99	5.8	3.4	32
k-22	China	62	105	5.8	3.6	33
k-204	Russia	61	90	5.6	3	36
HCP05					**4.1**	

The relationships between the following 7 quantitative characteristics were studied in the flax collection samples: vegetation period, plant height, number of pods per plant, number of seeds per pod, weight of 1000 seeds, productivity per plant, amount of oil. When analyzing the results of studies on the valuable farm signs of flax collection samples, the correlation between the main signs was revealed as follows.

Including: the length of the main stem with the duration of the vegetation period (r = 0.23), the number of pods per plant (r = 0.19), the weight of 1000 seeds (r = 0.16), the productivity of one plant (r = 0.13), the number of seeds in one pod (r = 0.23) and the amount of oil in the seed (r = 0.09) showed weak correlation (Table 6).

Table 6. The degree of correlation between the main economic characteristics of flax samples

Signs	Plant height, cm	The number of pods in 1 plant	Number of seeds in 1 pod	Weight of 1000 seeds, g	Productivity of 1 plant, g	Oil content, %
Vegetation period, days	0.23	0.19	0.23	0.16	0.13	0.09
Plant height, cm		0.64	0.64	0.20	0.40	-0.37
Number of pods per plant			-0.45	0.36	**0.80**	0.20
Number of seeds in one pod				0.40	0.44	0.24
Weight of 1000 seeds, g					0.37	0.03
Productivity of 1 plant, g						0.28

It was observed that there is a correct average correlation between the height of the plant and the number of pods in the plant and the number of seeds in one pod (r = 0.64), the productivity of one plant (r = 0.40), the weight of 1000 seeds (r = 0.20). It was found that there is a moderate inverse correlation between height and seed oil content (r =-0.37).

Among the main economic traits of flax, the highest correlation was found between the total number of bolls per plant and the productivity trait per plant (r = 0.80). Weak positive and negative correlations were observed among the remaining traits.

4. Conclusions

The three-year research with the flax collection resulted in the selection of seven samples with complex valuable economic traits. These samples, identified as k-125 (Pamir), k-158, k-201, k-205 (Uzbekistan), k-182 (Portugal), k-22 (China), and k-204 (Russia), exhibited desirable characteristics such as early maturity, high yield, and high oil content. These samples were chosen based on their performance in the dry climate of Uzbekistan and their potential to serve as valuable genetic resources for the development of new flax varieties.

Moving forward, these selected samples will be presented to scientific research institutes for further evaluation and utilization in breeding programs. They are considered promising starting materials for the creation of new flax varieties that are well-adapted to the climatic conditions of Uzbekistan, offering the potential to enhance flax production and oil yield in the region.

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