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Research Article

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Production of Oil Flax Seed in Non-Black Earth Zone of Russia

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ABSTRACT

The article proposes statistical data on the cultivation of oil flax in the Russian Federation, including Ryazan region, as well as experimental studies on the identification of effective for the region agrotechnical elements of the crop cultivation (sowing time, variety, herbicides and their tank mixtures).

The growth of oil flax popularity, which is observed in Russia, is due to the growth in demand at the primary industry market. Thus, this situation makes it possible to make the cultivation and processing of oilseeds very profitable. Most recently, oil flax crops in Russia did not exceed 31.9 thousand hectares, but since 2009 they have increased to 145.9 thousand hectares, and in 2019 the growth will be more than 700 thousand hectares.

Effective use of weed control chemicals or their tank mixtures is mainly determined by the precursors, the peculiarities of the cultivation technology, the soil and climatic conditions of the region (temperature and humidity), the species composition of weeds, and the number of weeds per unit area of crops.

The aim of our research was to improve the technological elements of cultivation of oil flax varieties, by identifying the optimal sowing dates, herbicides and their tank mixtures in crops on the gray forest soils of the Non-Chernozem zone of Russia.

The studies were carried out in the conditions of the agrotechnological experimental station of Ryazan State Agrotechnological University Named after P.A. Kostychev in Ryazan region. Two field two-factor experiments took place: 1. The influence of the seeding rate on the productivity of oil flax varieties. 2. The effect of zero tillage and herbicides tank mixtures on the yield at different planting dates. Experiments were performed according to a two-factor scheme.

It was found that during the sowing period in the first decade of May, the yield of flax crop was higher than when sown in the second term.

The maximum yield of flax seeds was obtained in 2018 using the Agritox and Panther tank mixture variant (0.8 l / ha and 1 l / ha, respectively) when sown in the first decade of May (21.5 decitonnes / ha). In 2017, the minimum yield of flax in the control plot was 13.3 dt / ha when sown in the second decade of May.

Thus, tank mixtures of herbicides provided a significant increase in the yield of Sanlin oilseed flax, where the most effective treatment option was Agritox and Panther (0.8 l / ha and 1 l / ha, respectively) with an average yield of 20.7 dt / ha.

Keywords: flax, crop structure, Non-Chernozem zone of Russia, seeding rate, herbicide, sowing time, yield, oil content

INTRODUCTION

One of the most important tasks of crop production is to increase the production of vegetable oils. In Russia, it does not provide even the minimum needs of the national economy. Currently no more than 12 kg is consumed per capita at a rate of 13.2 kg per year.

In general, in recent years there has been an increase in oilseed production in the Russian Federation, including Ryazan region [6,14]. As a result of the work carried out over a number of years to diversify the plant growing industry, the acreage occupied by sunflower, rapeseed, flax oilseed, mustard and other crops increased significantly.

Ryazan region is not among the regions - traditional producers of vegetable oil. However, in recent years, the production of oilseeds and their processing has been actively developing in the region (Fig. 1).

Table 1 - Dynamics of oilseeds production in Ryazan region (in weight after processing), thousand tons

Crop	Year						2018 to 2017, +/-
	2013	2014	2015	2016	2017	2018	
Oilseeds - total	107.8	148.6	141.8	139.6	147.0	167.2	+20.2
sunflower	45.0	39.1	39.3	55.5	56.7	85.2	+28.5
soy	6.0	18.6	16.3	19.3	18.2	17.2	-1.0
rape	39.1	55.7	57.7	41.6	58.9	55.3	-3.6
flax oilseed	0.6	1.0	1.6	1.3	0.8	1.5	+0.7

Current economic conditions are characterized by uncertainty and risk. To reduce their negative impact in agriculture, it is necessary to expand the range of crops grown, paying attention to those that are in steady and high demand from consumers. Oilseeds are among these crops and they are harvested for food, technical, feed and other purposes.

Currently, cultivation of oilseeds takes a special place in agriculture of Ryazan region.

In accordance with the calculations, the gross yield of oilseeds in Ryazan region will increase in the next three years by 62.75 thousand tons or 47.19 % and will be 195.75 thousand tons by 2019. This situation is largely due to favorable pricing environment. The farmers' price level of sales for oilseeds in 2015-2019 was higher than in previous years. The price conjuncture of oilseeds at the domestic market is currently taking shape under the influence of a decrease in their initial stocks and an increase in demand from oil refineries. In the coming years, according to specialists, oilseed sales prices will continue to grow, as raw materials will only decline. Moreover, against the background of market prices for grain, the additional increase in acreage under oilseeds, the price of which is the most stable, becomes vitally important.

At the same time, in the course of the analysis it was found that there are quite significant out-of-use on-farm reserves in agricultural farms of Ryazan region and their implementation in production will help to increase the yield of oilseeds and gross output, reduce costs and, consequently, increase the economic efficiency of the branch.

Currently, there are high rates, both in the production of oil flax and at industrial markets of the European Union, where demand for it is characterized by stable growth, in particular for Russian seeds [2].

Of 100 types of flax that are used on Earth, including in the temperate and subtropical areas, only common flax can be considered a cultural form. Arable flax is divided into three types, which are characterized by different features of the plant structure and the possibility of use. Oilseeds include oil flax, often called crown flax. Intermediate species that are also used for the production of flaxseed oil - flax hybrid, are quite widespread.

This plant has shown itself as a worthy phytosanitary one and a predecessor for other crops. It is an environmentally friendly crop, freeing the soil from pollution by radionuclides and heavy metals. It is highly resistant to changes in environmental factors and agricultural technology. Oilseed flax provides fairly high and stable yields of oilseeds, and also has various applications. With minimum technological and agrochemical requirements there exists high probability of obtaining high yields in the southern regions and in the northern latitudes of the central part of Russia, including the conditions of Ryazan region [1, 6, 7].

Unfortunately, the yield of this crop in Russia is unstable and does not exceed 1.3-1.5 t / ha. In

connection with this, special attention should be paid to the observance of cultivation technology and its improvement, since the increase in seed yield and its quality depend on this, especially in the central and southern regions. At the same time, one can strengthen the position at the market.

Modern varieties of oil flax give stable yields and respond well to a high agricultural background. They are drought-resistant, technological and reliable [1, 4]. In Ryazan Region, Sanlin, Itil, Istok, Lyrina, Mix, Severny, VNIIMK-620 and others can be classified as highly productive varieties of oil flax.

Currently, the development of flax breeding throughout the world is aimed at increasing yields and oil content with the fatty acid composition of the oil, improving properties of varieties to reduce the growing season and susceptibility to various diseases of the crop [3].

Flax has a food quality at the world market of oilseeds, according to FAO, more than 450 million tons, as it is produced in the amount of 2.2-2.7 million tons and occupies less than 1 % of the total.

At this time, interest in flax production is not weakening, as the world continues to have a high demand for edible seeds and oil for the chemical industry.

In the 2010s, Russia moved from outsiders in the production of oil flax to one of the leading countries. The simplicity of agrotechnics, the plasticity of the crop in environmental terms, the relatively small cost of cultivation, and the situation at the world market for oil flax contributed to such a take-off.

The Russian flax complex occupies more than 3 % in the world oilseed production.

Thus, in the “Concept of providing enterprises of the flax complex with technological equipment for growing, harvesting and deep processing of flax for 2008-2012 and for the period up to 2020” the Ministry of Agriculture of the Russian Federation reflected the direction of development of the industry. In this program, it was proposed to increase the production and the range of flax seeds for food and pharmaceuticals.

This project is intended to promote the construction of new and reconstruction of old enterprises for the integrated processing of flax for oil, cake, meal, flour, edible seeds, thereby reducing the import of oils and providing an opportunity to create additional jobs in villages.

The share of this crop acreage for in the structure of oilseeds increased by 3 % for six years and thereby amounted to 5.8 %. From 2006 to 2019, the area of oil flax crops increased from 76 to 709 thousand hectares, which is more than 10 times. The gross yield of seeds has increased dramatically and in recent years has exceeded 600 thousand tons, thereby the total crop yield in 2015-2016 was 8.5 dt / ha.

Statistics in Russia show that even with low seed yields (0.6 t / ha) it is economically advantageous to grow the crop seeds at the level of 20 %. With a seed yield of 1t / ha, profitability is approaching already 100 %. With a seed yield of more than 1-1.5 t / ha, profitability approaches 120-135 %.

Stavropol and Altai Krai, Samara, Rostov, Saratov and Volgograd Regions are the main flax-growing regions of the Russian Federation. Such regions as Penza, Voronezh, Ryazan, Kursk, Orenburg, republics of Kabardino-Balkaria, North Ossetia-Alania, Bashkortostan and Krasnodar territory are also engaged in its cultivation. Based on data from the Ministry of Agriculture and Food of Russia, in 2018, Ryazan Region has an area of 3,000 hectares of oil flax (Table 2).

Table 2 - The main parameters of oil flax cultivation in Ryazan region

Parameter	2015	2016	2017	2018
Yield, dt / ha	11.2	9.1	8.0	10.3
Acreage, ha	1,446	1,458	1,126	1,744
Gross yield, t	1,622	1,277	851	1,545

Farms, having the acreage of more than 2,000 hectares, in addition to profits from sales of oilseeds, may have an additional opportunity to get the profit from the primary processing of oil flax stems, creating a liquid, short fiber using specialized production lines.

Thus, with large sowing areas, profitability will increase. Consequently, the payback period of native lines will be reduced. These lines are recommended to regions in which no more than 20-25 thousand hectares are sown: Oryol, Tula,

Tambov, Lipetsk, Kurgan, Orenburg, and some other regions.

Producing countries compose more than 85 % in the total amount. Globally, oilseed flax is cultivated on an area of 2-3 million hectares in 58 countries, with Canada, Kazakhstan, Russia, China, India, Argentina and the United States being the largest producers. In 2010, a decrease in the share of oil flax imported by Canada was noted, a ban on the supply of genetically modified flax varieties to Europe was also made, that is why there was a sharp increase in the production of this crop in Russia.

From 2006 to 2016, the Russian Federation increased the area of oil flax crops by 10 times, which amounted to about 700 thousand hectares. This culture is grown in 33 regions of our country. Today, in terms of the size of the acreage of the Russian Federation, oil flax, occupies the last but one place among the leading oilseeds.

Flax seed producers depend on export prices and global market needs. That is why the construction of new and improvement of old processing plants of oil flax can contribute to the development of seed processing in Russia.

Thus, we note that the importance of foreign and domestic oil flax, both of food and natural fiber raw material resources, grows annually along with the demand for it. These facts prove its effectiveness and prospects in the range of products obtained from it.

Flax hybrid is one of the few cultivated plants, which has long been used both for the production of dietary oil and fiber. Flax seeds are used in traditional medicine for the soft and natural treatment of many diseases, as well as for nutritional and culinary purposes [3, 7-10]. Flaxseed oil is a biologically valuable product, a source of vitamins and polyunsaturated fatty acids necessary for the body, which are generally not capable of being synthesized in the human body [4, 11-13]. On the content of unsaturated fatty acids flaxseed oil is not inferior to many more well-known vegetable oils, such as sunflower, rapeseed, bird rape [6, 19, 20, 23, 24].

Despite the positive aspects of the quality of flaxseed oil, its sale in many countries is strictly prohibited. The main reason is that it easily goes rancid and becomes carcinogenic during storage, as it has a high content of unsaturated and polyunsaturated fatty acids, which are easily oxidized under the influence of oxygen [25].

According to its biological and morphological characteristics it is possible to assign flax variety Sanlin to hybrids. It is the characteristic features of this variety that make it possible to expand the geography of flaxseed oil production in our country and abroad, promoting the area of its cultivation far to the north compared to traditional varieties of oil flax, which are grown much more to the south. Flax cultivation technology for oilseeds is not as complex as some other oilseeds. Flax threshes quite well when harvested [5, 15, 16]

The oil obtained from flax seeds of variety Sanlin has a lower content of linolenic acid and a higher amount of linoleic acid, which allows it to be stored for a very long time without deteriorating its quality and changing its beneficial properties [1, 14].

Flax yield losses, like many other cultivated plants, with medium and strong weed infestation of fields can reach 20 ... 40 % and more.

Weeds are quite tough to compete with crops, suppress plants, shading them, secrete specific toxins that inhibit growth processes, disrupting metabolism. For the most part, having a more developed root system, weeds do not allow plants to receive optimal minerals and moisture from the soil, thereby having a negative effect on flax yield.

There are more than two dozen herbicides at the agricultural market that are approved for use in flax crops, mostly crown. But there are relatively few preparations for crops of flax oilseed and hybrid [2, 18].

Effective use of weed control chemicals or their tank mixtures is mainly determined by the predecessors, the peculiarities of the cultivation technology, the soil and climatic conditions of the region (temperature and humidity), the species composition of weeds, and the number of weeds per unit area of crops [17, 21, 22].

The aim of our research was to improve the elements of the technology of cultivation of oil flax varieties, by identifying the optimal sowing dates, herbicides and their tank mixtures in crops on the gray forest soils of the Non-Chernozem zone of Russia.

Conditions and methods of research

The studies were conducted in the period in 2016-

2018 in the conditions of the agrotechnological experimental station of Ryazan State Agrotechnological University Named after P.A. Kostychev in the educational and scientific innovation center "Agrotechnopark" in Ryazan district of Ryazan region.

Two field two-factor experiments took place:

1) the influence of the seeding rate on the productivity of oil flax varieties;

2) the effect of zero tillage and herbicides tank mixtures on the yield at different planting dates.

The experiments were carried out according to a two-factor scheme.

Experiment 1. The influence of seeding rate on the productivity of oil flax varieties. The two-factor experiment scheme included two options for factor A (variety): 1. variety VNIIMK-620; 2. variety Sanlin, 3. variety Istok and five variants for factor B (seeding rate):

1. a seeding rate of 6 million viable seeds / ha;
2. a seeding rate of 8 million viable seeds / ha;
3. a seeding rate of 10 million viable seeds / ha;
4. a seeding rate of 12 million viable seeds / ha;
5. a seeding rate of 14 million viable seeds / ha.

The plot area was 30 m² and the control one was 20 m². The replication was fourfold. The variants placement was systematic.

In experiment 2, factor A was the period of flax sowing (the first and second decade of May), factor B was the variants of the zero tillage of flax and herbicides tank mixtures:

The first treatment variant was a tank mixture of Agritox and Panther herbicides (0.8 l / ha and 1 l / ha, respectively).

The second treatment variant was a tank mixture of Secateur-Turbo and Panther herbicides (0.8 l / ha and 1 l / ha, respectively).

The third treatment variant was a tank mixture of herbicides Cortes and Harmony (6 g / ha and 20 g / ha, respectively).

The fourth variant was without the use of herbicides.

Agrotechnical measures for growing flax hybrid (oilseed) were carried out in accordance with existing recommendations. Flax varieties Istok, VNIIMK-620 and Sanlin were the object of research in experiment 1 and Sanlin was the object of research in experiment 2.

The predecessor in the experiments was winter wheat. Winter plowing was carried out to a depth of 22-24 cm, then the soil was harrowed with the help of BZSS-1.0 in a coupling, cultivated to a depth of 12-15 cm with the help of KPS-4 and before sowing it was cultivated again with the help of UNIA KOMBI 4.2 to a depth of sowing flax seeds.

Directly before the pre-sowing cultivation, nitrogen mineral fertilizers were applied in the calculation of the active substance N_{45} per hectare and ammonium nitrate was used.

Sowing was carried out in a continuous ordinary way with a row spacing of 15 cm to a depth of 2.2-2.4 cm, with a Lemken / EuroDril -250 seeder in an aggregate with an MTZ-82.1 tractor.

The seeding rate of flax in experiment 1 was according to the scheme; on variants of experiment 2 it was 10 mln of viable seeds / ha. After sowing, the soil was rolled on with a KKSH-9.2 roller in an aggregate with an MTZ-82.1 tractor to ensure its careful alignment and uniformity of shoots.

Then, in the phase of "herringbone" in order to combat weed vegetation, flax crops were treated with tank mixtures of herbicides in experiment 2 according to the scheme.

The treatment was performed using OPSh-15-01 sprayer in the evening or in the morning in windless or gentle wind weather at an air temperature of 15–20° C with a working mixture consumption rate of 250 l / ha.

The crops were harvested by the TERRION-SAMPO SR2010 combine harvester, by direct combining when more than 75 % ripening of flax seeds.

RESULTS

In the experiment on the study of the influence of the seeding rate on the productivity of oil flax varieties, the seeding rate did not affect significantly the main phases of the development of oil flax. Increasing the seeding rate increased the length of the growing season by 2-4 days.

The seeding rate had a significant impact on the structure of the crop.

The results of the experiment showed that the higher the seeding rate, the lower the indicators of the number of bolls per plant, the number of seeds in the boll and the number of seeds per plant (Table 3).

Table 3 - Elements of the crop structure, depending on the seeding rate and variety, average for 2016-2018

Seeding rate, mln viable seeds / ha	Variety	Crop structure elements		
		Number of bolls on one plant, pieces	The number of seeds per plant, pieces	Weight of 1,000 seeds, g
6	Sanlin	17.9	124.5	6.1
	VNIIMK-620	15.9	110.4	6.8
	Istok	16.7	109.6	6.2
8	Sanlin	17.7	121.5	6.1
	VNIIMK-620	15.0	97.3	6.9
	Istok	17.6	114.0	6.1
10	Sanlin	15.5	100.6	6.0
	VNIIMK-620	14.7	90.5	6.9
	Istok	15.6	106.0	6.2
12	Sanlin	14.3	83.4	6.1
	VNIIMK-620	12.9	78.2	6.8
	Istok	14.2	96.5	6.1
14	Sanlin	14.1	77.1	5.9
	VNIIMK-620	12.5	70.9	6.6
	Istok	13.9	81.7	5.9

On average, over the years of research, variety Sanlin has high parameters of crop structure with a seeding rate of 6-8 million viable seeds / ha. With an increase in the seeding rate to 10 million viable seeds / ha, the number of bolls and the number of seeds in the boll decreased.

Maximum yield results were achieved at a seeding rate of 8 million seeds per hectare. For variety Sanlin, this parameter was 23.3 centners per hectare, and for variety VNIIMK-620 it was 23.0 centners per hectare (Fig. 2).

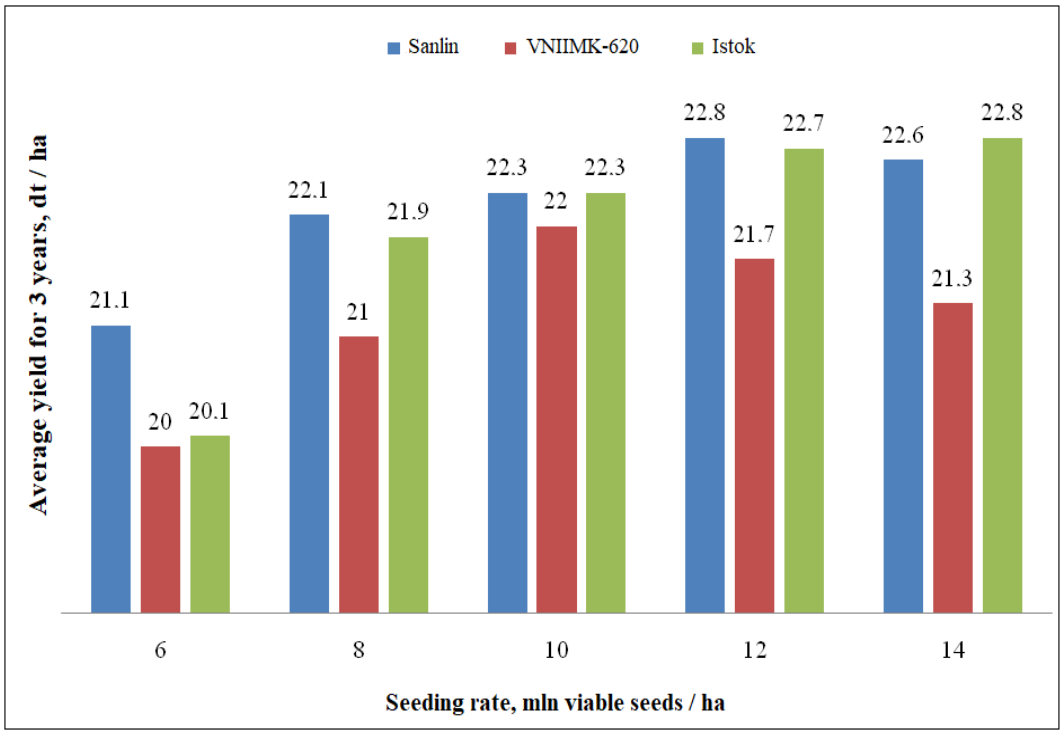

Figure 2 - Yield of oil flax varieties depending on seeding rates, average for 2016-2018

On average, over three years of research, with a seeding rate of 6 and 8 million viable seeds / ha, the yield structure and yield of Sanlin variety were higher than those of VNIIMK-620 and Istok varieties. With a seeding rate of 12 and 14 million viable seeds / ha, the yield of VNIIMK-620 variety exceeded the yield of

plants of the same variety with a seeding rate of 6-8 million viable seeds / ha by 1.7 and 1.3 dt / ha, respectively. At higher seeding rates of Istok plant, the yields were on average 13-14 % higher than in a case of a seeding rate of 6 million pcs / ha.

The studies have shown that variety Sanlin must be sown with a seeding rate of 8-10 million viable seeds / ha and varieties VNIIMK-620 and Istok - with a seeding rate of 10–12 million viable seeds / ha.

It should be noted that a further increase in the seeding rate over 12 million pieces / ha caused thick planting. The crop had lower parameters of the elements of the crop structure, which led to the crop shortage. Highly thick crops of oil flax were self-dimming, which was accompanied by an increase in the moisture content of the crop seeds and had a negative effect when harvesting. As a result of competition between plants very often thick crops had fewer bolls and smaller seeds, especially in dry conditions.

On average, over the years of the research, the oil content of the varieties was 42–46 %. On variants with a seeding rate of 10, 12, 14 million viable seeds / ha, the 1-3 % decrease in oil content of all experimental varieties was noted.

The average field germination of flax seeds of variety Sanlin in the experiment of studying the effect of zero tillage and herbicides tank mixtures on the yield at different sowing dates varied during the years of research and depended on the following factors: air temperature and soil moisture. At the control, the field germination of flax plants ranged from 86.2 to 95.1 %. With the sowing period in the first decade of May, the field germination of flax plants was 4-8 % higher than when sowing during the second decade of May, which was due in the first case to excessive waterlogging, and in the second case - to a lack of moisture in the upper soil layer (Table 4).

Table 4 - Parameters of field germination, density of planting, survival rate of flax plants at different times of sowing and variants of zero tillage

Treatment variants	Field germination of plants, %	Density of planting (pieces / m^2)		Plant survival, %
		full germination	before harvesting	
The first term of sowing is the first decade of May				
Tank mixture of herbicides Agritox and Panther (0.8 l / ha and 1 l / ha, respectively)	96.2	962	942	97.9
Tank mixture of herbicides Secateur-Turbo and Panther (0.8 l / ha and 1 l / ha, respectively)	96.3	963	923	95.8
Tank mixture of herbicides Cortes and Harmony (6 g / ha and 20 g / ha, respectively)	96.9	969	902	93.1
Control (without the use of herbicides)	95.1	951	731	76.9
The second term of sowing is the second decade of May				
Tank mixture of herbicides Agritox and Panther (0.8 l / ha and 1 l / ha, respectively)	90.8	908	848	93.4
Tank mixture of herbicides Secateur-Turbo and Panther (0.8 l / ha and 1 l / ha, respectively)	88.0	880	782	88.9
Tank mixture of herbicides Cortes and Harmony (6 g / ha and 20 g / ha, respectively)	90.4	904	821	90.8
Control (without the use of herbicides)	86.2	862	594	68.9

The density of flax plants during the period of sprouting and before harvesting the crop is one of the main factors influencing the formation of the yield of flax seeds.

With more thinned crops, it is possible that a part of the crop is lost, as in the case with thick ones, where flax plants compete not only with weeds, but also with each other.

In our experiments, the effect of preparations on the growth and development of flax plants was in varying degrees. The best survival was observed when using the Agritox and Panther tank mixture (0.8 l / ha and 1 l / ha, respectively), this parameter ranged from 93.4 to 97.9 %, the worst one was observed in control. The

main reason is that in control a large number of weeds strongly competed with flax plants, suppressing them. We note the best survival rate of flax plants during the sowing period in the first decade of May for all treatment variants with tank mixtures of pesticides and in control. This fact indicates that with the early sowing period, flax plants managed to gain the necessary growth and more successfully competed with monocotyledonous and dicotyledonous weeds.

Analysis of the parameters of the structure of the flax crop showed that the tank mixtures of herbicides significantly influenced the following parameters: density of planting, the number of bolls per flax plant and the weight of 1000 seeds (Table 5).

Table 5 - Parameters of the elements of flax crop structure depending on the time of sowing and the effect of tank mixtures of herbicides

Treatment variants	Density of planting, pieces / m^2	Number of seeds in a boll, pcs.	Number of bolls per one plant, pcs.	Weight of 1000 seeds, g	Height of flax plants, cm
The first term of sowing					
Tank mixture of herbicides Agritox and Panther (0.8 l / ha and 1 l / ha, respectively)	942	7.4	32.6	6.8	75.9
Tank mixture of herbicides Secateur-Turbo and Panther (0.8 l / ha and 1 l / ha, respectively)	923	7.4	32.2	6.6	70.9
Tank mixture of herbicides Cortes and Harmony (6 g / ha and 20 g / ha, respectively)	902	7.2	28.1	6.5	66.6
Control (without the use of herbicides)	731	7.0	25.8	6.1	66.0
The second term of sowing					
Tank mixture of herbicides Agritox and Panther (0.8 l / ha and 1 l / ha, respectively)	848	7.3	32.1	6.6	74.4
Tank mixture of herbicides Secateur-Turbo and Panther (0.8 l / ha and 1 l / ha, respectively)	782	7.3	30.9	6.7	69.4
Tank mixture of herbicides Cortes and Harmony (6 g / ha and 20 g / ha, respectively)	821	7.1	26.2	6.6	63.7
Control (without the use of herbicides)	594	6.9	24.9	6.3	64.2

The efficiency of the use of herbicides as a means of weed control in crops of flax variety Sanlin, depended on the time of sowing, as well as the different variants of the used tank mixtures of preparations. The use of chemical means of weed control contributed to an increase in the number of bolls in all variants where herbicides were used, as well as an increase in the number of seeds in the bolls, which further contributed to increasing the yield of this crop.

When treating crops with Cortez (Harmony) tank mixture and, to a lesser extent, Secateur-Turbo (Panther), the effect of insignificant inhibition of Sanlin flax plants during the first two weeks after treating the crops was observed.

The height of flax plants in the experiments with the use of herbicides varied within 2-3 cm and depended primarily on the time of the crop sowing. When sowing in the first decade of May the height of the crops was higher, due to the fact that at earlier sowing dates the best combination of favorable factors was observed, contributing to increased energy of flax plant growth in the initial periods of development.

The initial weed infestation of crops was lower, because weeds did not have time to develop optimally and maximize their biomass, and thus their negative impact on the growth and development of flax plants was much lower.

When examining the experimental crops of flax, 23 species of weeds from 9 families were identified. Of these, 9 perennial species were identified as well as 14 non-perennial ones, including 1 ephemerous, 10 spring and 3 winter ones. Usually dicotyledonous weeds (15 species) were identified.

Wild spin was most popular weed in crops, accompanied with a relatively small number of other types of weeds.

On average, over two years of research, this figure was 24 % of the total weeds, 10 % were

chamomile species and hemp nettle and common spurrey comprised 9 % each.

The distribution of the main types of weeds by botanical families was as it follows: the goosefoot family (17.9 %), Asteraceae (14 %), Cereal (16 %), Brassicaceae, chickenwort and Lamiaceae (each 9 %).

Thus, the greatest number of weeds belonged to the class of dicotyledonous plants. Among monocotyledonous weeds of the family of cereal or Poaceae, barnyard grass, silky bent grass, tufted hair grass and annual bluegrass were the most common ones, and the choice of antimicrobial herbicides (Panther and Cortes) in different variants of our research was associated with these factors.

According to the results of the survey and phytosanitary evaluation of the experimental plots, we have proposed variants for herbicidal treatments in flax crops: Agritox and Panther (0.8 l / ha and 1 l / ha, respectively), as well as Secateur-Turbo and Panther (0.8 l / ha and 1 l / ha, respectively). Weed stocks on the control variants were 45.6 pieces / m^2 when sowing flax in the first decade of May, and 49.8 pieces / m^2 when sowing in the second decade of May.

The green weight of weeds on the control was 2.7 times higher than when using Agritox and Panther tank mixtures (0.8 l / ha and 1 l / ha, respectively), as well as Secateur-Turbo and Panther (0.8 l / ha and 1 l / ha, respectively). Thus, in all variants of pesticide treatments, a decrease in the mass of one weed was observed due to its inhibition by pesticides, this figure varied from 39 to 69 %.

Herbicide Agritox, with an active ingredient consisting of a mixture of sodium, potassium and dimethylamine salts of 2-methyl-4-chlorophenoxyacetic acid, effectively fought against one-year dicotyledonous weeds, such as wild spin and various species of knotweed. The preparation actively suppressed the synthesis of growth substances of weeds, inhibited the processes of photosynthesis, as well as respiration (Krebs cycle). We also pay attention to the insufficiently rapid absorption by the weeds of the Harmony preparation, whose active ingredients are tifensulfuron-methyl and chlorimuron-ethyl. Herbicide was ineffective in the fight against dicotyledonous annuals and perennial weeds, in particular wild spin, which occupies a leading position in the agrocenoses of weeds in the experimental plots, was weakly suppressed.

Preparation Panther, with active ingredient quizalofop-P-tefuril, effectively fought most of the grass weeds, except for oat grass. Due to its systemic synergistic properties, the preparation completely penetrated into the plants during the day, suspended growth and began to suppress weeds. This herbicide was especially effective against barnyard grass and bluegrass.

Obtaining a high yield of flax is closely dependent on the nature of the growth and development of plants. Since the harvest is the result of the interaction of various factors, it is important to take into account the influence of their entire complex, the so-called synergistic effect, therefore, in crop production it is necessary to take into account all the conditions on which the final crop yield depends. The reduction of weeds has a positive effect on the yield of flax seeds in all variants of treatments with tank mixtures of herbicides (Table 6).

Table 6 - Parameters of flax yield depending on the variants of herbicidal treatment and seeding time

Treatment variants	The yield of flax seeds, t / ha			Yield increase (to control)	
	2017	2018	average value	dt / ha	%
The first term of sowing is the first decade of May					
Control (without the use of herbicides)	14.2	16.1	15.2	-	-
Tank mixture of herbicides Agritox and Panther (0.8 l / ha and 1 l / ha, respectively)	19.9	21.5	20.7	5.5	36.2
Tank mixture of herbicides Secateur-Turbo and Panther (0.8 l / ha and 1 l / ha, respectively)	17.2	20.0	18.6	3.4	22.4
Tank mixture of herbicides Cortes and Harmony (6 g / ha and 20 g / ha, respectively)	14.2	18.3	16.3	1.1	7.2
The second term of sowing is the second decade of May					
Control (without the use of herbicides)	13.3	15.6	14.5	-	-

Tank mixture of herbicides Agritox and Panther (0.8 l / ha and 1 l / ha, respectively)	19.8	19.0	19.4	4.9	33.8
Tank mixture of herbicides Secateur-Turbo and Panther (0.8 l / ha and 1 l / ha, respectively)	18.8	18.2	18.5	4.0	27.6
Tank mixture of herbicides Cortes and Harmony (6 g / ha and 20 g / ha, respectively)	14.6	16.9	15.8	1.3	9.0
LSD_{05} dt / ha, AB interactions	1.44	2.33			

The average yield of flax seeds of Sanlin variety varied from 14.5 dt / ha in the control area to 20.7 dt / ha in the variant with the use of the Agritox and Panther tank mixture (0.8 l / ha and 1 l / ha, respectively). With the term of sowing in the first decade of May, the yield of flax crop was higher than that when sown in the second term.

The maximum yield of flax seeds was obtained in 2018 using the Agritox and Panther tank mixture (0.8 l / ha and 1 l / ha, respectively) when sown in the first decade of May (21.5 dt / ha). In 2017, the minimum yield of flax in the control area was 13.3 dt / ha when sown during the second decade of May.

CONCLUSION

Thus, studies have shown that variety Sanlin should be sown with a seeding rate of 8–10 million viable seeds / ha and varieties VNIIMK-620 and Istok should be sown with a seeding rate of 10–12 million viable seeds / ha.

It should be noted that a further increase in the seeding rate of over 12 million seeds / ha caused thickened crops. The culture formed lower parameters of the elements of the crop structure, which led to a shortage of the crop. Highly thickened crops of oil flax were self-dimming, which was accompanied by an increase in the moisture content of the crop seeds and had a negative effect on harvesting. In thickened crops, especially in dry conditions, as a result of competition between plants, there were often fewer bolls and the seeds were smaller. On average, over the years of research, the oil content of the varieties was 42-46 %. On variants with a seeding rate of 10, 12, 14 million viable seeds / hectare, a 1-3 decrease in oil content was observed in all experimental varieties. In the experiment with tank mixtures of herbicides, a significant increase in the yield of Sanlin oilseed flax variety was noted in the variant of treating with Agritox and Panther tank mixture (0.8 l / ha and 1 l / ha, respectively) with an average yield of 20.7 dt / ha. With the sowing period in the first decade of May, the yield of flax crop was higher than that with sowing in the second term.

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