

Culture of priority oil crops in the north of Kazakhstan

Vasilij G. Vasin¹, Altynaj B. Abuova², Saniya A. Tulkubaeva^{1,3,*}, Dinara B. Zhamalova⁴, and Marat B. Tashmuhamedov

¹Samara State Agrarian University, 446442 Kinel, Samara region, Russia

²Zhangir Khan West Kazakhstan Agrarian-Technical University, 090009 Uralsk, The Republic of Kazakhstan

³Agricultural Experiment Station “Zarechnoe”, 111108 Zarechnoe, The Republic of Kazakhstan

⁴Kostanay engineering and economics university named after M. Dulatov, 110000 Kostanay, The Republic of Kazakhstan

3

Abstract. The research was carried out in order to increase the productivity of oilseed flax and spring rape in Northern Kazakhstan. Experimental studies were conducted from 2012 to 2014 in Kostanay research Institute of agriculture (Republic of Kazakhstan). The experiment studied the sowing of flax and spring rape – 2nd decade of May; 3rd decade of May; 1st decade of June and the seeding rate for flax is 6.5; 7.0 and 7.5 million viable seeds/ha for spring rape – 2.0; 2.5 and 3.0 million viable seeds/ha. During the years of research, the best coefficient of water consumption of the studied crops showed the second sowing period – the third decade of May. According to the seeding standards, the formation of an optimal stem density increased the efficiency of moisture use. It was noted that moisture was most rationally consumed when sowing oilseed flax with a norm of 7.0 million sunflower seeds/ha (16.5-17.7 mm/c), spring rapeseed with a seeding rate of 2.5 million sunflower seeds/ha (9.9-11.2 mm/c). Oilseed flax sowing in the 3rd decade of May with a seeding rate of 7.0 million seeds/ha allowed to obtain the highest indicators of plant productivity in the experiments: yield is 13.1 c/ha, oil yield is 5.4 c/ha. In spring rape, the optimal sowing period was also the third decade of May; according to the seeding rate, the variant of 2.5 million suns excelled. seeds/ha sown in a given period: yield is 22.9 c/ha, oil collection is from 1 ha - 9.4 c.

1 Introduction

Oil flax (*Linum usitatissimum* L.) is valuable technical multi-use culture with a yield potential of up to 2.5 t/ha [1]. In the total structure of flax crops in the world, oil flax prevails, which occupies about 84% of all areas, and only 16% is accounted for by flax varieties cultivated mainly for fiber production. The main cultivation of culture is concentrated in Canada, China, USA, Russia and Kazakhstan [2].

This culture is characterized by excellent biological and economic qualities, namely, high drought tolerance, short growing season, manufacturability, high yields and profitability [3, 4]. Therefore, in addition to traditional oilseeds, the introduction of oil flax in many regions as an important source of edible oil and high-grade protein becomes relevant [5–7].

Rapeseed, like no other culture, successfully combines the high potential seed yield (3.0-4.0 and more tons per hectare), with a high content of oil (45-48%) and protein in seeds (22-25%) and in green mass (3-4%) [8].

Due to its high profitability, cultivated areas under rapeseed are increasing every year, including in Kazakhstan. Rapeseed oil is one of the most used oils in the world, in the countries of Europe it takes the third

place after olive and linseed. The price of rapeseed is always high and exceeds the price of wheat, while the demand for rapeseed is constantly growing and there are no sales problems [9].

Rapeseed is an extremely high-tech culture, the cost-effective production of which is possible only under the conditions of strict implementation of a complex of very expensive agrotechnical and organizational measures for its cultivation [10–12].

To obtain high yields of any crop, it is necessary to create optimal conditions for the growth and development of plants. It is well known that one of the important technological methods of cultivating field crops is the sowing period. Depending on the sowing period, the growth and development of the plant takes place at different levels of moisture, heat and light [13–15].

The optimal seeding rate is also one of the fundamental factors that have a significant impact on the yield of this crop. The seeding rate of culture seeds depends on many factors: the purpose of cultivation, biological and morphological features, environmental features of the zone, the method of sowing. The smaller the habit of the plant, the smaller the area it occupies [16, 17].

* Corresponding author: tulkubaeva@mail.ru

The purpose of the research is to study the influence of sowing dates and sowing rates on the development and productivity of oilseed and spring rape plants in the conditions of Northern Kazakhstan. The research objectives included the establishment of optimal sowing dates and sowing rates of oilseed and spring rape for Northern Kazakhstan, contributing to an increase in the oilseed crop and an increase in its quality.

This work was carried out as part of the state budget program 212 "Scientific research and activities in the field of agriculture" of the Ministry of Agriculture of the Republic of Kazakhstan.

2 Materials and methods

Experimental studies were conducted from 2012 to 2014 at the Kostanai Research Institute of Agriculture (the Republic of Kazakhstan). In the experiment, the timing of sowing flax of oilseed and spring rape was studied - the 2nd decade of May; 3rd decade of May and 1st decade of June and seeding rates - for oilseed flax - 6.5; 7.0 and 7.5 million germinating seeds/ha; for spring rape - 2.0; 2.5 and 3.0 million germinating seeds/ha. The experiment was laid down by the method of split plots. The repetition of the experiment is three times. The area of 1 plot is 60 m², the accounting area is 40.5 m². The experimental plot area is 0.4 ha.

The experience is laid on a herbicidal pair, the preparation of which is carried out using soil-protective moisture-saving technology. Moisture closure is performed as the physical ripeness of the soil is achieved by the BCD-12 rotating harrow, which does not violate the mulching layer. 10 days before sowing, a chemical herbicide treatment Hurricane forte. Sowing was carried

out within the time stipulated by the experimental design, with the SS-11 seeder in an aggregate with a MTZ tractor. Seeding rates are also according to the experimental design.

To control weeds, oil flax was sprayed with herbicides (against millet - Bars, 1.5-2.0 l/ha, against annual dicotyledons - Sekator, 150-180 g/ha).

In the period from germination to the rosette, spring rape crops were 2 times treated with insecticides Karate Zeon, 0.03 l/ha and Confidor, 0.07 l/ha (systemic action) against cruciferous flea species. In the phase of the outlet, rape crops were treated with a tank mixture of Aramo herbicides, 1.5 l/ha and Lontrel, 0.3 l/ha to destroy cereal and dicotyledonous weeds. In the phase of "budding is the beginning of the flowering of rapeseed", a Biscay insecticide was treated with 0.3 l/ha against rapeseed beetle, sawfly and cabbage. In addition, during the growing season of rapeseed, several inter-land weeding and machining of the inter-tier roads were carried out. In the green pod phase, butt rows and marginal plants were cut out with sickles.

Harvesting was carried out directly by continuous threshing of the plots with the Sampo-2010 and Vektor combine, with seed moisture 12-13%, followed by cleaning and drying up to 8%.

3 Results

The climate in the research area is sharply continental: hot and dry summers, little snowy cold winters. According to long-term data, the annual rainfall in the experimental area is 323 mm. Precipitation of the warm period (April-October) is 75.6% of the annual amount. Most of them fall in the second half of summer (Fig. 1).

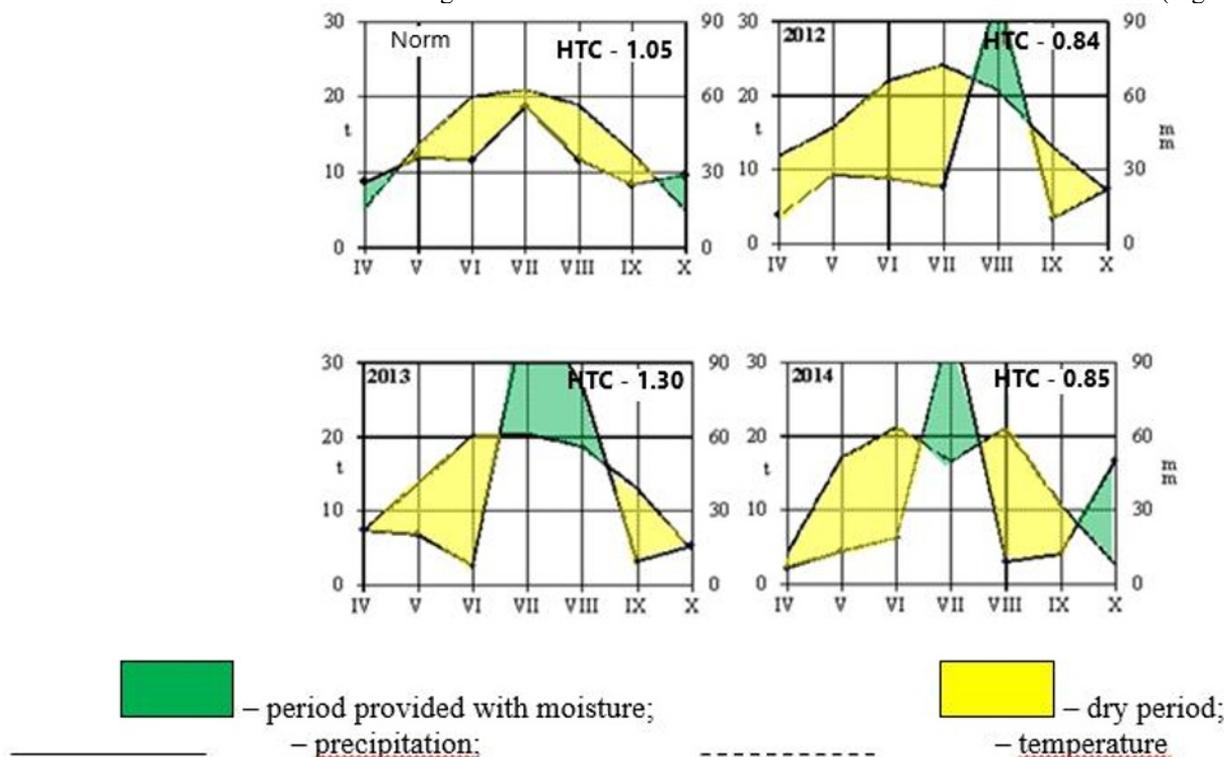


Fig. 1. Climagrams (according to the method of H. Walter). HTC - hydrothermic coefficient

In 2012, the amount of precipitation for the warm period of the year was 252.3 mm, which is slightly higher than the average long-term norm (244.0 mm). At the same time, 179.0 mm, or 114.8% of the annual norm, fell during the growing season (May-August). However, more than half of these precipitations (101.1 mm) fell in August, when the harvest was already underway. June and July were very unfavorable for precipitation. Over

the course of 50 days, not a single mm of precipitation fell. The average daily air temperature in the spring and summer periods was higher than the average annual values by 2.9-8.20C. In June-July, high air temperatures, along with soil, caused atmospheric drought. The hydrothermal coefficient (HTC) for the growing season of oilseed and spring rape flax in 2012 was 0.4-0.8 (Tables 1, 2).

Table 1. Hydrothermal conditions of the growing season of oil flax, depending on the timing of sowing, 2012-2014.

Sowing date	Spring moisture reserves, mm	Moisture reserves before harvesting, mm	The consumption of moisture from the soil during the growing season, mm	Rainfall for vegetation, mm	Total water consumption, mm	Water consumption ratio, mm/c	Sum of Effective Temperatures, 0C	HTC
2012								
2 decade of May	124.6	28.5	96.1	53.0	149.1	28.7	1217.2	0.4
3 decade of May	116.7	24.3	92.4	53.0	145.4	25.5	1197.8	0.4
1 decade of June	98.0	19.4	78.6	96.9	175.5	29.3	1195.6	0.8
2013								
2 decade of May	139.6	55.5	84.1	203.4	287.5	21.1	1360.9	1.5
3 decade of May	128.0	47.1	80.9	194.6	275.5	21.2	1401.8	1.4
1 decade of June	115.6	33.2	82.4	204.8	287.2	19.9	1488.2	1.4
2014								
2 decade of May	145.3	46.2	99.1	143.2	242.3	15.6	1162.4	1.2
3 decade of May	134.6	39.3	95.3	133.4	228.7	14.9	1060.0	1.3
1 decade of June	117.5	28.9	88.6	135.3	223.9	13.8	1228.5	1.1
average for 2012-2014								
2 decade of May	136.5	43.4	93.1	133.2	226.3	21.8	1246.8	1.1
3 decade of May	126.4	36.9	89.5	127.0	216.5	20.5	1219.9	1.0
1 decade of June	110.4	27.2	83.2	145.7	228.9	21.0	1304.1	1.1

During the warm period of 2013, 286.2 mm of precipitation fell, which is 44.2 mm or 18.3% higher than the long-term average. At the same time, during the growing season (May-August) 225.3 mm fell, which is 144.4% of the long-term norm.

However, 87.3% of these precipitations fell in July (116.6 mm) and August (80.0 mm), when the ripening of oil flax had already begun. Precipitation in June in 2013 amounted to only 8.1 mm (18% of the norm). The average daily air temperature in the spring (April, May) was at the level of long-term average values. In June, the average daily air temperature was at the level of long-term values (20.20°C). The average daily temperature in July in 2013 (20.40°C) was almost one degree higher than long-term values. HTC for the growing season of 2013 in flax oilseed and spring rape is 1.4-1.5.

In 2014, during the growing season of 2014, precipitation was greater than the average annual norm. However, the first half of the growing season (May, June and until July 12) was acrid arid. So, over the whole of June, 18.9 mm of precipitation fell with an average annual norm of 35.0 mm. The process of accumulation of fat in the seeds took place with sufficient moisture in the soil. Thus, by the amount of precipitation during the

growing season, 2014 is characterized as favorable. The average daily air temperature over the entire period (May-August) was higher than long-term average values. The HTC for the growing season of 2014 was at the level of 1.1-1.3 - in oilseed flax, 1.0-1.1 - in spring rape.

On average, over the years of research, spring stocks of productive moisture in the soil before sowing depended on the timing of sowing. In the experiments, the dynamics of a decrease in spring moisture reserves from early to late sowing periods is traced - an average of 20%. A general decrease in soil moisture reserves is observed by the harvesting period. Reserves of productive moisture in a meter soil layer on oilseed flax amounted to 27.2-43.4 mm, on spring rape - 15.9-32.2 mm.

The total water consumption of the studied crops (the difference between the spring moisture reserves and its residual reserves after harvesting plus precipitation during the growing season) by the sowing dates had the following values. Oilseed flax: 1 period - 226.3 mm; 2 term - 216.5 mm; 3 term - 228.9 mm; in spring rape: 1 period - 227.5 mm; 2 term - 225.6 mm; 3 term - 229.9 mm. Based on this, there was a slight advantage in water consumption of the third sowing period.

Table 2. Hydrothermal conditions of the growing season of spring rape, depending on the timing of sowing, 2012-2014

Sowing date	Spring moisture reserves, mm	Moisture reserves before cleaning, mm	The consumption of moisture from the soil during the growing season, mm	Rainfall for vegetation, mm	Total water consumption, mm	Water consumption ratio, mm/c	Sum of Effective Temperatures, °C	HTC
2012								
2 decade of May	129.4	24.1	105.3	48.5	153.8	7.8	1189.1	0.4
3 decade of May	116.9	20.7	96.2	53.0	149.2	7.2	1181.7	0.4
1 decade of June	99.3	17.3	82.0	100.0	182.0	9.9	1232.1	0.8
2013								
2 decade of May	116.0	38.2	77.8	203.4	281.2	13.9	1375.6	1.5
3 decade of May	110.0	24.1	85.9	194.6	280.5	13.3	1401.8	1.4
1 decade of June	89.6	13.5	76.1	205.3	281.4	13.3	1506.5	1.4
2014								
2 decade of May	135.0	34.3	100.7	146.7	247.4	11.3	1361.6	1.1
3 decade of May	124.8	24.6	100.2	147.0	247.2	10.7	1349.1	1.1
1 decade of June	103.9	16.9	87.0	139.4	226.4	10.4	1352.1	1.0
average for 2012-2014								
2 decade of May	126.8	32.2	94.6	132.9	227.5	11.0	1308.8	1.0
3 decade of May	117.2	23.1	94.1	131.5	225.6	10.4	1310.9	1.0
1 decade of June	97.6	15.9	81.7	148.2	229.9	11.2	1363.6	1.1

The coefficient of water consumption is of great importance for assessing the effectiveness of moisture use by plants of flax oilseed and spring rape. So, comparing the water consumption of oilseed flax by sowing dates with productivity, we came to the conclusion that the total consumption of moisture reserves (soil and atmospheric) for transpiration and

evaporation from the soil surface in terms of unit of production (1 kg of seeds) for sowing periods amounted to: 1 term - 21.8 mm; 2 term - 20.5 mm; 3 term - 21.0 mm. The smallest coefficient of water consumption in 2012 was noted on the second sowing term, in 2013 - on the second and third terms, in 2014 - on the second and third terms of sowing.

Table 3. Productivity, oil content of oil flax and oil yield per 1 ha depending on the sowing time and sowing rate, 2012-2014.

Term sowing	Seeding rates, mln. seed/ha	Productivity by years, c/ha				Oiliness, %	Oil yield, c/ha
		2012	2013	2014	average		
2 decade of May	6.5	5.1	13.7	15.5	11.4	41.5	4.8
	7.0	6.4	14.7	17.4	12.8	41.2	5.3
	7.5	4.0	12.4	13.5	10.0	41.4	4.2
average for factor A		5.2	13.6	15.5	11.4		
3 decade of May	6.5	3.8	11.5	12.7	9.3	40.9	3.9
	7.0	9.5	12.0	17.7	13.1	41.2	5.4
	7.5	3.9	15.3	15.8	11.7	41.3	4.9
average for factor A		5.7	13.0	15.4	11.4		
1 decade of June	6.5	5.1	13.6	15.4	11.4	40.8	4.7
	7.0	8.1	13.7	17.2	13.0	41.3	5.4
	7.5	4.9	15.9	16.0	12.3	41.1	5.1
average for factor A		6.0	14.4	16.2	12.2		
average for factor B	6.5	4.7	13.0	16.5	11.4		
	7.0	8.0	13.5	16.2	12.6		
	7.5	4.3	14.6	16.3	11.7		
LSD ₀₅ for factor A		0.1	1.3	0.7			
LSD ₀₅ for factor B		0.8	0.8	0.8			

Analyzing the water consumption of spring rape by the sowing dates and its productivity, we can conclude that the total consumption of moisture reserves (soil and atmospheric) for transpiration and evaporation from the soil surface in terms of unit of production (1 kg of seeds) by sowing dates amounted to: 1 term - 11.0 mm; 2 term - 10.4 mm; 3 term - 11.2 mm. The lowest values of the coefficient of water consumption in 2012 were recorded on the second sowing term, in 2013 - on the second and third sowing dates, in 2014 - on the third term.

The yield of oilseed flax under adverse weather conditions in 2012 was at the level of 3.8-9.5 kg / ha, and in terms of time amounted to (Table 3): the first term (2nd decade of May) was 4.0-6, 4 kg/ha, the second term (3rd decade of May) - 3.8-9.5 kg/ha, the third term (1st decade of June) - 4.9-8.1 kg / ha. The optimum sowing rate for all three terms was 7.0 million seeds/ha (LSD05 by factor A = 0.1, LSD05 by factor B = 0.8).

Under the conditions of 2013, the yield of oil flax by terms was within the following limits: the first term (2nd decade of May) - 12.4-14.7 kg/ha, the second term (3rd decade of May) - 11.5- 15.3 kg/ha, the third term (1st decade of June) - 13.6-15.9 kg/ha. The optimal seeding rate of oil flax in the first term of sowing was 7.0 million sunflower seeds/ha - 14.7 centner/ha; in the second and third periods, a high yield was shown by the variant with a seeding rate of 7.5 million suns. seeds/ha - 15.3 and

15.9 c/ha, respectively (LSD05 by factor A = 1.3, LSD05 by factor B = 0.8).

The maximum yield of oilseed flax over the years of research was 2014, when the best options reached yields of 17.2-17.7 kg/ha. The crop yield of oil flax seeds in terms of time amounted to: the first term (2nd decade of May) - 13.5-17.4 kg/ha, the second term (3rd decade of May) - 12.7-17.7 kg/ha, third term (1st decade of June) - 15.4-17.2 kg /ha. The best indicators for the sowing rate of oil flax for all three periods of sowing showed the option of 7.0 million sunflower seeds/ha: the highest seed yield in the first term was 17.4 kg/ha, in the second - 17.7 kg/ha, in the third - 17.2 kg/ha, respectively (LSD05 by factor A = 0.7, LSD05 by factor B = 0.8).

Oilseed flax seeds obtained in the conditions of 2012-2014 were characterized by a relatively high oil content in seeds, an average of 40.8-41.5%.

The yield of spring rape in the conditions of 2012 was in the range of 17.6-21.1 centner/ha, and in terms of time amounted to (table 4): the first term (2nd decade of May) was 18.5-20.6 centner/ha, the second term (3rd decade of May) - 20.2-21.1 kg/ha, the third term (1st decade of June) - 17.6-19.0 kg/ha. Optimal for the first and second terms was a seeding rate of 2.5 million seeds/ha, for the third - 2.0 million suns. seed/ha (LSD05 for factor A = 0.4, LSD05 for factor B = 1.2).

Table 4. The yield, oil content of spring rape and the oil yield per 1 ha depending on the sowing dates and sowing rates, 2012-2014.

Term sowing	Seeding rates, mln. seed/ha	Productivity by years, c/ha				Oiliness, %	Oil yield, c/ha
		2012	2013	2014	average		
2 decade of may	2.0	19.6	19.1	21.3	20.0	41.6	8.3
	2.5	20.6	19.4	22.0	20.7	41.7	8.6
	3.0	18.5	21.9	22.2	20.9	41.5	8.6
average for factor A		19.6	20.2	21.8	20.5		
3 decade of may	2.0	20.2	17.9	21.0	19.7	41.7	8.2
	2.5	21.1	23.2	24.4	22.9	41.2	9.4
	3.0	21.0	22.0	23.7	22.2	41.3	9.2
average for factor A		20.8	21.1	23.0	21.6		
1 decade of June	2.0	19.0	19.5	21.2	19.9	41.7	8.3
	2.5	18.4	21.3	21.9	20.5	41.3	8.5
	3.0	17.6	22.3	22.0	20.6	41.6	8.6
average for factor A		18.3	21.1	21.7	20.4		
average for factor B	2.0	19.6	18.8	21.2	19.9		
	2.5	20.0	21.3	22.8	21.4		
	3.0	19.0	22.1	22.6	21.2		
LSD ₀₅ for factor A		0.4	1.7	0.7			
LSD ₀₅ for factor B		1.2	1.0	1.0			

Under the conditions of 2013, the yield of spring rape by terms was within the following limits: the first term (2nd decade of May) - 19.1-21.9 kg/ha, the second term (3rd decade of May) - 17.9- 23.2 kg/ha, the third term (1st decade of June) - 19.5-22.3 kg/ha. The optimal norm for sowing spring rape in the first and third periods of sowing was the norm of 3.0 million seeds/ha - 21.9 and 22.3 c/ha, respectively, in the second term, high yield was shown by the option with a seeding rate of 2.5

million suns seed/ha - 23.2 c/ha (HLSD05 for factor A = 1.7, LSD05 for factor B = 1.0).

The highest yield of spring rape over the years of research was 2014, the best options showed 22.0-24.4 kg/ha. The yield of spring rape seeds in terms of time amounted to: the first term (2nd decade of May) - 21.3-22.2 centner/ha, the second term (3rd decade of May) - 19.7-22.9 centner/ha, third term (1st decade of June) - 19.9-20.6 kg/ha. The best indicators for the sowing rate of spring rape in the first and third periods of sowing

showed the option of 3.0 million seed/ha: the highest seed yield in the first term was 22.2 c/ha, in the third - 22.0 c/ha. In the second term of sowing spring rape, a variant with a seeding rate of 2.5 million seeds/ha and yield 24.4 c/ha (LSD05 for factor A = 0.7, LSD05 for factor B = 1.0).

Spring rape seeds obtained for the period 2012-2014 are marked by good indicators for the oil content in the seeds - in the range of 41.2-41.7% for the experimental options.

4 Discussion

Over the years of research, the best water consumption coefficient of the studied crops showed a second sowing period: oilseed flax - 20.5, spring rape - 10.4. According to the seeding standards, the formation of an optimal stem density increased the efficiency of moisture use. It was noted that moisture was most rationally consumed when sowing oilseed flax with a norm of 7.0 million seeds/ha (16.5-17.7 mm/c), spring rapeseed with a seeding rate of 2.5 million seeds/ha (9.9-11.2 mm/c). An increase in the sowing rate of oilseed and spring rape flax provoked competition between plants, and, conversely, at a lower rate, unproductive evaporation increased, i.e. in both cases there was a decrease in the efficiency of moisture use.

The most productive flax varieties of oilseed and spring rape have shown a greater yield of oil per 1 ha. As a result, the yield of oil from 1 ha, taking into account the productivity of the options, was as follows. In oilseed flax, a second term with a sowing rate of 7.0 million seed/ha - oil collection amounted to 5.4 kg/ha, and the third term with the same sowing rate - this indicator was equal to 5.4 kg/ha, in the first term, the variant with the sowing rate of 7.0 million seeds/ha - the oil yield from 1 ha was 5.3 c/ha.

In spring rape, the experiment with the highest yield is in the lead: the second sowing period is the norm of 2.5 million seeds per 1 hectare, where 9.4 centners of oil per hectare are obtained.

5 Conclusion

The most stable indicators for the productivity of flax oilseed and spring rape had options for a second sowing season, because the plants were provided with soil moisture reserves, with a seeding rate of 7.0 and 2.5 million seed/ha, respectively.

Harvest of flaxseed oil seeds on average for 2012-2014. by the terms: in the first term (2nd decade of May) - 10.0-12.8 kg/ha, in the second term (3rd decade of May) - 9.3-13.1 kg/ha, in the third term (1st decade of June) - 11.4-13.0 kg/ha. The average yield for spring rapeseed over the years of research was: in the first term (2nd decade of May) - 20.0-20.9 kg/ha, in the second term (3rd decade of May) - 19.7-22.9 kg/ha, in the third term (1st decade of June) - 19.9-20.6 kg/ha.

The optimal seeding rate of oil flax on average for 2012-2014. in all three periods of sowing was 7.0 million seed/ha: the highest seed yield in the first term

was 12.8 kg/ha, in the second - 13.1 kg/ha, in the third - 13.0 kg/ha. The optimal sowing rate of spring rape for 2012-2014 in the first and third terms there was a norm of 3.0 million seeds/ha - 20.9 and 20.6 kg/ha, respectively, in the second - 2.5 million seeds/ha - 22.9 c/ha.

References

1. V.T. Piven, N.M. Tishkov, S.A. Semerenko, *Protection of oil flax from pests in the conditions of the Kuban Oilseeds*. Scientific and Technical Bulletin of the All-Russian Research Institute of Oilseeds **1(153-154)**, 135-140 (2013)
2. F. Rashid, Z. Ahmed, S. Hussain, Jen-Yi Huang, A. Ahmad, *Linum usitatissimum L. seeds: Flax gum extraction, physicochemical and functional characterization* Carbohydrate Polymers **215**, 29-38 (1 July 2019)
3. S.V. Zelencov, L.G. Ryabenko, E.V. Moshnenko, *Obtaining two generations of oil flax during one field season as a reserve to accelerate the breeding process (Report I)* Oilseeds. Scientific and Technical Bulletin of the All-Russian Research Institute of Oilseeds **1(157-158)**, 73-80 (2014)
4. T.V. Mahova, *Yield of oil flax, depending on the methods of sowing and seeding rates in Materials of the VII int. conf. of young scientists and specialists "Actual issues of biology, breeding, technology of cultivation and processing of oilseeds" dedicated to the 100th anniversary of the founding of ARSRIO* 150-155 (Krasnodar, 2013)
5. A.A. Kuncевич, N.S. Egorova, D.V. Vinogradov, *Use of herbicides in oilseed flax crops in Scientific and Practical Aspects of Oilseed Processing Cultivation Technologies: Materials of the Int. Scientific Conf.* 118-119 (The publishing house RSAU, Ryazan, 2013)
6. H.K. Marambe, J.P.D. Wanasundara, *Chapter 8: Protein From Flaxseed (Linum usitatissimum L.) Sustainable Protein Sources* 133-144 (2017)
7. Y. Y. Shim, B. Gui, P. G. Arnison, Y. Wang, M. J.T. Reaney, *Flaxseed (Linum usitatissimum L.) bioactive compounds and peptide nomenclature: A review* Trends in Food Science & Technology **38(1)**, 5-20 (July 2014)
8. J. A. Kirkegaard, J. M. Lilley, R. D. Brill, A. H. Ware, C. K. Walela, *The critical period for yield and quality determination in canola (Brassica napus L.)* Field Crops Research **222**, 180-188 (1 June 2018)
9. I.F. Levin, *All about rapeseed* J. Agricultural sector **2**, 70-76 (2013)
10. N.A.M. Eskin, *Rapeseed Oil/Canola. Encyclopedia of Food and Health* 581-585 (2016)
11. S.L. Kendall, H. Holmes, C.A. White, S.M. Clarke, P.M. Berry, *Quantifying lodging-induced yield losses in oilseed rape* Field Crops Research **211**, 106-113 (September 2017)

12. A. Baux, J. Wegmüller, A. Holzkämper, *Exploring Climatic Impact on Oilseed Rape Yield in Switzerland* Procedia Environmental Sciences **29**, 123 (2015)
13. A.V. Vasin, *Formation of highly productive polyvide agrophytocenoses of forage crops in the Middle Volga region: abstract of the doctoral thesis* (Samara State Agrarian University, Kinel, 2006)
14. S.N. Zudilin, *Formation of stable agrocenoses of forage crops in the crop rotation of the forest-steppe of the Middle Volga: abstract of the doctoral thesis* (Samara State Agrarian University, Kinel, 2005)
15. K. Sieling, U. Böttcher, H. Kage, *Sowing date and N application effects on tap root and above-ground dry matter of winter oilseed rape in autumn* European J. of Agronomy **83**, 40-46 (February 2017)
16. G.R. Dorozhko, V.M. PENCHUKOV, A.A. Sentyabrev, *Influence of the sowing rate of oil flax seeds on competitive ability in weed control* Plant Protection and Quarantine **1**, 24-25 (2014)
17. J.M. Finnan, L. Hyland, B. Burke, *The effect of seeding rate on radiation interception, grain yield and grain quality of autumn sown oats* European J. of Agronomy **101**, 239-247 (November 2018)