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CONTENT

AGRICULTURAL SCIENCES

BIOLOGICAL SCIENCES

CHEMISTRY SCIENCES

PHYSICS AND MATHEMATICS

TECHNICAL SCIENCES

заболевания, особенно при высоком уровне заспорённости семян. В связи с этим, цель наших исследований заключалась в оценке биологической эффективности химических препаратов, применяемых в производстве для контроля развития возбудителя твёрдой головни пшеницы.

В качестве материала исследований использовался семенной материал озимой пшеницы сорта Мироновская 808. Семена пшеницы заражали телиоспорами возбудителя твёрдой головни (Tilletia caries Tul.) из расчета 2 грамма спор на 100 грамм семян [3]. Затем их обрабатывали химическими препаратами. В контроле семенной материал был без обработки. Через сутки семена высевали на делянках. Площадь делянки 0,3 м^2, повторность четырёхкратная. По достижению растениями пшеницы фазы восковой спелости их убирали с делянок и определяли количество здоровых и больных колосьев. Распространенность заболевания и биологическую эффективность испытываемых препаратов рассчитывали согласно общепринятым формулам. Следует отметить, что испытание препаратов при более низкой инфекционной нагрузке (0,1 – 0,15 г спор на 100 г семян) не позволило дифференцировать фунгициды по уровню эффективности. Все препараты полностью ингибировали развитие заболевания. В этих условиях было практически невозможно сделать какие – либо выводы о преимуществах того или иного средства. По этой причине для выявления наиболее эффективных фунгицидов применялся достаточно жесткий инфекционный фон с нагрузкой 2 г спор на 100 г семян.

Исследования по изучению влияния фунгицидов на развитие возбудителя твёрдой головни озимой пшеницы проводились в 2010-2018 гг. Установлено, что в условиях искусственного инфекционного фона не все испытываемые препараты обладали одинаковой эффективностью (таблица 1). За годы испытания наилучший показатель (99,5 %) был у фунгицида Дивиденд Стар, применяемого в рекомендованной норме расхода (1 л/т). Он практически полностью ингибировал развитие патогена. Биологическая эффективность препаратов Виал ТТ и Раксил была ниже – 93,2 и 96,9 %, соответственно. Поражение растений озимой пшеницы грибом Tilletia caries в контроле находилось на уровне 38,5 %.

Таблица 1

Эффективность протравителей семян против возбудителя твёрдой головни озимой пшеницы (среднее за 2010 – 2018 гг.)

Препарат, норма расхода	Поражение твёрдой головней, %	Биологическая эффективность, %
Дивиденд Стар КС, 1 л/т	0,2	99,5
Раксил КС, 0,5 л/т	1,2	96,9
Виал ТТ ВСК, 0,4 л/т	2,6	93,2
Контроль	38,5	-

Таким образом, использование жёсткого инфекционного фона позволило получить достоверные данные о биологической эффективности фунгицидов-протравителей семян, применяемых в производстве для борьбы с возбудителем твёрдой головни пшеницы. Выявлен наиболее действенный препарат – Дивиденд Стар, снижающий развитие заболевания на 99,5 %. Результаты исследований могут быть использованы в практике сельского хозяйства, при выборе оптимального средства для предпосевной подготовки семенного материала пшеницы.

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YIELD AND QUALITATIVE PROPERTIES OF WINTER RAPESEED HYBRIDS DEPENDING ON THE APPLIED NORMS OF FERTILIZERS AND TERMS OF SOWING

Matsera O.
Vinnytsia National Agrarian University,
Vinnytsia

Abstract

The most significant impact on the formation of winter productivity rapeseed had sowing dates, and a hybrid reaction to this indicator was observed. Thus, on average over the years of research, the maximum yield was achieved by early-maturing hybrid Exotic for the first sowing period with the application of the maximum fertilizer $N_{240}P_{120}K_{240}$ - 4.10 t / ha. The lowest level of yield, on average over the years of research, was obtained by the middle-late hybrid Exagon for the first sowing period in the control variant without fertilizer application - 0.77 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 the yield of hybrid Exotic was 84%, hybrid Excel - 90% and Exagon - 85%.

It is established that the increase in the rate of fertilizer affected the change formation of qualitative indicators of seeds. Thus, the value of the acid number decreased with increasing norm, the best values of the acid number

were in the hybrid Exagon for the first sowing period - 1.38-1.10 mg KOH / g. The sowing period and the fertilizer variant influenced the change in the value of erucic acid content in winter rape seeds, 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 hybrids Exotic and Excel was observed during the second sowing period on August 21 and increased with increasing fertilizer from 19.07 to 22.57% and from 19.57 to 22.65%. Plants of winter rapeseed hybrid Exagon formed the highest protein values during the third sowing period on September 5 - from 19.33 to 22.35%. The maximum value of oil content (total yield) in all hybrids was obtained in the variant with the introduction of $N_{240}P_{120}K_{240}$: in the hybrid Exotic - 1.85 t / ha for the first sowing period, in the hybrid Excel - 1.76 t / ha for the third sowing period and in hybrid Exagon - 1.71 t/ha for the second sowing period.

Kewwords: winter rapeseed, hybrids, yield, quality, sowing terms, fertilizer rates.

Introduction. The area under winter rapeseed in Ukraine and around the world is constantly expanding, rapeseed is one of the leading oilseeds, due to the rapid growth in demand for its seeds in Europe for the production of bioethanol.

An important integral indicator of the productivity of winter oilseed rape in ontogenesis is the value of its yield. Seeding density, its moisture content, light, temperature regimes and biological features of a hybrid or variety determine its productivity. Optimal supply of plants with the main nutrients is an important condition for obtaining high yields.

A modern feature of agriculture in Ukraine is to increase the area under this crop, because it solves a number of issues and problems of agriculture, namely - the shortage of vegetable oil and protein, improve phytosanitary condition and soil structure, expand the composition of winter crops, enrich the soil with organic matter. A lot of researchers devoted their investigations to the problem of rapeseed yield and quality improvement all over the world [1-10].

Thus, the yield of winter rapeseed hybrid Exotic increased with increasing fertilizer rate and varied depending on the sowing period (Table 1).

Table 1

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

Temperature-calendar terms of sowing	Mineral fertilizers	Year			average	deviation		Indicators of variation	
		2013	**2014**	**2015**		t/ha	%	X±Sx	**V, %**
10.08 the second decade of August	$N_0P_0K_0$	1,05	1,17	0,92	1,05	-	-	1,05±0,13	11,9%
	$N_{60}P_{30}K_{60}$	1,93	2,23	1,85	2,00	0,95	47,5	2,00±0,20	10,0%
	$N_{120}P_{60}K_{120}$	2,69	3,49	2,79	2,99	1,94	64,9	2,99±0,44	14,6%
	$N_{180}P_{90}K_{180}$	3,37	4,17	3,47	3,67	2,62	71,4	3,67±0,44	11,9%
	$N_{240}P_{120}K_{240}$	3,70	4,70	3,90	**4,10**	3,05	74,4	4,10±0,53	12,9%
21.08 the third decade of August	$N_0P_0K_0$	0,96	1,15	0,90	1,00	-	-	1,00±0,13	13,0%
	$N_{60}P_{30}K_{60}$	1,76	2,16	1,64	1,85	0,85	45,7	1,85±0,27	14,7%
	$N_{120}P_{60}K_{120}$	2,28	2,91	2,44	2,54	1,53	60,2	2,54±0,33	12,9%
	$N_{180}P_{90}K_{180}$	2,67	3,47	2,77	2,97	1,96	66,0	2,97±0,44	14,7%
	$N_{240}P_{120}K_{240}$	3,83	4,67	3,72	4,07	3,06	75,2	4,07±0,52	12,8%
05.09 the first decade of September	$N_0P_0K_0$	0,85	0,98	0,73	0,85	-	-	0,85±0,13	14,7%
	$N_{60}P_{30}K_{60}$	1,48	1,67	1,28	1,48	0,63	42,6	1,48±0,20	13,2%
	$N_{120}P_{60}K_{120}$	2,00	2,28	1,91	2,06	1,21	58,7	2,06±0,19	9,4%
	$N_{180}P_{90}K_{180}$	2,50	3,19	2,52	2,74	1,89	69,0	2,74±0,39	14,4%
	$N_{240}P_{120}K_{240}$	2,89	3,69	2,99	3,19	2,34	73,4	3,19±0,44	13,7%

Factor	The sum of the squares	Degrees of freedom	Middle square	F
A (sowing date)	1,237	2	3,093	25,64
B (fertilizer)	14,703	4	11,027	91,42
Interaction of AB	0,368	8	0,276	2,29
Error in the group	3,619	30	0,121	-
Total	19,927	44	-	-

Table of impacts and LSD

Factor	The impact	LSD
A (sowing date)	0,07	0,12
B (fertilizer)	0,84	0,16
AB (interaction)	0,02	0,27
Remainder	0,07	-
Accuracy of the experiment	3,87%	
Data variation	44,82%	

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

Increasing the yield of winter rapeseed is a key condition for the development of the rapeseed industry. An important reserve for increasing the gross harvest of rapeseed is further improvement of agricultural cultivation techniques: the use of high-yielding and high-oil hybrids of winter rape with the use of intensive cultivation technology, including the use of optimal sowing dates, fertilization system, crop protection and tillage system, etc.

The maximum yield of 4.70 t / ha was achieved for the first sowing period when applying $N_{240}P_{120}K_{240}$ in 2014, the minimum - 0.73 t / ha for the third sowing period on September 5 in the version without fertilizers in 2015. In general, the lowest yield levels were obtained in 2015, which was a consequence of adverse weather conditions.

On average over three years, the yield level for the first sowing period increased from 1.05 t / ha in the variant without fertilizer application to 4.10 t / ha in the variant with maximum fertilizer, which in physical weight was 3.05 t / ha and 74 , 4 percent. The average yield at the time of sowing was 2.76 t / ha.

During the second sowing period, the yield increased from 1.00 to 4.07 t / ha, so the increase was 3.06 t / ha and 75.2%. According to the sowing period, the average yield was 2.49 t / ha.

The third sowing period on September 5 was characterized by the lowest yield, which ranged from 0.85 t / ha in the version without fertilizers to 3.19 t / ha in the version with the application of $N_{240}P_{120}K_{240}$, which in physical weight was 2.34 t / ha and in percent - 73.4%. The average yield at the time of sowing was 2.06 t / ha.

Thus, according to the results of research, plants of the Exotic hybrid formed the highest level of yield during the first sowing period - 2.76 t / ha.

The results of two-factor analysis of variance indicate that the tabular value of the criterion with degrees of freedom $v_1 = 2$ and $v_2 = 30$, $F_{table.} = 3.32$; $25,64 > F_{table}$, respectively, the data contradict hypothesis H_o, and it should be assumed that the levels of factor A have an impact on the average result, as well as the tabular value of the criterion with degrees of freedom $v_1 = 4$ and $v_2 = 30$, $F_{table.} = 2.69$; $91,42 > F_{table}$, respectively, the data contradict hypothesis H_o, and it should be assumed that the levels of factor B have an impact on the average result, and the tabular value of the criterion with degrees of freedom $v_1 = 8$ and $v_2 = 30$, $F_{table.} = 2.27$; $2.29 > F_{table}$, respectively, the data contradict hypothesis H_o, and it should be assumed that the levels of factors A and B have an impact on the average result.

Since the null hypothesis about the interaction effect was rejected, it can be concluded that the combination of factors A and B has a significant effect on the average result. Evaluation of the strength of the studied factors on the result showed that the formation of yields of winter rapeseed hybrid Exotic was most affected by the rate of fertilizer - the share was 84% (influence of sowing time - 7%, interaction factors - 2%, residue - 7%).

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

Thus, the maximum yield value of the Excel hybrid 4.40 t / ha was obtained during the second sowing period on August 21 when $N_{240}P_{120}K_{240}$ was applied in 2014. Yields of 4.15 t / ha were obtained during the same sowing period in the variant with 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 $N_{240}P_{120}K_{240}$ during the third sowing period. September 5.

Table 2

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

Temperature-calendar terms of sowing	Mineral fertilizers	Year			average	deviation		Indicators of variation	
		2013	**2014**	**2015**		t/ha	%	X±Sx	**V, %**
10.08 the second decade 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%
21.08 the third decade 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%
05.09 the first decade 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

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 norm of snow 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.

The maximum yield of the hybrid 3.8 t / ha, on average for three years of research, was obtained during 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 figure 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 the 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 $v_1 = 8$ and $v_2 = 30$, $F_{table.} = 2.27$; $3,42 > F_{table}$, respectively, the data contradict hypothesis H_o, 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) $3.43 > F_{table.}$, (Factor B) $110.36 > F_{table.}$ accordingly, the data contradict hypothesis H_o.

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

The yield of Exagon hybrid changed under the influence of fertilizer and depended on the sowing period (Table 3).

Among the three studied hybrids, the most productive on average over the years of research was Exotic, whose average yield exceeded the yield of the hybrid Excel by 0.06 t / ha, and the yield of the hybrid Exagon - by 0.23 t / ha.

According to the results of two-factor analysis of variance, the following can be stated: the tabular value of the criterion with degrees of freedom $v_1 = 2$ and $v_2 = 30$, $F_{table.} = 3.32$; then $19,32 > F_{table.}$, so the data contradict the null hypothesis, and it should be assumed that the levels of factor A have an impact on the average result. The tabular value of the criterion with degrees of freedom $v_1 = 4$ and $v_2 = 30$, $F_{table.} = 2.69$; then $107,52 > F_{table.}$, so the data contradict the null hypothesis, and it should be assumed that the levels of factor B have an impact on the average result. The levels of factors A and B (interaction) also have an impact on the average result - $F_{table.} = 2.27$; $4.43 > F_{table}$.

Evaluation of the strength of the studied factors on the result showed that the formation of winter rapeseed yield of hybrid Exagon was most affected by the rate of fertilizer - the share was 85% (influence of sowing time - 5%, interaction of factors - 4%, residue - 6%).

The range of variability and the coefficient of variation varied depending on the sowing date and fertilizer variant. The coefficient of variation in the yield of hybrid Exotic for the first sowing period ranged from 11.9 to 12.9%, which averaged 12.3%, for the second sowing period - 13.6% and for the third - 13.0%. The average value of the coefficient of variation in yield in the hybrid Excel for the first sowing period was 11.1%, for the second - 12.9% and for the third - 13.1%.

Table 3

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

Temperature-calendar terms of sowing	Mineral fertilizers	Year			average	deviation		Indicators of variation	
		2013	**2014**	**2015**		t/ha	%	X±Sx	**V, %**
10.08 the second decade of August	$N_0P_0K_0$	0,76	0,88	0,68	0,77	-	-	0,77±0,10	13,0%
	$N_{60}P_{30}K_{60}$	1,38	1,65	1,34	1,46	0,69	47,3	1,46±0,17	11,6%
	$N_{120}P_{60}K_{120}$	1,86	2,33	1,96	2,05	1,28	62,4	2,05±0,25	12,1%
	$N_{180}P_{90}K_{180}$	2,49	2,81	2,29	2,53	1,76	69,6	2,53±0,26	10,4%
	$N_{240}P_{120}K_{240}$	2,47	3,07	2,55	2,70	1,93	71,5	2,70±0,33	12,1%
21.08 the third decade of August	$N_0P_0K_0$	0,84	0,99	0,73	0,85	-	-	0,85±0,13	15,3%
	$N_{60}P_{30}K_{60}$	1,33	1,65	1,28	1,42	0,57	40,1	1,42±0,20	14,1%
	$N_{120}P_{60}K_{120}$	2,26	2,66	2,16	2,36	1,51	64,0	2,36±0,26	11,2%
	$N_{180}P_{90}K_{180}$	3,05	3,85	3,15	3,35	2,50	74,6	3,35±0,44	13,0%
	$N_{240}P_{120}K_{240}$	3,3	4,22	3,87	**3,80**	2,95	77,6	3,80±0,46	12,2%
05.09 the first decade of September	$N_0P_0K_0$	0,98	1,14	0,88	1,00	-	-	1,00±0,13	13,1%
	$N_{60}P_{30}K_{60}$	1,57	1,8	1,35	1,57	0,57	36,3	1,57±0,23	14,3%
	$N_{120}P_{60}K_{120}$	2,07	2,71	2,27	2,35	1,35	57,4	2,35±0,33	13,9%
	$N_{180}P_{90}K_{180}$	3,14	3,94	3,24	3,44	2,44	70,9	3,44±0,44	12,7%
	$N_{240}P_{120}K_{240}$	3,16	3,96	3,26	3,46	2,46	71,1	3,46±0,44	12,6%

Factor	The sum of squares	Degrees of freedom	Middle square	F
A (sowing date)	0,702	2	1,756	19,329
B (fertilizer)	13,025	4	9,769	107,526
Interaction of AB	0,537	8	0,403	4,434
Error in the group	2,726	30	0,0909	-
Total	16,991	44	-	-

Table of impacts and LSD

Factor	Сила впливу	HIP
A (sowing date)	0,05	0,11
B (fertilizer)	0,85	0,15
Interaction of AB	0,04	0,26
Remainder	0,06	-
Accuracy of the experiment	3,99%	
Data variation	46,08%	

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

The coefficient of variation of yield of hybrid Exagon for the first sowing period on August 10, depending on the fertilizer rate varied from 13.0 to 12.1%, which averaged 11.8%, for the second sowing period on August 21, it varied from 15.3 to 12 , 2%, which averaged 13.2%, and during the third sowing period the change in value occurred from 13.1 to 12.6%, which averaged 13.3%. In general, the coefficient of variation in the yield of the studied hybrids was at the average level (10-20%), which indicates the reliability of the obtained experimental data.

Among the three studied winter rape hybrids and three sowing dates, on average over the years of research, the highest yield was obtained by Exotic hybrid for the first sowing period on August 10 - 2.76 t / ha (Fig. 1).

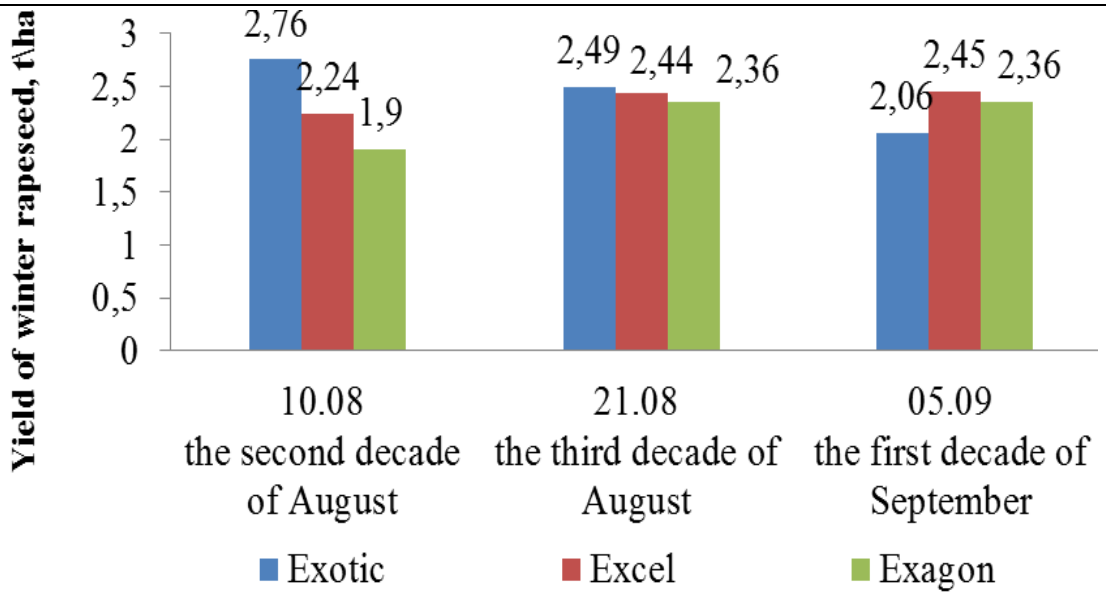
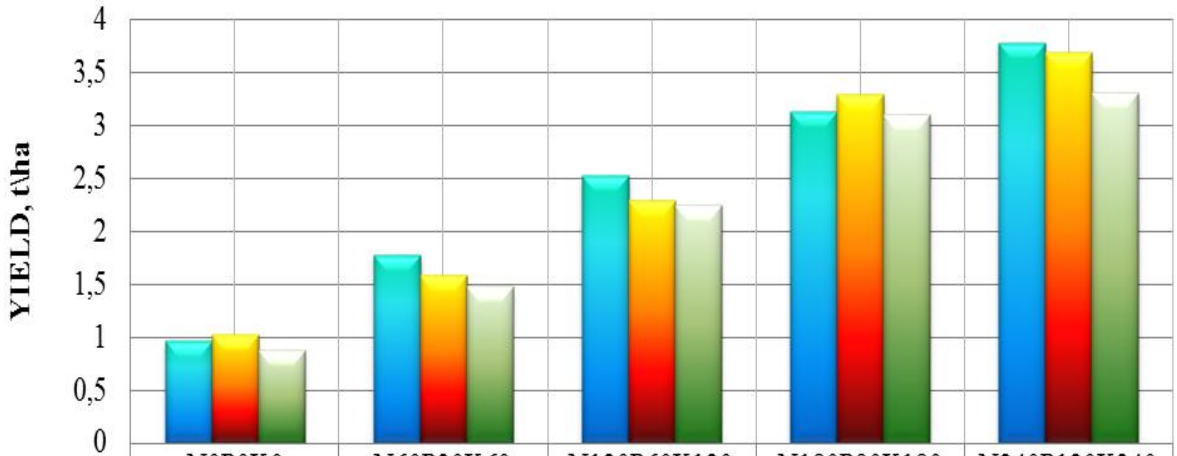


Figure 1.
The influence of temperature-calendar terms of sowing on the formation of yields of winter rapeseed hybrids
Source: made by the author on the basis of his own research

To analyze the impact of the fertilizer system on the obtained yield, its average value for each sowing period was calculated and Figure 2 was constructed.



	N0P0K0	N60P30K60	N120P60K120	N180P90K180	N240P120K240
EXOTIC	0,97	1,78	2,53	3,13	3,79
EXCEL	1,02	1,59	2,3	3,3	3,69
EXAGON	0,88	1,48	2,25	3,11	3,32

Figure 2. The influence of fertilizer system on the formation of winter rapeseed hybrids yields
Source: made by the author on the basis of his own research

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. Therefore, 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 4).

Table 4

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

Indexes	Regression equation	Correlation coefficient, R	Coefficient of determination, D
EXOTIC			
Number of plants per 1 m^2, pcs.	$y = 0,939x^2 + 5,2911x + 22,391$	0,933	87,9
The number of pods on the plant, pcs.	$y = 0,5886x^2 + 4,2782x + 92,706$	0,787	72,4
Weight of 1000 seeds, g	$y = 4,6686x^2 + 79,068x + 82,511$	0,966	93,6
EXCEL			
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
EXAGON			
Number of plants per 1 m^2, pcs.	$y = 1,4396x^2 + 3,0312x + 27,321$	0,858	74,9
The number of pods on the plant, pcs.	$y = 0,034x^2 + 1,873x + 94,864$	0,866	75,0
Weight of 1000 seeds, g	$y = 11,436x^2 + 56,011x + 116,61$	0,875	77,3

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

The established correlation coefficients make it possible to characterize the interaction of features with each other. Positive correlation coefficients indicate a relationship between traits in which an increase in one quantity increases an increase in another. A negative correlation indicates a decrease in the magnitude of one trait with an increase in another. 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 0.966, 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, ie the extent to which the obtained observations confirm the model. Thus, the variation in yield depends on the elements of the yield structure by 52.4-93.6%, depending on the hybrid.

Analyzing the obtained results, we can conclude that the sowing time and the level of mineral nutrition significantly affect the change in the yield of winter oilseed rape, which is also confirmed by the results of analysis of variance, which indicates the influence of individual factors and their interaction on the average result.

The importance of high quality vegetable oil for food and industrial purposes is difficult to overestimate. In this light, rapeseed, which contains about 35-45% of low-drying oil, with an iodine value of 101, 20-26% protein and 17-18% carbohydrates, has an advantage in the food market compared to other oilseeds and ranks third. on the world oil market after palm and soybean oils.

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: CH3 (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. 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 determine the direction of its application. 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.

Rapeseed can be used to produce biodiesel using oil as the main raw material. This necessitates the creation of varieties and hybrids, the fatty acid composition of which will correspond to special markets. Ukraine has favorable conditions for rapeseed cultivation. Subject to the cultivation of 10% of agricultural land and a yield of 25 kg / ha, the country can grow up to 8.5 million tons of seeds per year, the processing of which provides about 3 million tons of biofuels per year.

Many scientists have studied the problem of studying the change in the quality of winter rapeseed grain depending on the elements of cultivation technology. In particular, Goysalyuk J. and Shavalyuk O., studied the influence of sowing dates on the quality of hybrids Artus and NPC 9800 and varieties Black Giant and Antaria winter oilseed rape in the Western Forest-Steppe. Rudnyk-Ivashchenko O.I., Shovgun O.O., Ivanytska A.P. studied rapeseed varieties and hybrids of domestic and foreign selection by biochemical composition, which made it possible to assess the potential of rapeseed varieties and hybrids in terms of quality

composition and to identify varieties with increased oil content. Nosenko V. Such scientists as Koval G.V. and Novak V.G. were engaged in the analysis of factors influencing the quality of rapeseed production in Ukraine (namely soil-climatic, agrotechnical and genetic factors) and the quality of oil as a final product. characteristics of varietal characteristics of winter oilseed rape by applicants.

Rapeseed for industrial processing must meet certain technical requirements. According to DSTU 4966: 2008, rapeseed of the highest class, ie intended for food purposes, must contain a mass fraction of erucic acid in the oil not more than 1.5% and not more than 20.0 μmol / g glucosinolates. Restrictive standards for rapeseed harvested indicate that the acid value of the oil in the seed should not exceed 3.5 mg KOH / g and baseline standards for rapeseed harvested and supplied set the oil content at 36% in dry matter. The main quality indicators used to characterize the degree of freshness of fat is the acid number, which is regulated by standards for all types of dietary fats. This is a conditional value, expressed in milligrams of potassium hydroxide, which is necessary to neutralize the free fatty acids present in 1 g of oil and is the difference between the saponification number and the ether number. The acid number conventionally indicates the amount of free fatty acids that did not react with glycerol. Free fatty acids impair the taste of vegetable oil and accelerate its rancidity. Oils used in the food industry must have a low acid number.

Analyzing the data in the table, we see that the acid number increases with the subsequent sowing dates, and therefore the quality of the oil deteriorates. These values do not exceed the standard limits for rapeseed (3.5 mg KOH / g).

Thioglycoside compounds are glucosinolates, which are harmful sulfur-containing substances that can cause growth retardation, reduced growth of live weight of domestic animals, which is manifested by an increase in the size of the thyroid gland. Rapeseed contains the following glucosinolates: gluconapine, glucobrasicanapine and progoytrin. The results of our studies (table 5) showed that the hybrid Exotic content of glucosinolates in the first sowing period increased from 13.62 ($N_0P_0K_0$) to 20.25 ($N_{240}P_{120}K_{240}$) μmol / g; for the second sowing period - from 14.81 to 21.54 μmol / g; from the third sowing period - from 14.67 to 19.89 μmol / h.

Table 5

Influence of sowing dates and fertilizer norms on quality indicators of winter rapeseed hybrid Exotic (average 2012-2015)

Temperature-calendar terms of sowing	Mineral fertilizers	Acid number, mg KOH / g	Content of			Total oil yield, t / ha
			glucosinolates, μmol / g	protein, %	oil, %	
10.08 the second decade of August	$N_0P_0K_0$	1,44	13,62	18,85	45,57	0,48
	$N_{60}P_{30}K_{60}$	1,34	15,55	19,42	45,33	0,91
	$N_{120}P_{60}K_{120}$	1,30	18,02	20,88	44,43	1,33
	$N_{180}P_{90}K_{180}$	1,25	19,21	21,21	44,76	1,64
	$N_{240}P_{120}K_{240}$	1,13	20,25	21,84	45,17	1,85
21.08 the third decade of August	$N_0P_0K_0$	1,61	14,81	19,07	46,75	0,47
	$N_{60}P_{30}K_{60}$	1,49	16,87	20,00	46,02	0,85
	$N_{120}P_{60}K_{120}$	1,46	19,24	21,12	45,87	1,17
	$N_{180}P_{90}K_{180}$	1,35	20,52	21,33	45,45	1,35
	$N_{240}P_{120}K_{240}$	1,17	21,54	22,57	45,25	1,84
05.09 the first decade of September	$N_0P_0K_0$	1,50	12,45	17,79	45,78	0,39
	$N_{60}P_{30}K_{60}$	1,40	14,67	18,65	45,05	0,67
	$N_{120}P_{60}K_{120}$	1,36	17,22	19,23	44,90	0,92
	$N_{180}P_{90}K_{180}$	1,29	18,12	20,66	44,48	1,22
	$N_{240}P_{120}K_{240}$	1,25	19,89	21,87	44,28	1,41

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

Therefore, analyzing the data in the table, we can conclude that the sowing period does not affect the accumulation and content of glucosinolates, while there is a clear tendency to increase their content with increasing fertilizer rate.

One of the main indicators of the quality of winter rapeseed is the oil content (Table 5). It is known that oil and protein accumulate in rapeseed from the moment of fertilization to full ripening of the seeds, at the same time, seed reserves such as lipids and starch and protein are formed from carbohydrates synthesized during photosynthesis in green parts of plants from carbon dioxide and water.

The table shows that the protein content increased with increasing fertilizer rate, while sowing dates did not significantly affect the change in this indicator. Thus, the maximum value of protein content in the hybrid Exotic was observed during the second sowing period on August 21 and increased with increasing fertilizer rate from 19.07 to 22.57%, during the first sowing period the increase was from 18.85 to 21.84% and during the third sowing period - from 17.79 to 21.87%.

The total oil yield depends on the yield, so this figure in the hybrid Exotic increased with increasing fertilizer rate, reaching maximum values in the version with the introduction of $N_{240}P_{120}K_{240}$ - for the first sowing period, the total oil yield was 1.85 t / ha, for the second - 1.84 t / ha and for the third - 1.41 t / ha, which gives grounds to claim that the sowing period did not have a significant impact on the formation of this indicator.

A similar tendency to change the quality of winter rapeseed was observed in the hybrid Excel (Table 6).

Table 6

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

Temperature-calendar terms of sowing	Mineral fertilizers	Acid number, mg KOH / g	Content of			Total oil yield, t / ha
			glucosinolates, μmol / g	protein, %	oil, %	
10.08 the second decade 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
21.08 the third decade 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
05.09 the first decade 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 his own research

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 period and the level of fertilization, 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 application of $N_{240}P_{120}K_{240}$ - 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, ie the maximum value of 1.76 t / ha was obtained for the third sowing period in the variant with the introduction of $N_{240}P_{12}0K_{240}$, 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.

The formation of qualitative indicators of seeds of winter rapeseed hybrid Exagon was also exposed to the studied factors (Table 7).

It is well known that oils for food processing must have a low acid number; Thus, according to the results of our research, the evaluation of this indicator in plants of the hybrid Exagon showed that all experimental variants had a low value of the acid number (not more than 1.45 KOH / g), which allows the use of oil from these plants for food purposes.

The content of glucosinolates varied depending on the time of sowing and fertilizer option. The lowest value of this indicator was obtained for the first sowing period in the variant without fertilizer application - 10.84 μmol / g, the highest - for the third sowing period in the variant with $N_{240}P_{120}K_{240}$ application - 21.15 μmol / g, which exceeds the technical requirements by 1.15 %.

The maximum value of protein content - 22.35% was obtained for the third sowing period in the variant with the introduction of $N_{240}P_{120}K_{240}$, the minimum - 18.00% - for the first sowing period in the variant without fertilizer. In general, this indicator increased with each variant of fertilization and the next sowing period, ie its highest values were obtained during the third sowing period.

The sowing dates and fertilizer rates did not have a significant effect on the oil content. The highest rate of total oil yield - 1.71 t / ha was obtained for the second sowing period on August 21 with maximum fertilization, the difference between this option for the first sowing period was 0.46 t / ha for the first sowing period and 0.14 t / ha for the third.

Among the three studied winter rape hybrids, the best values of the acid number were in the hybrid Exagon for the first sowing period - 1.38-1.10 mg KOH /g.

Table 7

Influence of sowing dates and fertilizer rates on the quality of winter rapeseed hybrid Exagon (average 2012-2015)

Temperature-calendar terms of sowing	Mineral fertilizers	Acid number, mg KOH / g	Content of			Total oil yield, t / ha
			glucosinolates, μmol / g	protein, %	oil, %	
10.08 the second decade of August	$N_0P_0K_0$	1,38	10,84	18,00	46,68	0,36
	$N_{60}P_{30}K_{60}$	1,28	12,89	19,02	46,45	0,68
	$N_{120}P_{60}K_{120}$	1,25	15,77	20,24	45,77	0,94
	$N_{180}P_{90}K_{180}$	1,21	17,15	21,67	45,90	1,16
	$N_{240}P_{120}K_{240}$	1,10	18,67	21,93	46,05	1,24
21.08 the third decade of August	$N_0P_0K_0$	1,42	13,56	18,55	45,89	0,39
	$N_{60}P_{30}K_{60}$	1,35	15,34	19,59	45,78	0,65
	$N_{120}P_{60}K_{120}$	1,31	18,01	20,21	44,40	1,05
	$N_{180}P_{90}K_{180}$	1,24	18,85	21,78	44,87	1,50
	$N_{240}P_{120}K_{240}$	1,11	19,07	22,03	44,89	1,71
05.09 the first decade of September	$N_0P_0K_0$	1,45	15,33	19,33	45,66	0,46
	$N_{60}P_{30}K_{60}$	1,37	16,02	20,13	46,45	0,73
	$N_{120}P_{60}K_{120}$	1,33	19,45	21,48	45,80	1,08
	$N_{180}P_{90}K_{180}$	1,28	20,34	21,87	45,97	1,58
	$N_{240}P_{120}K_{240}$	1,16	21,15	22,35	45,12	1,56

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

The maximum value of protein content in hybrids Exotic and Excel was observed during the second sowing period on August 21 and increased with increasing fertilizer rate from 19.07 to 22.57% and from 19.57 to 22.65%. Plants of winter rapeseed hybrid Exagon formed the highest protein values during the third sowing period on September 5 - from 19.33 to 22.35%.

The oil content in winter rapeseed first decreased with increasing fertilizer rate, and then increased.

Thus, the maximum oil content was obtained in the hybrid Excel for the third sowing period when applying $N_{180}P_{90}K_{180}$ - 47.19% and when applying $N_{240}P_{120}K_{240}$ - 47.99%, in the hybrid Exotic - for the second sowing period in the version without fertilizers - 46.75 % and in the hybrid Exagon - for the first sowing period also in the variant without fertilizer application - 46.68%, while for the third sowing period in the variant with application $N_{60}P_{30}K_{60}$ the value of oil content did not differ significantly from the previous variant and was 46.45%.

The total oil yield increased with increasing fertilizer rate and varied depending on the sowing period. The maximum value of oil content in all hybrids was obtained in the variant with the introduction of $N_{240}P_{120}K_{240}$: in the hybrid Exotic - 1.85 t / ha for the first sowing period, in the hybrid Excel - 1.76 t / ha for the third sowing period and in the hybrid Exagon – 1.71 t / ha for the second sowing period.

It is well known that rapeseed contains erucic acid, which is harmful to animals in large quantities and leads to pathological changes in the heart muscle, liver and kidneys, inhibits growth, inhibits reproductive function. The analysis of qualitative indicators of winter rape seeds allowed to build a histogram (Fig. 3) of erucic acid content depending on the influence of the studied factors.

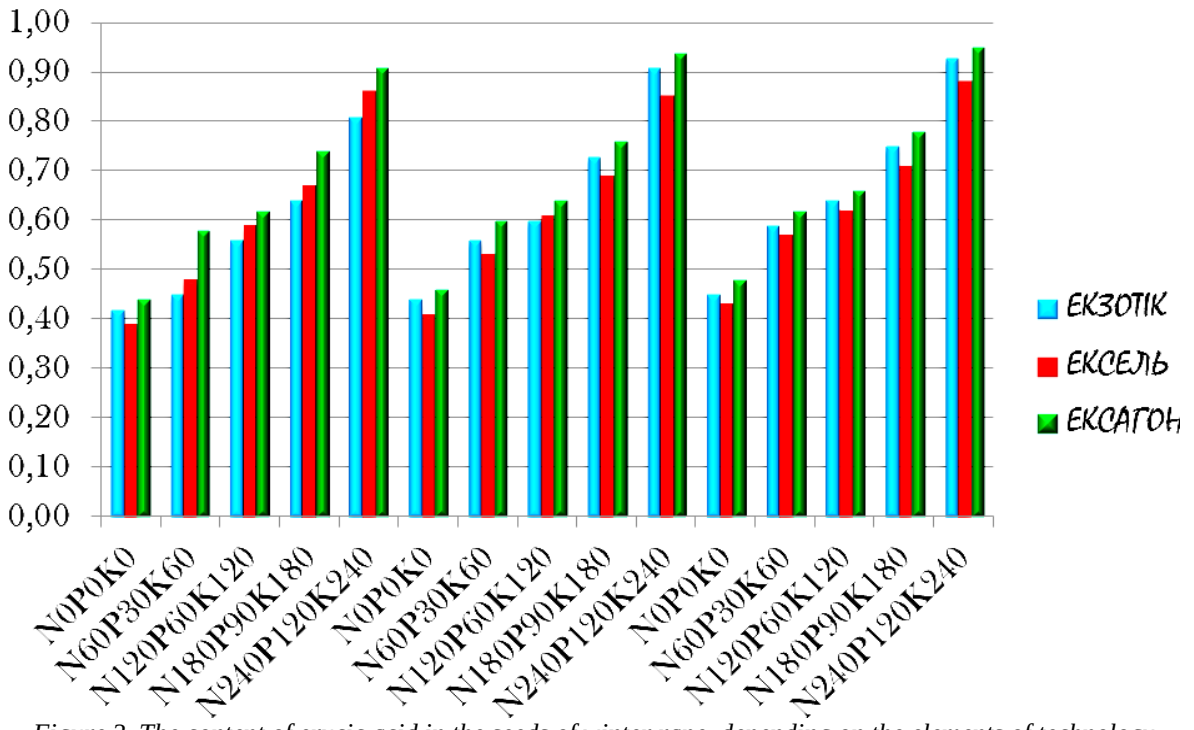


Figure 3. The content of erucic acid in the seeds of winter rape, depending on the elements of technology
Source: made by the author on the basis of his own research

Thus, the research results show that the maximum content of erucic acid in the seeds of each of the hybrids was obtained in variants with the maximum fertilizer $N_{240}P_{120}K_{240}$: in the hybrid Exotic - 0.93%, in the hybrid Excel - 0.88% and in the hybrid Exagon - 0.95 %, while the obtained values did not exceed the permissible norms for seeds of the highest class, ie intended for food purposes. The lowest content, respectively, in the control variants without fertilizers: in the hybrid Exotic - 0.42%, in the hybrid Excel - 0.39% and in the hybrid Exagon - 0.44% during the first sowing period.

Conclusions. It is established that the increase in the rate of fertilizer affected the change formation of qualitative indicators of seeds. Thus, the value of the acid number decreased with increasing norm, the best values of the acid number were in the hybrid Exagon for the first sowing period - 1.38-1.10 mg KOH / g. The sowing period and the fertilizer variant influenced the change in the value of erucic acid content in winter rape seeds, 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 hybrids Exotic and Excel was observed during the second sowing period on August 21 and increased with increasing fertilizer from 19.07 to 22.57% and from 19.57 to 22.65%. Plants of winter rapeseed hybrid Exagon formed the highest protein values during the third sowing period on September 5 - from 19.33 to 22.35%. The maximum value of oil content (total yield) in all hybrids was obtained in the variant with the introduction of $N_{240}P_{120}K_{240}$: in the hybrid Exotic - 1.85 t / ha for the first sowing period, in the hybrid Excel - 1.76 t / ha for the third sowing period and in hybrid Exagon - 1.71 t / ha for the second sowing period.

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УРОЖАЙНОСТЬ ОГУРЦА В УСЛОВИЯХ ЗАЩИЩЕННОГО ГРУНТА НА СЕВЕРО-ЗАПАДЕ РОССИИ

Пушкарев В.Г.,
кандидат с.-х. наук, доцент ФГБОУ ВО Великолукская ГСХА
Мартынова Е.Ю.
магистрант ФГБОУ ВО Великолукская ГСХА

CUCUMBER YIELD IN PROTECTED GROUND CONDITIONS IN THE NORTH-WEST OF RUSSIA

Pushkarev V.,
Candidate of Agriculture, docent State Agricultural Academy of Velikie Luki FGBOU VO
Martynova E.
Master student State Agricultural Academy of Velikie Luki FGBOU VO

Аннотация

Изучена возможность повышения продуктивности огурца в условиях защищенного грунта при различных уровнях минерального питания. Рассчитана экономическая эффективность технологии возделывания культуры.

Abstract

The possibility of increasing the productivity of cucumber in protected soil conditions at different levels of mineral nutrition was studied. The economic efficiency of crop cultivation technology is calculated.

Ключевые слова: гибриды огурца, малообъемная гидропоника, урожайность, экономическая эффективность.

Keywords: cucumber hybrids, low-volume hydroponics, yield, economic efficiency.

Огурец с давних пор наиболее распространенная овощная культура в нашей стране, в том числе и в Нечерноземье.

Огурец содержит 94-97% воды, 0,38-0,53% золы, 0,38-0,68% клетчатки, 0,65-0,94% азотистых веществ, 0,11-0,98% глюкозы, 0,55-0,68% сахарозы. В нем имеются минеральные соли калия, кальция, фосфора, а также витамины С, B_1, РР, каротин, ферменты [1, с. 3].

В структуре производимой в России овощной продукции огурцы занимают 67%. Тепличные комбинаты страны на 84% удовлетворяют потребности населения в данном виде продукции [2, с. 23].

В этой связи актуальным направлением исследований является повышение продуктивности огурца за счет совершенствования элементов технологии его возделывания.

В условиях защищенного грунта при выращивании гибридов огурца Яни F_1 и Атлет F_1 на гидропонике изучались три уровня питания растений: минимальный, оптимальный и максимальный (таблица 1).

Наблюдения за ростом и развитием растений гибридов огурца позволили установить, что гибриды Яни F_1 и Атлет F_1 отличались лучшим ростом и развитием при увеличении уровня минерального питания.

В зависимости от биологических особенностей гибрида плодоношение огурца наступает в среднем через 40-45 дней после посадки. Период от начала образования плода до его уборки может составлять 15-20 дней и зависит от множества факторов: особенности сорта (гибрида), степень освещенности, уровень минерального питания и т.д.