VOL 3, No 56 (56) (2020)

The scientific heritage
(Budapest, Hungary)
The journal is registered and published in Hungary.
The journal publishes scientific studies, reports and reports about achievements in different scientific fields.
Journal is published in English, Hungarian, Polish, Russian, Ukrainian, German and French.
Articles are accepted each month.
Frequency: 24 issues per year.
Format - A4
ISSN 9215 — 0365

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THE EFFECT OF GROWING TECHNOLOGY ELEMENTS ON DEVELOPMENT, YIELD AND QUALITY OF WINTER RAPESEED SEEDS

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Abstract

Aim. The investigation of peculiarities of winter rapeseed (Brassica napus L.) growing technology elements, such as sowing time and fertilization level, on yield and quality indexes of crop seeds. **Methods.** It was used the general scientific and special research methods: field method, balance-calculation method for the planned yield, taking into account the content of nutrients in the soil, visual, measurement-weight, biochemical method and mathematical, and statistical in the process of performing the work.

Results. There was an improvement of biometric parameters for plant overwintering and plant condition at the time of spring vegetation renewal with increasing fertilizer rates, the most optimal ones were formed during the second sowing period on August 21 for all sowing dates. The highest yield was obtained on the second sowing period in the version with the maximum fertilization, it was 3.8 t / ha. The strongest correlation - 0.827 was observed when comparing the yield with the mass of 1000 seeds, according to the coefficient of determination, the variation of the yield depended on the elements of the crop structure by 52.4-68.5%. The minimum acid value of 1.05 KOH / g was obtained for the second sowing period on August 21, with the maximum fertilizer variant; in general, the value of this indicator decreased with the increase of fertilizer rate; the content of glucosinolates increased with increasing rate of fertilizer; protein content was influenced by both the sowing period and the fertilizer level, the highest value of which was 22.65% achieved during the second sowing period with maximum fertilization. The highest oil content was also obtained with the introduction of $N_{240}P_{120}K_{240}$ - 47.99%, but for the third sowing period on September 5. The content of erucic acid increased proportionally with the increase in the level of fertilizer, with no significant effect of the sowing period on this indicator. **Conclusions.** The results of the study indicate a significant influence of the sowing period, fertilizer system and biological features of the hybrid on the key moments of plant growth and development, the formation of their biometric parameters, yields and quality indicators, which is confirmed by the results of mathematical data processing.

Keywords: winter rapeseed, sowing date, fertilization, yield, glucosinolates, erucic acid.

Introduction. Winter rape is one of the most common oilseeds in Ukraine and the world. The main purpose of rapeseed cultivation is to obtain high-quality oil, the content of which in the seeds is about 50%. Rapeseed oil, which is obtained from "00" and "000" varieties and hybrids has good taste properties, contains essential linoleic and linolenic fatty acids, is widely used for processing into biodiesel [1, 2]. In this light, obtaining a high yield of rapeseed with the appropriate quality is a particularly important task for scientists working on the cultivation of rapeseed. The solution to this problem, in our opinion, is possible through the improvement of technological elements of cultivation technology, such as compliance with optimal sowing dates, introduction of scientifically sound fertilizer rates, selection of hybrids that correspond to the growing area and have high yield potential.

Many scientists in all countries are studying the improvement of technological elements of winter rapeseed cultivation, as rapeseed oil is the third most popular oil in the world, after palm and soybean oils. Thus, the study of the effect of nitrogen fertilizers on the oil and protein content of rapeseed was carried out by Brennan RF, Mason MG, Walton GH [3], such scientists as Bauchet AS, Laperche A., Snowdon R. and others. [4] reviewed the literature on the effectiveness of nitrogen use by rapeseed plants.

Nitrogen nutrition of winter rape plants, as well as nutrition of other macro- and mesoelements, such as sulfur, magnesium and others. in combination with growing on irrigation, the use of mulching to increase yields, many scientists pay attention [5-9]. The influence of sowing period, pre-sowing seed treatment, plant density and sowing depth has been studied by various scientists [10-13], as well as seed yield losses caused by delays in sowing dates [14]. Therefore, the study of the influence of sowing time, fertilizer rates and biological characteristics of the hybrid on the yield and quality of winter rapeseed was the aim of our study. We hope that the data obtained as a result of the study will contribute to the spread of scientifically sound fertilizer rates and sowing dates, as well as the use of adapted to the growing zone of winter rape hybrids in our region, and provide sufficient information for further development of effective methods to increase yields and improving the quality of winter rapeseed seeds.

Materials and methods. The scientific research program included the study of elements of the technology of growing winter oilseed rape and their impact on the phenological, biometric parameters of plants, the general condition of crops and seed productivity and seed quality.

Studies to determine the effectiveness of different sowing dates of winter oilseed rape and mineral nutrition backgrounds on crop yields were conducted on the basis of Vinnytsia National Agrarian University in the research farm "Agronomiche", which is located in the

Right Bank Forest-Steppe of Ukraine in Vinnytsia region village Agronomichne during 2012-2015 years.

Monsanto's Excel (medium-ripe) hybrid was selected for research; three sowing dates - August 10, August 21 and September 5; levels of mineral fertilizer - $N_0P_0K_0$, $N_{60}P_{30}K_{60}$, $N_{120}P_{60}K_{120}$, $N_{180}P_{90}K_{180}$, $N_{240}P_{120}K_{240}$.

The following methods were used for research: plant density was determined twice during the growing season - the first - at the beginning of growth and development of plants in the phase of full germination, the second - after the restoration of spring vegetation (when the average daily temperature exceeds 50C. Field and visual methods were used to assess the condition of the plants at the time of spring vegetation recovery. is the removal of oil from the seeds with ethyl ether using a Soxhlet apparatus, the titrometric method was used to determine the protein content and acid value, the content of glucosinolates was determined on a photoelectrocolorimeter using the palladium method, the content of erucic acid (mass fraction) was indicated by a gas chromatographic method with a flame ionization detector. Statistical method, analysis of variance and correlation were used to develop mathematical models of the dependence of rapeseed yield on the studied factors.

Results and discussion. Scientific research has shown that non-compliance with the elements of the technology of growing crops, including winter oilseed rape, leads to a decrease in their productivity [15]. For winter rape, the correct choice of sowing dates is the basis for good overwintering of plants, formation and obtaining a high yield [16].

Sowing dates are an important element of winter rapeseed growing technology. Mistakes in sowing dates cannot be corrected and can cause complete crop failure. At late stages, plants do not have time to form a sufficient number of leaves in the basal rosette and a developed root system. Therefore, areas of winter oilseed rape do not overwinter where sown at a later date.

To obtain high yields of winter rape, it is necessary to take into account the biological characteristics of modern varieties and hybrids, environmental factors, as well as elements of cultivation technology.

To analyze the condition of plants before entering the winter, we evaluated the following indicators: the density of standing plants, pcs / m^2; diameter of the root neck, cm; height of the growth point above the soil surface, cm; number of leaves on the plant, pcs.; length of the root system, see Autumn plant development of winter rape hybrid Excel is shown in table 1.

The plants of the Excel hybrid ensured the receipt of optimal parameters of autumn vegetation for the second sowing runoff on August 21st at the rate of $N_{240}P_{120}K_{240}$ fertilizer application.

Thus, the number of plants per 1 m^2 was 76.20 pieces, which exceeded the option without fertilizer by 12.43 plants or 19.5%, the diameter of the root collar was 1.14 cm, which exceeded the control option by 0.29 cm or 34.1%, the height of the growth point from the soil surface was at the mark of 1.51 cm, which was lower than the control by 0.44 cm, and this figure should not exceed 2 cm for good overwintering rape, the number of leaves was 7.44 pcs., the length of the root system - 126.27 cm.

Table 1

Biometric parameters of winter rapeseed hybrid plants Excel at the time of termination of autumn vegetation (average for 2012-2014)

Sowing date	Fertilizers	Parameters of plant growth and development				
		The density of plant standing, pcs. / m^2	Diameter of the root neck, cm	Height of the growth point above ground level, cm	Number of leaves on the plant, pcs..	The length of the root system, cm
10th of August	$N_0P_0K_0$	56,83	0,68	2,57	4,77	104,10
	$N_{60}P_{30}K_{60}$	60,93	0,68	2,31	5,59	109,40
	$N_{120}P_{60}K_{120}$	64,60	0,74	2,02	6,13	112,60
	$N_{180}P_{90}K_{180}$	67,47	0,78	1,96	6,72	117,53
	$N_{240}P_{120}K_{240}$	70,10	0,86	1,91	7,09	119,70
21st of August	$N_0P_0K_0$	63,77	0,85	1,95	5,90	108,90
	$N_{60}P_{30}K_{60}$	66,83	0,92	1,82	6,20	112,50
	$N_{120}P_{60}K_{120}$	71,10	0,96	1,69	6,63	118,00
	$N_{180}P_{90}K_{180}$	74,27	1,04	1,58	7,14	121,40
	$N_{240}P_{120}K_{240}$	76,20	1,14	1,51	7,44	126,27
05th of September	$N_0P_0K_0$	60,80	0,80	2,10	5,37	107,00
	$N_{60}P_{30}K_{60}$	64,73	0,88	1,94	5,71	110,53
	$N_{120}P_{60}K_{120}$	67,83	0,93	1,82	6,10	116,63
	$N_{180}P_{90}K_{180}$	71,73	0,99	1,69	6,56	118,97
	$N_{240}P_{120}K_{240}$	74,00	1,08	1,63	6,79	122,73

Source: made by the author on the basis of own research

One of the main problems and losses of yield in the cultivation of winter oilseed rape is overwintering plants [17]. It is known that thickened crops and plants of late sowing dates freeze and die. In addition, an important factor is the morphological features of plants, which also depend on the time of sowing, because to form the optimal parameters of plants before winter has a certain amount of time with the appropriate temperature and humidity. The main organ of winter rape is the root collar, the diameter of which before entering winter should be 8-10 mm and the size and number of leaves, which in winter will cover the root collar from

freezing, which is also provided by the optimal sowing period [18].

Overwintering of plants depended on the adaptive properties of the hybrid to respond to different sowing dates and under such conditions the intensity of plant nutrition. Due to the better development in the autumn with the introduction of fertilizers, the percentage of plants that overwintered well increased.

Winter hardiness of the hybrid is an important indicator that directly determines the area of its distribution and affects yields. The adaptive properties of winter rape plants in our experiments were directly dependent on weather conditions in winter and the options studied.

In recent years, January-February temperatures were 1–2 ° C higher than the average long-term data.

The average temperature in January over the years of research was higher than the long-term average by 2.15 ^{0}C, and in February by 1.7 ^{0}C. This led to frequent thaws and reduced snow cover. However, no damage to the root collar of plants was observed during the selection of monoliths.

Calculation of standing density after vegetation restoration and overwintering of plants showed that the highest percentage of overwintering in the Excel hybrid was found for the second sowing period on August 21 - 85.3% (65.0 pcs / m^2) when applying $N_{240}P_{120}K_{240}$. It was found that the lowest percentage of overwintering plants - 46.9% on the restoration of vegetation was also observed during the first sowing period on August 10 in the version without fertilizers, i.e. increasing the level of fertilizer contributed to better survival of plants in winter.

The formation of the yield of the Excel hybrid was influenced by fertilizer, sowing date and weather conditions (Table 2).

Thus, the maximum yield value of the Excel hybrid 4.40 t / ha was obtained for the second sowing period on August 21 when applying $N_{240}P_{120}K_{240}$ in 2014. Yields of 4.15 t / ha were obtained for the same sowing period in the variant with the application of $N_{180}P_{90}K_{180}$, with a slight difference in yield, which was 0.02 t / ha, compared with this variant was obtained with the application of $N_{240}P_{120}K_{240}$ for the third sowing period September 5. Difficult weather conditions in 2012-2013, which were due to insufficient rainfall during the period August-October, had a negative impact on the formation of winter rapeseed yields. The spring restoration of vegetation was also complicated, when in the conditions of Vinnytsia region at the beginning of the second decade of March 2013 the monthly snow rate per day fell and the temperature dropped to -14.6^{0}C, which led to a decrease in yield. The minimum yield of 0.87 t / ha was obtained for the third sowing period in the variant without fertilizer application.

Table 2

Yield of winter rapeseed hybrid Excel, t / ha (average 2012-2015)

Sowing date	Fertilizer rates	Year			average	difference		Indicators of variation	
		2013	**2014**	**2015**		t/ha	%	X±Sx	**V, %**
10th of August	$N_0P_0K_0$	1,08	1,19	0,96	1,08	-	-	1,08±0,12	10,7%
	$N_{60}P_{30}K_{60}$	1,62	1,8	1,44	1,62	0,54	33,3	1,62±0,18	11,1%
	$N_{120}P_{60}K_{120}$	2,03	2,33	1,89	2,08	1,00	48,1	2,08±0,22	10,8%
	$N_{180}P_{90}K_{180}$	2,52	3,12	2,81	2,82	1,74	61,7	2,82±0,30	10,7%
	$N_{240}P_{120}K_{240}$	3,30	4,10	3,40	3,60	2,52	70,0	3,60±0,44	12,1%
21st of August	$N_0P_0K_0$	1,01	1,10	0,89	1,00	-	-	1,00±0,11	10,5%
	$N_{60}P_{30}K_{60}$	1,61	1,84	1,39	1,61	0,61	37,9	1,61±0,23	13,9%
	$N_{120}P_{60}K_{120}$	1,80	2,38	2,23	2,14	1,14	53,3	2,14±0,30	14,1%
	$N_{180}P_{90}K_{180}$	3,35	4,15	3,45	3,65	2,65	72,6	3,65±0,44	11,9%
	$N_{240}P_{120}K_{240}$	3,55	4,40	3,45	**3,80**	2,80	73,7	3,80±0,52	13,7%
05th of September	$N_0P_0K_0$	0,92	1,12	0,87	0,97	-	-	0,97±0,13	13,6%
	$N_{60}P_{30}K_{60}$	1,52	1,75	1,30	1,52	0,55	36,2	1,52±0,23	14,8%
	$N_{120}P_{60}K_{120}$	2,74	2,95	2,31	2,67	1,70	63,7	2,67±0,33	12,2%
	$N_{180}P_{90}K_{180}$	3,12	3,92	3,22	3,42	2,45	71,6	3,42±0,44	12,7%
	$N_{240}P_{120}K_{240}$	3,37	4,17	3,47	3,67	2,70	73,6	3,67±0,44	10,7%

Factor	The sum of squares	Degrees of freedom	Middle square	F
A (sowing date)	0,141	2	0,353	3,427
B (fertilizer)	15,163	4	11,372	110,363
Interaction of AB	0,47	8	0,352	3,419
Error in the group	3,091	30	0,103	-
Total	18,865	44	-	-

Table of impacts and LSD

Factor	The impact	LSD
A (sowing date)	0,01	0,14
B (fertilizer)	0,90	0,18
Interaction of AB	0,03	0,31
Remainder	0,06	-
Accuracy of the experiment	4,45%	
Data variation	45,08%	

Source: made by the author on the basis of own research

The maximum yield of the hybrid 3.8 t / ha, on average for three years of research, was obtained for the second sowing period on August 21 with the application of $N_{240}P_{120}K_{240}$, which exceeded the option without fertilizer by 2.80 t / ha, which in percentage terms was 73, 7%. The average yield on the sowing period was 2.44 t / ha, exceeding the average value on the first sowing period by 0.20 t / ha and was close to this indicator for the third sowing period, differing only by 0.01 t / ha.

During the first sowing period on August 10, the yield increased from 1.08 t / ha in the variant without fertilizer application to 3.60 t / ha in the variant with maximum fertilizer $N_{240}P_{120}K_{240}$. The average yield at the time of sowing was 2.24 t / ha. The third sowing period on September 5 was characterized by an average yield of 2.45 t / ha, with indicators ranging from 0.97 to 3.67 t / ha.

The conducted two-factor analysis of variance indicates that the tabular value of the criterion with degrees of freedom v1 = 8 and v2 = 30, F table. = 2.27; 3.42> Table, respectively, the data contradict hypothesis But, and it should be assumed that the levels of factors A and B have an impact on the average result. Also, the levels of factors A and B separately affected the average result - (factor A) 3.43> Table, (factor B) 110.36> Table, accordingly, the data contradict hypothesis No.

Estimation of the strength of the influence of the studied factors on the result showed that the formation of winter rapeseed yields of the Excel hybrid was most intensively affected by the fertilizer rate - the share was 90% (influence of sowing period - 1%, interaction of factors - 3%, residue - 6%).

Modern agriculture has acquired a high technological level, which requires more accurate processing of new techniques and methods studied by science. The further the technological methods are introduced, the less noticeable the difference between them, it is difficult to predict their qualitative development over time. In this regard, there is a need to develop models for the development of the results, for which it is necessary to apply mathematical and statistical methods of study and calculation.

The results of the correlation-regression analysis reliably determined the dependence of yield on the elements of the yield structure (Table 3).

Table 3

Mathematical models of the dependence of the actual yield and elements of the yield structure of the winter rapeseed hybrid Excel

Indexes	Regression equation	Correlation coefficient, R	Coefficient of determination, D
Number of plants per 1 m^2, pcs.	$y = 0{,}3722x^2 + 11{,}155x + 22{,}505$	0,796	63,4
The number of pods on the plant, pcs.	$y = 0{,}6705x^2 + 4{,}184x + 95{,}549$	0,648	52,4
Weight of 1000 seeds, g	$y = 4{,}9851x^2 + 119{,}88x + 119{,}88$	0,827	68,5

Source: made by the author on the basis of own research

It is assumed that at $r \leq \pm 0.3$ the correlation dependence is weak; at $r = \pm 0.3$-0.7 - average; at $r \geq \pm$ 0.7-1.0 - strong.

The correlation coefficient indicates only the degree of connection in the variation of two variables, but does not allow to judge how quantitatively one quantity changes as the other changes. This question is answered by regression analysis.

The results shown in the table show that the correlation coefficient between yield and the main elements of the yield structure is from 0.648 to 0.827, which indicates a strong correlation between these arrays of values. The coefficient of determination used as a measure of the dependence of the variation of the dependent variable on the variation of the independent variables, i.e. the extent to which the obtained observations confirm the model. Thus, the variation in yield depends on the elements of the yield structure by 52.4-68.5%.

Rapeseed, one of the most productive crops of the Cruciferae (Brasicaceae) family, whose oil contains a large amount (approximately 50-80% of the total oil) of erucic (cis-13-docosaic) acid with the following chemical formula: CH2) 7CH = CH (CH2) 11COOH and other unsaturated fatty acids: oleic, linoleic, linolenic and saturated fatty acids: stearic and palmitic. Rapeseed oil also contains thioglycosides (glucosinolates), which are compounds that are broken down by hydrolysis to form isothiocyanates - substances that have toxic properties and can irritate mucous membranes, respiratory organs, and even affect the activity of the thyroid gland. Thus the analysis of an estimation of qualitative indicators of grain of winter rape depending on elements of technology of cultivation has crucial value and urgency for producers of our region.

Table 4 shows the dynamics of changes in the quality of winter rapeseed depending on the studied factors.

Table 4

Influence of sowing dates and fertilizer rates on quality indicators of Excel rapeseed hybrid seeds (average 2012-2015)

Sowing date	Fertilizer rates	Acid number, mg KOH / g	Content of			Total oil yield, t / ha
			glucosinolates, μmol / g	protein, %	oil, %	
10th of August	$N_0P_0K_0$	1,44	11,22	18,67	45,16	0,49
	$N_{60}P_{30}K_{60}$	1,33	13,35	19,19	45,01	0,73
	$N_{120}P_{60}K_{120}$	1,28	16,42	20,29	44,59	0,93
	$N_{180}P_{90}K_{180}$	1,22	17,55	21,68	44,39	1,25
	$N_{240}P_{120}K_{240}$	1,09	18,88	21,86	44,92	1,62
21st of August	$N_0P_0K_0$	1,55	13,92	19,57	46,34	0,46
	$N_{60}P_{30}K_{60}$	1,42	15,87	20,09	46,78	0,75
	$N_{120}P_{60}K_{120}$	1,36	18,23	21,48	45,99	0,98
	$N_{180}P_{90}K_{180}$	1,29	19,68	21,87	46,15	1,68
	$N_{240}P_{120}K_{240}$	1,05	20,74	22,65	45,89	1,74
05th of September	$N_0P_0K_0$	1,45	12,4	17,59	45,66	0,44
	$N_{60}P_{30}K_{60}$	1,36	14,78	18,82	46,36	0,70
	$N_{120}P_{60}K_{120}$	1,33	17,94	19,21	46,56	1,24
	$N_{180}P_{90}K_{180}$	1,29	19,23	20,25	47,19	1,61
	$N_{240}P_{120}K_{240}$	1,10	19,96	21,22	47,99	1,76

Source: made by the author on the basis of own research

The unique biological and chemical properties of rapeseed oil provide the possibility of its use not only for food but also for technical purposes. Therefore, it is the composition and ratio of fatty acids in rapeseed oil, and determines the direction of its application [19].

Thus, the minimum value of the acid number of 1.05 KOH / g was obtained for the second sowing period on August 21 in the version with maximum fertilizer; In general, the value of this indicator decreased with increasing fertilizer rate: for the first sowing period from 1.44 to 1.09 KOH / h and for the third sowing period from 1.45 to 1.10 KOH / h.

The content of glucosinolates during the first sowing period increased from 11.22 to 18.88 μmol / g, during the second sowing period - from 13.92 to 20.74 μmol / g and during the third sowing period - from 12.40 to 19.96 μmol / g with increasing fertilizer rate.

The protein content was influenced by both the sowing date and the level of fertilizer; its maximum value of 22.65% was achieved during the second sowing period with maximum fertilization. The highest oil content was also obtained in the variant with the introduction of N240P120K240 - 47.99%, but for the third sowing period on September 5.

The rate of total oil yield of Excel hybrid, which depends on the yield and oil content in the seeds increased with increasing fertilizer rate: for example, for the first sowing period - from 0.49 to 1.62 t / ha, for the second sowing period - from 0.46 up to 1.74 t / ha and for the third sowing period - from 0.44 to 1.76 t / ha, i.e. the maximum value of 1.76 t / ha was obtained for the third sowing period in the version with the introduction of $N_{240}P_{120}K_{240}$, with this figure differed from the same option, but for the second sowing period only by 0.2 t / ha, which was 1.74 t / ha.

Conclusions. Analysis of the peculiarities of the autumn development of winter oilseed rape during the growing season 2012-2015 showed that the density of standing plants, pcs / m^2; diameter of the root neck, cm; height of the growth point above ground level, cm; number of leaves on the plant, pcs. and the diameter of the root system are affected by the timing of sowing and fertilization system, and depend on temperature and moisture conditions during sowing. Assessment of plant condition at the time of spring vegetation restoration showed that plant density, pcs / m^2, liquefaction and general crop condition were influenced by both sowing dates and fertilization system.

Sowing dates had a significant impact on the formation of winter rapeseed productivity. Thus, on average over the years of research, the maximum yield was achieved during the second sowing period with the application of the maximum fertilizer $N_{240}P_{120}K_{240}$ - 3.80 t / ha. The lowest level of yield, on average over the years of research was obtained during the third sowing period in the control variant without fertilizer application - 0.97 t / ha. The amount of fertilizer applied also significantly affected the yield of plants, which is confirmed by the results of analysis of variance. Thus, the influence of fertilizer on the formation of Excel hybrid yield was 90%.

It is established that the increase in the rate of fertilizer affected the change in the formation of quality indicators of seeds. Thus, the value of the acid number decreased with increasing fertilizer rate. The sowing period and the fertilizer variant influenced the change in the value of erucic acid content in winter rapeseed, while the increase in the fertilizer rate led to an increase in its content in the seeds. The accumulation and content of glucosinolates did not depend on the time of sowing, and fertilizer had a significant effect on this indicator - the content of glucosinolates increased with increasing amount of fertilizers. The protein and oil content were influenced by the studied factors - the maximum value of protein content in the hybrid Excel

was observed during the second sowing period on August 21 and increased with increasing fertilizer rate from 19.57 to 22.65%, the highest oil content - 47.99% was obtained for the third sowing period on September 5 in the variant with the maximum fertilizer.

References

1. Berrocoso, J.D., Rojas, O.J., Liu, Y., Shoulders, J., González-Vega, J.C., Stein, H.H. Energy concentration and amino acid digestibility in high-protein canola meal, conventional canola meal, and soybean meal fed to growing pigs (2015) Journal of Animal Science, 93 (5), pp. 2208-2217. DOI: 10.2527/jas.2014-8528.

2. Körbitz, W. Utilization of oil as a biodiesel fuel (1995) Brassica Oilseeds: Production and Utilization, pp. 353-371.

3. Walton, G.H. Effect of nitrogen fertilizer on the concentrations of oil and protein in canola (Brassica napus) seed (2000) Journal of Plant Nutrition, 23 (3), pp. 339-348. DOI: 10.1080/01904160009382020.

4. Bouchet, A.-S., Laperche, A., Bissuel-Belaygue, C., Snowdon, R., Nesi, N., Stahl, A. Nitrogen use efficiency in rapeseed. A review (2016) Agronomy for Sustainable Development, 36 (2), статья № 38. DOI: 10.1007/s13593-016-0371-0

5. Fismes, J., Vong, P.C., Guckert, A., Frossard, E. Influence of sulfur on apparent N-use efficiency, yield and quality of oilseed rape (Brassica napus L.) grown on a calcareous soil (2000) European Journal of Agronomy, 12 (2), pp. 127-141. DOI: 10.1016/S1161-0301(99)00052-0.

6. Gu, X.-B., Li, Y.-N., Du, Y.-D. Optimized nitrogen fertilizer application improves yield, water and nitrogen use efficiencies of winter rapeseed cultivated under continuous ridges with film mulching (2017) Industrial Crops and Products, 109, pp. 233-240. DOI: 10.1016/j.indcrop.2017.08.036.

7. Hamzei, J. Seed, oil, and protein yields of canola under combinations of irrigation and nitrogen application (2011) Agronomy Journal, 103 (4), pp. 1152-1158. DOI: 10.2134/agronj2011.0018.

8. Kuai, J., Sun, Y., Zhou, M., Zhang, P., Zuo, Q., Wu, J., Zhou, G. The effect of nitrogen application and planting density on the radiation use efficiency and the stem lignin metabolism in rapeseed (Brassica napus L.) (2016) Field Crops Research, 199, pp. 89-98. DOI: 10.1016/j.fcr.2016.09.025.

9. Li, H., Cong, R., Ren, T., Li, X., Ma, C., Zheng, L., Zhang, Z., Lu, J. Yield response to N fertilizer and optimum N rate of winter oilseed rape under different soil indigenous N supplies (2015) Field Crops Research, 181, pp. 52-59. DOI: 10.1016/j.fcr.2015.06.012.

10. Zhang, S., Liao, X., Zhang, C., Xu, H. Influences of plant density on the seed yield and oil content of winter oilseed rape (Brassica napus L.) (2012) Industrial Crops and Products, 40 (1), pp. 27-32. DOI: 10.1016/j.indcrop.2012.02.016.

11. Wang, R., Cheng, T., Hu, L. Effect of wide-narrow row arrangement and plant density on yield and radiation use efficiency of mechanized direct-seeded canola in Central China (2015) Field Crops Research, 172, pp. 42-52. DOI: 10.1016/j.fcr.2014.12.005.

12. Sieling, K., Christen, O. Effect of preceding crop combination and N fertilization on yield of six oilseed rape cultivars (Brassica napus L.) (1997) European Journal of Agronomy, 7 (4), pp. 301-306. DOI: 10.1016/S1161-0301(97)00009-9.

13. Sieling, K., Böttcher, U., Kage, H. Sowing date and N application effects on tap root and aboveground dry matter of winter oilseed rape in autumn (2017) European Journal of Agronomy, 83, pp. 40-46. DOI: 10.1016/j.eja.2016.11.006.

14. Rodrigues, M.Â., Afonso, S., Tipewa, N., Almeida, A., Arrobas, M. Quantification of loss in oilseed rape yield caused by delayed sowing date in a Mediterranean environment (2019) Archives of Agronomy and Soil Science, 65 (12), pp. 1630-1645. DOI: 10.1080/03650340.2019.1572119.

15. Waalen, W.M., Stavang, J.A., Olsen, J.E., Rognli, O.A. The relationship between vernalization saturation and the maintenance of freezing tolerance in winter rapeseed (2014) Environmental and Experimental Botany, 106, pp. 164-173. DOI: 10.1016/j.envexpbot.2014.02.012

16. Colnenne, C., Meynard, J.M., Roche, R., Reau, R. Effects of nitrogen deficiencies on autumnal growth of oilseed rape (2002) European Journal of Agronomy, 17 (1), pp. 11-28. DOI: 10.1016/S1161-0301(01)00140-X

17. 3Lääniste, P., Jõudu, J., Eremeev, V., Mäeorg, E. Sowing date influence on winter oilseed rape overwintering in Estonia (2007) Acta Agriculturae Scandinavica Section B: Soil and Plant Science, 57 (4), pp. 342-348. DOI: 10.1080/09064710601029554.

18. Béreš, J., Bečka, D., Tomášek, J., Vašák, J. Effect of autumn nitrogen fertilization on winter oilseed rape growth and yield parameters (2019) Plant, Soil and Environment, 65 (9), pp. 435-441. DOI: 10.17221/444/2019-PSE.

19. Jankowski, K.J., Sokólski, M., Szatkowski, A. The effect of autumn foliar fertilization on the yield and quality of winter oilseed rape seeds (2019) Agronomy, 9 (12), № 849. DOI: 10.3390/agronomy9120849