Cultivation of promising oil flax varieties in the Trans-Urals

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Abstract. In Russia, flax has been cultivated since ancient times; fiber linen fabrics and other products were produce to meet needs of the population and for exchange. Oil flax was a less common crop, but its cultivation is of great interest.In recent years, worldwide interest in the use of flaxseed oil has increased due to its healing properties and high content of linolenic acid. Flaxseed oil removes cholesterol, improves the metabolism of proteins and fats, normalizes blood pressure, and reduces the likelihood of blood clots and tumors. Flaxseed oil reduces the risk of cardiovascular and oncological diseases and allergies. Whole flaxseed is used in various countries as an additive to bread and cereal mixtures. Proteins extracted from flaxseed have a gelatinizing effect and can be used in cooking.Oil flax is a valuable food and industrial crop (seeds, oil, short-fiber, cake and meal). Its seeds contain up to 50% of the most valuable vegetable oil which is the richest source of omega-3 and omega-6. Linseed oil ranks first among industrial oils by the volume of production. It is used in the manufacture of environmentally friendly varnishes, paints, drying oils, which serve as a standard for reliability and durability. Linseed oil is widely used in printing, rubber, electrical and many other industries.

1 Introduction

Oil flax is a valuable industrial crop. However, one of the serious factors that impede the production of oil flax is pests and diseases, of which 14 species are considered to be harmful:fusarium, pasmo, and bacterial disease [1 - 3].

To solve this problem, it is necessary to develop an effective, environmentally acceptable and cost-effective technology for protecting oil flax by using the most effective methods of seed protection.

Oilseed flax is a multipurpose crop (oil, flax fiber, fodder cake and meal) that has been used since ancient times. It is unpretentious to cultivation conditions, provides high yields of oil seeds, has a relatively high yield stability, does not require special agricultural machines for cultivation. Flax seeds contain 46-50% of oil, and are superior to other oils in terms of consumer properties. It is used as a technical raw material in various industries: paint and varnish, soap, leather and footwear industries, etc.[4].

2 Problem Statement

Oil flax is a valuable industrial crop. In the world agricultural industry, the area of oil flax crops is 2.5-3.2 million hectares, the gross yield of seeds is 1.9-2.7 million tons. Countries producing flax seeds are India, China, Canada and the USA. In Russia, the volume of production of this valuable crop is increasing.

Of particular relevance is the selection of varieties and development of cultivation methods of cultivation adapted to the regional conditions and ensuring the implementation of the biological potential of the variety, including through the application of agrochemicals and plant protection products. In Kurgan region, the area occupied by flax increased from 2,750 hectares in 2012 to 86,600 in 2020 with a yield of 6.3 kg/ha; more than half of the area is occupied by the North variety. Oilseeds obtained from flax seeds of LM-98, Itil, Ural yellow varieties are a source of pigmented vegetable oil and high-quality feed concentrate. Flaxseed cake is a good concentrated feed for livestock, 1 kg equals 1.15 feed unit. It contains from 6 to 12% of fat, up to 30% of digestible protein [5, 6].

Oil flax is a promising and highly profitable crop, cultivated in the Trans-Urals, but its productivity has not reached the limits, and it is necessary to develop methods for increasing its productivity [8-10].

3 Research Questions

The research object is oil flax varieties. The North variety is an early maturing high-yielding variety. It is cultivated in the Volga-Vyatka, Lower Volga, Ural, West Siberian and East Siberian regions. The period from germination to maturation is 70-75 days. The seed yield is 2.1–2.4 t / ha. The oil content is 50-51%,the iodine number of oil is 190 units. The plant height is 50-65 cm.

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VNIIMK 620:sSeed yield is up to 2.5 t / ha, oil content - 50%, the iodine number of oil is up to 195 units, the plant height is 65-70 cm. It is mid-season (80-85 days), has brown seeds, the weight of 1000 seeds is 8-8.2 g, it has blue flowers.

Itilhas a stem of medium length. The sepal spotting is weak. The color of the petal at the bud stage is blue-violet. The color of the petal at full development is light blue. The pistil is blue at the base. It has a medium sized box. The seeds are yellow. The mass of 1000 seeds is medium.The flowering time is medium. Fat content is 44.2-45.9% [11].

The Ural variety was included in the State Register for the Volga-Vyatka (4), Middle Volga (7) and East Siberian regions. It is recommended for cultivation in Penza and Perm regions. The stem is of medium length. The sepal spotting is weak. The color of the corolla at the bud stage is blue-violet and blue when fully developed. The pistil is blue at the base. The box is medium. The seeds are brown. The flowering time is medium. In the Volga-Vyatka region, the fat content is 44.0%. The average seed yield is 8.5 c/ha, the standard is 9.5 c/ha. The mass of 1000 seeds is 7.0 g. The growing season is 96 days. The height of attachment of lower branches is 29.3 cm. Resistance to shedding is 4.2 points. In Perm region, the seed yield is 11.2 c/ha. During the years of testing, diseaseswere not observed. In the Middle Volga region, the fat content is 46.8%. The average seed yield is 16.0 c/ha, the standard yield is 17.0 c/ha. The mass of 1000 seeds is 7.1 g. The growing season is 103 days. The height of attachment of lower branches is 27.9 cm. Resistance to shedding is 4.0 points. In Penza region, the seed yield is 14.4 c/ha. During the years of testing, diseaseswere not observed. In the East Siberian region, the fat content is 42.5%. The average seed yield is 14.9 c / ha, it is equal to the standard. The mass of 1000 seeds is 7.4 g. The growing season is 94 days. Drought resistance is 4.0 points. During the years of testing, diseaseswere not observed [12].

The Ural yellow variety was created by the Ural Research Institute of Agriculture, a branch of the Ural Federal Research Center of the Ural Branch of the Russian Academy of Sciences by the method of hybridization of Racioland LM 98 varieties, followed by the multiple selection. The variety is mid-season, the growing season is 85-90 days, but in cool years with excessive moisture, it can be up to 100-105 days.

Raciolhas a stem of medium length. The sepal spotting is absent or weak. The color of the corolla at the bud stage is blue-violet, and blue when fully developed. The pistil is blue at the base. The box is small. The seeds are yellow. The flowering time is medium.

Lirina (patent holder: DEUTSCHE SAATVEREDELUNG AG) was included in the State Register for the Volga-Vyatka (4) region. The stem length is medium. The sepal spotting is absent. Corolla at the bud stage is blue-violet and blue when fully developed;the longitudinal folding is absent. The filament is white at the apex.

LM 98 (patent holder: GNU VNII LINA ROSSELHOZAKADEMIYA) was included in the State Register for the Middle Volga (7) region. Its height is 55-65 cm[11].

4 Purpose of the Study

The article aims to study promising varieties of oil flax, resistant to biotic and abiotic environmental factors, to develop measures for protecting flax using thephytosanitary cultivation technology.

5 Research Methods

Field experiments to study the effect of protective equipment and Biostims on oil flax varieties were conducted at the experimental site of Kurgan State Agricultural Academy named after T.S. Maltsevby the methodology of State Variety Testing (1985), methodological Guidelines for State Testing of Fungicides, Antibiotics and Seed Treatments for Agricultural Crops (1985);the plot size was 6m^2, there were four replications, the predecessor wasfallow land. The seeding rate was set taking into account local agricultural recommendations - 8 million viable grains / ha. The row spacing was 15 cm. The sowing time was the second decade of May.

Mineral fertilizers were applied in the spring before sowing. The normal plant density, the evenness of the stalk, the content and quality of flax fiber and seeds depend on the preparation of seeders. When using herbicides against weeds, it is necessary to follow recommendations and treat flax with herbicides [10, 13, 14].

The flax varieties were cultivated in pairs. To determine the quality of seeds, the method of rolls (GOST 50459-92) was used, accounting for root rot by the V.A. Chulkin's method; the mycological analysis was carried out; and phytopathogenswere determined by the method developed by Bilai; the number of plant seeds in the soil was determined by the Taskaeva's method; the contamination was determined by the quantitative-weight method.

6 Findings

Seed samples selected by Kurgan State Agricultural Academy from 2019, 2020, 2020 flax crops (North, Ural, Ural yellow, Itil, Raciol, Lirina, VNIIMK 620, LM 98) were heated and analyzed by the method established in GOST 50459-92. The following parameters were determined:

1. Germination, (%)
2. share of seedlings with signs of pathogen infection, brown spots on roots and seedlings (% of the total number of seedlings);
3. Infection of seeds with Fusarium spp., Alternaria spp., Penicillium spp., Bacteriosis, mottling (% of the total number of seeds).

The results are presented in Tables 1 and 2.Over the years of research, the oil flax varieties formed seeds with high sowing qualities, with the exception of individual batches of seeds.

The highest germination rates were formed in 2020. The seed germination ranged from 90% forLirina to 95% for LM 98.

High germination rates were observedin 2020:85% for Raciol, and up to 92% for Ural Yellow and and LM 98 with the worst phytosanitary condition of seeds. Seedling damage varied from 11.0% for LM 98 (below PV 15%) to 26.0% for North andLirina, and 26.3% for VNIIMK 620.

These seeds should be treated, especially taking into account the infection of seeds with fusarium, bacteriosis and mottling of seeds.

Table 1. Sowing qualities of oil flax seeds by years, % (2018-2020)

Year	North	Lirina	Itil	Ural yellow	Ural	RACIOL	VNIIMK 620	LM 98
Germination, %								
2018	92	90	91	-	-	-	91	95
2019	87	89	89	95	99	84	90	90
2020	90	90	87	92	95	85	89	92
average	89,7	89,7	89,0	93,5	97,0	84,5	90,0	92,3
HCP 0,95 by factor "year" = 1.5; by factor "variety" = 1,0								
The share of factor "year"= 77,8								
Energy, %								
2018	84	80	82	-	-	-	82	84
2019	80	79	75	82	83	70	80	82
2020	82	85	70	80	80	74	77	80
average	82,0	81,3	75,6	81,0	81,5	72,0	79,7	82,0
HCP 0,95 by factor "year" = 1.2; by factor "variety" = 1,3								
The share of factor "year"= 73,5								
Proportion of seeds with signs of pathogen damage, %								
2018	16	16	13	-	-	-	18	8
2019	28	27	19	18	25	18	28	10
2020	34	35	28	24	24	30	33	15
average	26,0	26,0	20,0	21,0	24,5	24,0	26,3	11,0
HCP 0,95 by factor "year" = 0.5; by factor "variety" = 2,0								
The share of factor "year"= 67,8*, the factor “variety”= 7,0								

The main diseases of oil flax identified on seeds in 2019, 2020, 2020 are Alternaria, Fusarium, mottling, and bacteriosis. A high degree of seed infection with Fusarium was observed in 2019 and 2020 for North, Lirina, Itil, Ural, and VNIIMK 620. The 2% threshold of harmfulness (TH) for fusarium was exceeded, which requires mandatory treatment in order to avoid a decrease in the field germination rate (Table 2).

Table 2. Infection of flax seeds with phytopathogens by research years, % (2018-2020)

Year	North	Lirina	Itil	Ural yellow	Ural	RACIOL	VNIIMK 620	LM 98
Fusariumlini								
2018	3	2	3	-	-	-	4	1
2019	6	5	4	2	10	2	6	1
2020	7	7	6	4	5	4	7	2
average	5,3	4,7	4,3	3,0	7,5	3,0	5,7	1,3
$HCP_{0,95}$by factor "year" = 0.5; by factor "variety" = 0,1								
The share of factor "year"= 58,6								
Alternariaspp.								
2018	4	5	4	-	-	-	5	3
2019	2	3	5	7	7	1	5	4
2020	5	7	8	9	9	4	6	5
average	3,7	5,0	5,7	8,0	8,0	2,5	5,3	4,0
$HCP_{0,95}$by factor "year" = 0.6; by factor " variety " = 0,1								
The share of factor "year"= 42,5								
Bacteriosis								
2018	4	4	3	-	-	-	5	2
2019	7	8	5	4	3	11	7	2
2020	8	9	7	5	4	15	8	3
average	6,3	7,0	5,0	4,5	3,5	13,0	6,7	2,3
$HCP_{0,95}$by factor "year" = 0.4; by factor " variety " = 0,5								
The share of factor "year"= 54,1								
Mottling								
2018	5	5	3	-	-	-	4	2
2019	13	11	5	5	5	4	10	3
2020	14	12	7	6	6	7	12	5
average	10,7	9,3	5,0	5,5	5,5	5,5	8,7	3,3
$HCP_{0,95}$by factor "year" = 0.8; by factor " variety " = 0,5								
The share of factor "year"= 56,2								

A high level of seed colonization with bacteriosis pathogens was observed in 2019: from 8% in North to 9% in Lirina and 15% in Raciol.

Another disease that decreases the field germination rate isseed mottling observed in 2019; this indicator ranged from 5% in LM 98 to 14% in North which indicates a high degree of seed colonization.

Fusariumwas observed in 2020; the harmfulness threshold (15%) was recorded in VNIIMK 620 and Raciol.

In 2020, fusarium was observed in North in (control) at the harvesting stage (59.3%); it varied from 9.3 in Lirina to 36.7 in Itil, which is much less than in the control variety. The prevalence of the disease varied greatly: the smallest value was observed in Lirina - 28%, LM 98 - 30%, Raciol -32%; in North it was 98% (Table 3).

When studying the reaction of oil flax varieties to reproduction conditions, attention was paid to the selection of ecologically plastic highly productive varieties adapted to specific conditions when cultivated using the phytosanitary technology (Duskaev G.K. et al., 2018). In the severely arid vegetation conditions of 2020, oil flax varieties reduced yields (Table 4).

Table 3. Development and prevalence of fusarium on oil flax varieties before harvesting, experimental site of Kurgan State Agricultural Academy, 2020

Variety	Growth (%)	K_a	Prevalence (%)
North	59,3	1,65	98,0
Ural	25,3	2,13	54,0
Ural yellow	23,0	2,31	54,0
Itil	36,7	2,18	80,0
Lirina	9,3	3,0	28,0
Raciol	10,7	3,0	32,0
VNIIMK 620	29,3	2,39	70,0
LM 98	10,3	3,0	30,0
August	24,7	2,43	60,0
Azurit	33,3	2,04	68,0
Amber	24,0	2,50	60,0
$HCP_{0,95}$	2,1		3,4

Table 4. Elements of the yield structure for oil flax varieties, 2020

No	Variety	Plant height, cm	Number of plants, pcs / m2	Number of cases per plant, pcs.	Number seeds in in a case, pcs.	Weight of 1000 seeds, g.	Biological productivity, t / ha seeds	beet
1	North (standard)	52	360	11,4	6,8	6,5	1,81	1,78
2	Ural	44	402	10,8	7,6	6,0	2,00	1,86
3	Ural yellow	50	399	11,5	8,4	4,6	1,77	1,67
4	Itil	44	402	10,8	7,6	6,0	1,99	1,78
5	Lirina	47	401	10,0	8,0	5,9	1,89	1,82
6	Raciol	50	352	10,8	8,2	4,5	1,40	1,35
7	VNIIMK 620	51	346	12,3	8,1	5,6	1,93	1,77
8	LM 98	55	453	11,2	8,0	4,8	1,95	1,89
9	August	54	384	10,9	7,8	5,5	1,80	1,69
10	Azurit	55	360	10,5	7,3	5,6	1,50	1,49
11	Amber	52	393	10,9	8,3	4,9	1,74	1,68
	$HCP_{0,95}$		13	0,9	0,1	0,2	0,051	0,142

The arid conditions of reproduction in 2020 influenced the stand density, the number of cases per plant, the number of grains per case and the weight of 1000 seeds. At a seeding rate of 8 million germinating grains / ha or 800 pcs / m2, the survival rate was lowest for three years of research.According to the results of three-year studies, a high yield of seeds was obtained for North and Ural varieties.

The North variety, which occupies more than two-thirds of the area in Kurgan region, produced a high yield - 29.2 c / ha. According to the results of the two-year study, Ural and Ural yellow varieties produced high yields.

Among the foreign varieties, Lirina, VNIIMK 620 and Raciol varieties reduced their yields in response to unfavorable weather conditions and fusarium development.

Table 5. Oil flax seed yield by research years (experimental site of Kurgan State Agricultural Academy)

No	Variety	Yield, ha 2018	2019	2020	Average
1	North (standard)	2,26	3,79	1,81	2,62
2	Itil	1,98	2,51	1,99	2,16
3	VNIIMK 620	1,87	2,04	1,93	1,95
4	LM 98	2,06	2,70	1,95	2,24
5	Lirina	2,19	2,75	1,89	2,28
6	Ural	-	3,91	2,00	2,96
7	Ural Yellow	-	2,78	1,77	2,28
8	Raciol	-	1,91	1,40	1,66
	$HCP_{0,95}$	0,06	0,13	0,08	x

7 Conclusion

The flax varieties under study have poor resistance to pests. The main diseases which were identified on seeds in 2018, 2019, 2020 arealternaria, fusarium, mottling, andbacteriosis. A high degree of seed infection with Fusarium was observed in 2018 and 2019 inLirina, Itil, Ural, and VNIIMK 620. A high level of seed colonization with bacteriosis pathogens was observed in 2019: from 8% in North to 9% in Lirina, and 15% in Raciol.

Infection of seeds with Fusariumlini had a negative link ($r = - 0.6205 \pm 0.2053$) with seed germination, which indicates a high harmfulness of the phytopathogen at the initial development stages.

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