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THE EFFECT OF GROWING TECHNOLOGY ELEMENTS ON WINTER RAPESEED SEEDS AND QUALITY UNDER CONDITIONS OF RIGHT-BANK FOREST-STEPPE IN UKRAINE

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Abstract

The article presents a theoretical generalization and a new solution to the scientific problem – increasing the yield and oil content in winter rapeseed, which is to improve the elements of cultivation technology and the use of hybrids of different maturity groups. The obtained results and developed recommendations are a set of approaches to the possibility of increasing the productivity of winter rapeseed hybrids.

For the first time in the conditions of the Right-Bank Forest-Steppe of Ukraine the peculiarities of growth and development of winter rapeseed hybrids Exotic, Excel, Exagon and their seed productivity at different sowing dates and norms of mineral fertilizers have been established; their influence on the formation of elements of productivity is determined, economic and energy efficiency of winter rapeseed growing is carried out.

Some elements of the technology of growing rapeseed hybrids have been improved, which has provided opportunities to increase the yield and improve the seed quality of the studied hybrids in the conditions of the Right-Bank Forest-Steppe of Ukraine.

Further developments are the scientific provisions to increase the productivity of winter oilseed rape, based on the evaluation of new hybrids of different maturity groups and the integrated application of elements of technology.

The best conditions for the synthesis of organic matter, which forms the productivity of plants, were created under the influence of the fertilizer rate $N_{240}P_{120}K_{240}$ and the sowing period inherent in the maturity group of the hybrid. The highest rate of net photosynthesis productivity of 15.41 g/m^2 per day was obtained by the hybrid Excel during the first sowing period when applying $N_{240}P_{120}K_{240}$. On average over the years of research, the maximum yield was achieved by medium-ripe hybrid Exotic for the first sowing period with the introduction of the maximum fertilizer $N_{240}P_{120}K_{240}$ – 4.10 t/ha. 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 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%. The maximum value of oil content (total yield) was obtained in the variant with the introduction of $N_{240}P_{120}K_{240}$ in the hybrid Exotic - 1.85 t/ha during the first sowing period.

According to the results of the study, the technology of growing winter rape was developed and recommended for production, which will ensure the formation of crop productivity at the level of 3.8-4.10 t/ha with high seed quality.

Keywords: winter rapeseed, photosynthesis, sowing dates, fertilizer system, yield, seed quality, glucosinolates, and erucic acid.

Introduction. In the structure of sown areas of winter rapeseed is a mandatory crop in the vast majority of regions of Ukraine. The crop frees up the field early, which ensures the timely receipt of funds, which are immediately used for the next sowing. The increase in the area under rapeseed in Ukraine is observed from year to year, because rapeseed is now the most expensive of the main oilseeds in Ukraine. There is an increase in the average yield of rape from 2.5 to 2.76 t / ha, although this value is below the genetic potential of modern hybrids. Winter oilseed rape is grown in conditions where there is sufficient moisture, and in an area with a critical lack of rainfall, which necessitates the differentiation of elements of technology for growing this crop under different soil and climatic conditions.

The scientific works of Sieling, K., Zhang, S., Liao, X., Zhang, C., Li, H., Cong, R., Ren, T., Rodrigues, M.Â., Afonso, S. and others [1-6], however, only certain elements of cultivation technology were developed or they were used in other soil-climatic zones [7, 8]. Changes in cultivation technologies, their intensification, the emergence of new high-yielding varieties and hybrids determine the urgency of establishing optimal, scientifically sound and economically feasible rates of mineral fertilizers, there is a need to clarify the timing of sowing. In the conditions of the Right-Bank Forest-Steppe of Ukraine there is a need for research, theoretical substantiation and development of practical recommendations on the technology of growing winter rape, which outlines the relevance of the topic of the dissertation and its applied significance.

Actuality of the article. One of the main factors that increase the productivity of winter oilseed rape is the use of quality seed. The use of winter rapeseed hybrids for sowing on farms increases the total cost of the technology, and at the same time allows to obtain a much higher level of yield at high quality, compared to domestic varieties or hybrids. In addition, the most effective factors that increase the yield of winter oilseed rape, both in the Right Bank Forest-Steppe of Ukraine and the country in general, are not only hybrid composition, but also the use of mineral fertilizers, which are

calculated by modern methods to preserve natural soil fertility. , increase crop yields, and sowing dates on which further development and productivity of winter oilseed rape depends.

Connection of work with scientific programs, plans, themes. Research on the topic of investigation work was performed during 2012-2015 and was part of research work of Vinnytsia National Agrarian University in accordance with the IPA "Oilseeds" on the task: "To establish optimal cultivation techniques to improve productivity and quality of winter rapeseed in conditions Vinnytsia region "(№ state registration 0113U007525).

The purpose and objectives of the study. The aim of the research was to study the peculiarities of winter rape harvest formation and seed quality in the conditions of the Right-Bank Forest-Steppe of Ukraine depending on the biological potential of the studied hybrids, different fertilizer backgrounds and sowing dates.

To achieve this goal it was planned to solve the following tasks:

- to establish features of growth and development of winter rape plants depending on sowing dates and fertilizer rates;
- to study the influence of the studied factors on the formation of leaf area, photosynthetic potential of hybrids, the dynamics of accumulation of dry mass of plants and net productivity of photosynthesis;
- to find out the influence of sowing dates and fertilizer rates on the formation of crop structure elements of winter oilseed rape;
- to identify the influence of structural elements of productivity on the formation of winter rape yield depending on sowing dates and fertilizer rates;
- to assess the quality of seeds of winter rape hybrids;
- to determine the economic and energy efficiency of the studied elements of technology.

The object of research is the process of formation of winter rape yield depending on the elements of cultivation technology in the conditions of the Right-Bank Forest-Steppe of Ukraine.

The subject of research is winter rape hybrids, norms of mineral fertilizers, sowing dates, photosynthetic productivity of crops, elements of crop structure, productivity and quality of seeds, economic and energy efficiency of elements of cultivation technology.

Research methods: field and laboratory - to monitor the growth and development of plants, environmental conditions and other factors; statistical - used for analysis and statistical data processing to assess the reliability of research results, development of mathematical models of winter rapeseed crops and computational-comparative used to assess the economic and energy efficiency of elements of winter rapeseed cultivation technology.

Scientific novelty of the obtained results. For the first time in the conditions of the right-bank Forest-Steppe of Ukraine the peculiarities of growth and development of winter rape hybrids Exotic, Excel, Exagon and their seed productivity at different sowing dates and norms of mineral fertilizers are established, economic and energy efficiency of winter rape growing.

Some elements of the technology of growing rapeseed hybrids were improved, which provided opportunities to increase the yield and improve the seed quality of the studied hybrids in the conditions of the right-bank Forest-Steppe of Ukraine.

Scientific provisions for increasing the productivity of winter oilseed rape have been further developed, based on the evaluation of new hybrids of different maturity groups and integrated application of elements of technology, namely: compliance with sowing dates and application of mineral fertilizers.

The practical significance of the obtained results. According to the results of the research, an intensive technology of growing winter rape was developed and recommended for production, which will ensure the formation of crop productivity at the level of 3.8-4.10 t / ha with high seed quality.

The proposed technology of growing winter rape is introduced in agricultural firms "AGROFIRMA KRASNE" Vinnytsia region, Tyvriv district, p. Krasne and in "Avangard" Vinnytsia region, Tulchyn district, village Silnytsia.

Personal contribution of the dissertation in obtaining scientific results. The author elaborates and generalizes domestic and foreign scientific works on the topic of dissertation, executes the program of field and laboratory researches, analyzes and formulates conclusions from the received experimental data, carries out introduction of scientific developments in production. Co-authored and personally received experimental material was covered in the form of abstracts, articles, reports at scientific and practical conferences.

The influence of elements of growing technology on yield and quality of winter raps seeds. A detailed review of literature sources, recent research on the growth and development of winter oilseed rape depending on sowing dates and fertilizer rates, special attention is paid to the selection of varieties and hybrids of winter oilseed rape, as one of the factors intensifying cultivation technology. The working hypothesis is formulated and the substantiation of necessity of carrying out of researches on a dissertation theme is given.

Conditions, methodology and agricultural techniques of research. The characteristics of soil and climatic conditions are given, hydrothermal conditions in the years of research are analyzed in detail, the scheme of the experiment, materials, methods of research are given and the technology of growing the crop is determined.

Studies to determine the effectiveness of different sowing dates of winter oilseed rape, hybrids of different maturity groups, mineral nutrition backgrounds on crop yields were conducted on the basis of Vinnytsia National Agrarian University in the research farm "Agronomichne", which is located in the Right Bank Forest-Steppe of Ukraine in Vinnytsia region in village Agronomichne during 2012-2015

The soils of the experimental plot - gray forest podzolic, are characterized by the following agrochemical parameters: the humus content in the arable layer (according to Tyurin) is 2.16%, the reaction of the soil

solution - pH of the salt extract 5.8; hydrolytic acidity - 2.3-2.7 mg. - eq. per 100 g of soil, the amount of absorbed bases 15 mg. - eq. per 100 g of soil, the degree of saturation of the bases - 79-88%. The soils contain nitrogen available to plants (according to Cornfield) 81-89 mg per 1 kg of soil, mobile phosphorus and exchangeable potassium (according to Chirikov) 205-251 and 83-90 mg per 1 kg of soil, respectively.

Based on the purpose of the research, the solution of the tasks, field experiments were conducted according to the scheme shown in table 1.

Table 1

The scheme of the experiment

Factor A - temperature-calendar terms of sowing	***Factor B - the background of mineral nutrition***	***Factor C - rapeseed hybrids***
10th of August	Control (without fertilizers)	Exotic (medium ripe)
21th of August	$N_{60}P_{30}K_{60}$	Excel (mid-late)
5th of September	$N_{120}P_{60}K_{120}$	Exagon (mid-late)
	$N_{180}P_{90}K_{180}$	
	$N_{240}P_{120}K_{240}$	

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

The assessment of hydrothermal conditions was performed on the basis of data from the Vinnytsia Regional Center for Hydrometeorology.

The most favorable year for moisture supply was 2013, where the highest amount of precipitation was observed - 616.4 mm, which is 248.2; 112.4 and 66.3 mm, more than in 2015, 2012 and 2014. Giving a general description of weather conditions prevailing over the years of research, it should be noted that September 2012 was abnormal for a small amount of precipitation, which was 11.0 mm, March 2013, when in the third decade the monthly snowfall fell, September 2013 for the amount of precipitation, which was 121.8 mm at a rate of 46.0 mm and in May 2014, also for the amount of precipitation, which was equal to 134.6 mm at an average long-term rate of 63.0 mm

The average daily air temperature during the years of research indicates an increase in this indicator in all years of research. The maximum deviations of the values of the average daily temperature in the direction of increase from the long-term indicators were obtained in March 2014 - +6.4 0C, in November 2013 - +5.2 0C and in January and December 2015 - +4.9 and 5.1 0C, respectively.

Hybrids of different maturity groups were selected for the research - Exotic (medium ripe), Excel (medium late) and Exagon (medium late) of Monsanto.

Sowing was carried out with a seeder SZ-3.6 in the unit with a tractor MTZ-80 with row spacing of 15 cm to a depth of 3 cm. The sowing rate is 0.6 million units / ha, which is 4 kg / ha in physical weight. The total area of the sown area is 60 m2, the accounting area is 50 m2. Repetition - three times.

The cultivation technology in the experiment was traditional for the conditions of the Right-Bank Forest-Steppe, except for the factors that were studied. Fertilizer rates were calculated using the balance-calculation method for the programmed yield, taking into account the content of nutrients in the soil and the coefficients of their use from the soil and fertilizers. Thus, the system of winter rape fertilization was carried out according to the scheme shown in table 2.

Table 2

Scheme of winter rapeseed mineral fertilization

Variant	Fertilizers and type of fertilizer *				
	main	with sowing	foliar fertilization		
			I-st	II-nd	III-rd
$N_0P_0K_0$	-	-	-	-	
$N_{60}P_{30}K_{60}$	$P_{15}K_{45}$ Рсд; Кск	NPK_{15} Рнафк	N_{30} Naa	N_{15} Naa	-
$N_{120}P_{60}K_{120}$	$P_{30}K_{90}$ Рсд; Кск	NPK_{30} Рнафк	N_{30} Naa	N_{30} Naa	N_{30} Naa
$N_{180}P_{90}K_{180}$	$P_{30}K_{120}$ Рсд; Кск	NPK_{60} Рнафк	N_{60} Naa	N_{30} Naa	N_{30} Naa
$N_{240}P_{120}K_{240}$	$P_{30}K_{150}$ Рсд; Кск	NPK_{90} Рнафк	N_{60} Naa	N_{60} Naa	N_{30} Naa

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

Phosphorus and potassium fertilizers were applied under plowing according to the experimental scheme. Phosphorus fertilizers were applied in the form of double superphosphate (P_{48}), and potassium - in the form of potassium sulfate (K_{50}). When sowing, 15-16% of the norms of nitrogen, phosphorus and potassium fertilizers were applied, depending on the variant. The rest of the nitrogen fertilizers were applied in the spring: for the first time - on permafrost soil, using ammonium nitrate (N_{34}) with the help of a mounted spreader for mineral fertilizers; the second time - in two weeks (at intensive growth of a stalk in height); the third feeding with ammonium nitrate was carried out in two or three weeks, at the beginning of flowering. Fertilizers were applied using a MVU-900 fertilizer application machine in combination with an MTZ-80 tractor.

Field studies were accompanied by observations, records and laboratory analyzes: before field experiments, soil samples were taken and the content in the layer of 0-30 cm was determined: humus, pH of salt extract, alkaline hydrolyzed nitrogen, mobile forms of phosphorus and exchangeable potassium; phenological observations were carried out on the phases of growth and development of winter oilseed rape in accordance with the "Methodology of state varietal testing of crops"; field similarity was determined on plots with an area of 0.25 m^2 in four places diagonally, plots were 1 m^2 on two non-adjacent repetitions according to the method of B. O. Dospekhov, 1985; the density of standing winter rape plants by the usual row method of sowing was determined twice for the growing season in fixed areas (at the beginning of the growing season - in the phase of full germination and before harvest) to establish plant survival during the growing season according to the methods of B. O. Dospekhov, 1985 .; evaluation of photosynthetic activity was performed according to the method of A. A. Nichiporovich (1961) on the following indicators: the leaf surface area was determined using an electro-optical device V. G. Didora; photosynthetic potential (ФП) was calculated by the formula:

$$\Phi\Pi = \frac{t \times (S_1 + S_2)}{2}$$

where t is the period from S_1 to S_2 in the number of days; S_1 and S_2 - leaf area of plants; the dynamics of the accumulation of dry mass of winter oilseed rape was determined by drying the samples to an air-dry state at a temperature of 105 ^{0}C; net productivity of photosynthesis (ЧПФ) was calculated by the formula of Kidd, West and Briggs:

$$\text{ЧПФ} = \frac{B_2 - B_1}{\frac{(Л_1 + Л_2) \times T}{2}},$$

where B1 and B2 - weight of dry mass of plants from 1 m^2 or from 1 ha of sowing at the beginning and end of the considered period of time in n days; Л1 and Л2 - the area of the plant leaf from the same sowing area at the beginning and end of the same period of time; T - period of time, days; yield structure was determined by the method of sampling from two replicates; the yield of the main product was determined in part by the method of continuous threshing by direct combining (SAMPO-500); for biochemical evaluation of seeds the following indicators were determined: oil content by extraction method, its removal from seeds by ethyl ether (using Soxhlet apparatus), GOST 10857-64; protein content by titrimetric method (according to Kjeldahl), GOST 13496.4-93; acid number by titrimetric method with oil extraction with ethyl ether, GOST 10858-77; the content of glucosinolates by the palladium method (using a photoelectrocolorimeter); mass fraction of erucic acid, other unsaturated fatty acids (oleic, linoleic, linolenic) and saturated fatty acids (palmitic and stearic) by gas chromatography (Chromium-5), with flame-ionization detector GOST 30089-93.

The obtained research results presented in the experiments were processed according to modern methods of statistics with the use of computer programs.

Excel and Statistica 6.0.

Features of growth and development of winter rapes depending on the elements of growing technology. Field germination of winter rape seeds. Over the years of research, the field germination of seeds varied depending on the time of sowing and was influenced by the biological characteristics of hybrids, i.e. the maturity group of the hybrid determined the timing of germination; Thus, plants of the medium-ripe hybrid Exotic provided the highest percentages of field germination for the first sowing period on August 10, plants of medium-late hybrids Excel and Exagon for the second on August 21 and the third on September 5, respectively. The highest percentage of field germination - 90.8% was obtained during the sowing period on August 10 by hybrid Exotic for application $N_{240}P_{120}K_{240}$, and the difference between the maximum values of hybrids Excel and Exagon, for the same option was insignificant and amounted to 0.7%.

Development of winter rape plants in autumn. Analyzing the results of research, we can conclude that the sowing period, the levels of basic and pre-sowing fertilizer, as well as the biological type of maturity of the hybrid have a significant impact on the autumn vegetation of winter rape and the formation of overwintering parameters. Thus, the most optimal biometric indicators of winter rapeseed were formed according to $N_{240}P_{120}K_{240}$ fertilizer, Exotic hybrid for the first sowing period on August 10, Excel hybrid for the second sowing period on August 21 and Exagon hybrid for the third sowing period on September 5.

The condition of plants at the time of resumption of spring vegetation. Calculation of the density of standing after the restoration of vegetation and overwintering of plants showed that the highest percentage of overwintering was found in the hybrid Excel 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% for the restoration of vegetation was also observed in the hybrid Excel, but for the first sowing period on August 10 in the version without fertilizers.

In plants of the Exotic hybrid, the maximum percentage of restored plants - 83.2% was observed in the first sowing period for fertilizer $N_{240}P_{120}K_{240}$, the minimum - 47.6% - in the third sowing period in the version without fertilizers. The largest number of plants in the hybrid Exagon - 60.9 pieces / m^2 and the percentage of overwintering - 82.8% was set for the third sowing period with maximum fertilization, the smallest - 25.5 pieces / m^2 and 48.8%, respectively - for the first sowing date without fertilizer.

Phenological observations of the phases of growth and development of plants and photosynthetic productivity of winter rapeseed crops. Delays in sowing dates in plants of the medium-ripe hybrid Exotic and medium-late hybrid Excel caused a shortening of the growing season, while during the sowing period on September 5 in the hybrid Exagon there was a slight lengthening of the growing season. The best conditions for the synthesis of organic matter, which forms the productivity of plants, were created under the influence of the fertilizer rate $N_{240}P_{120}K_{240}$ and the sowing period inherent in the maturity group of the hybrid. The maximum value of the photosynthetic potential was obtained in the variant with the application of $N_{240}P_{120}K_{240}$ - 3.493 million m^2-days / ha, and this value was the highest in comparison with other hybrids, exceeding the maximum value of the medium-ripe hybrid Exotic

by 0.256 and 0.22 million -day / ha. During the first sowing period, the maximum value was obtained for fertilizer variant $N_{180}P_{90}K_{180}$ and amounted to 2.484 million m^2-days / ha, for the second sowing period - for variant $N_{240}P_{120}K_{240}$ and amounted to 2.877 million m^2-days / ha, which was less than the largest variant by 1.009 and 0.616 million m^2-days / ha, respectively.

Dynamics of dry biomass accumulation and net productivity of photosynthesis of winter rapeseed crops depending on the influence of the studied elements of technology. Analyzing the obtained data on the dynamics of dry biomass accumulation, t / ha and net productivity of photosynthesis, g / m^2 per day, we can say that the studied elements of the technology affected the NPV. In particular, the magnitude and rate of accumulation of dry biomass depended on the time of sowing, fertilization system and weather conditions and biological characteristics of the hybrid. The highest rate of net photosynthesis productivity of 15.41 g / m^2 per day was obtained by the hybrid Excel during the first sowing period when applying $N_{240}P_{120}K_{240}$.

Formation of elements of the structure of winter rapeseed harvest depending on the influence of the studied factors. The increase in fertilizer rates significantly affected the formation of structural elements of the winter rapeseed crop, increasing all indicators. In all hybrids for each sowing period, the most optimal indicators were formed when applying $N_{240}P_{120}K_{240}$. Thus, the largest number of pods on the plant - 105 pcs. and the number of seeds in the pod - 17.76 pcs were in the Excel hybrid for the first sowing period and maximum fertilization. The maximum number of seeds per 1 m^2 is 111.74 pieces was obtained from the hybrid Excel for the second sowing period. The highest value of the mass of 1000 seeds - 4.97 g was obtained in the hybrid Exagon for the third sowing period when applying $N_{180}P_{90}K_{180}$.

Influence of elements of growing technology on yield and quality indices of winter rape seeds. Influence of sowing dates and norms of mineral fertilizers on seed yield of winter rape hybrids. The most significant influence on the formation of winter rapeseed productivity was the timing of sowing, while a hybrid response to this indicator was observed. Thus, on average over the years of research, the maximum yield was achieved by medium-ripe hybrid Exotic for the first sowing period with the introduction of 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 yield of hybrid Exotic was 84%, hybrid Excel - 90% and Exagon - 85%.

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%. 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 in 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 on the yield of the studied hybrids was at the average level (10-20%), which indicates the reliability of the obtained experimental data.

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 winter rape hybrids

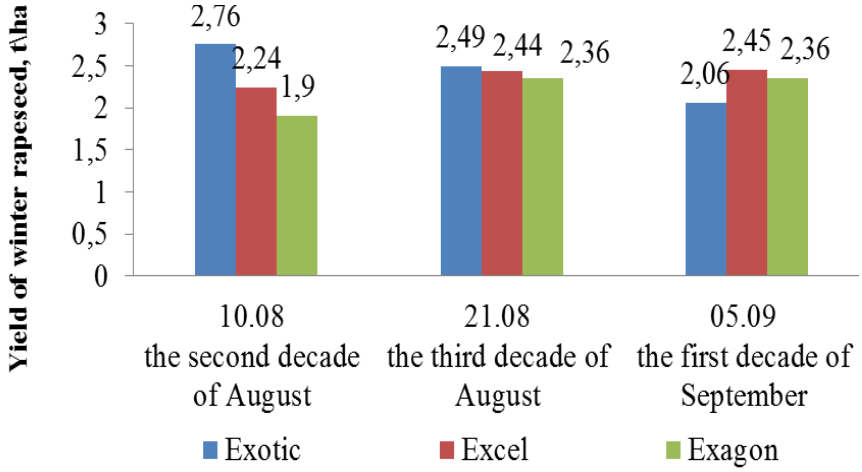
Indexes	Regression equation	Correlation coefficient, R	Coefficient of determination, D
EXOTIC			
Number of plants per 1 m^2, pcs.	$y = 0,939x^2 + 5,2911x + 22,391$	0,933	87,9
The number of pods on the plant, pcs.	$y = 0,5886x^2 + 4,2782x + 92,706$	0,787	72,4
Weight of 1000 seeds, g	$y = 4,6686x^2 + 79,068x + 82,511$	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

From the data shown in table 3 it is seen that the correlation coefficient between the yield and the main elements of the crop structure is from 0.648 to 0.966, which indicates a strong correlation between these indicators. 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 yield variation depended on the elements of the crop structure by 52.4-93.6%, depending on the hybrid.

Among the 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).

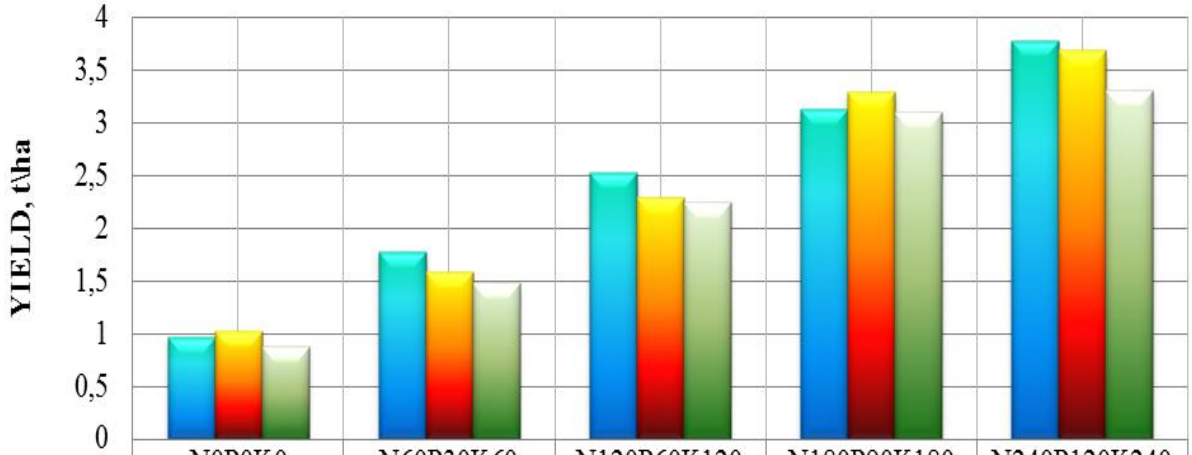


Source: made by the author on the basis of his own research

Figure 1.

The influence of temperature-calendar terms of sowing on the formation of yields of winter rapeseed hybrids

To analyze the impact of the fertilizer system on the obtained seed 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

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

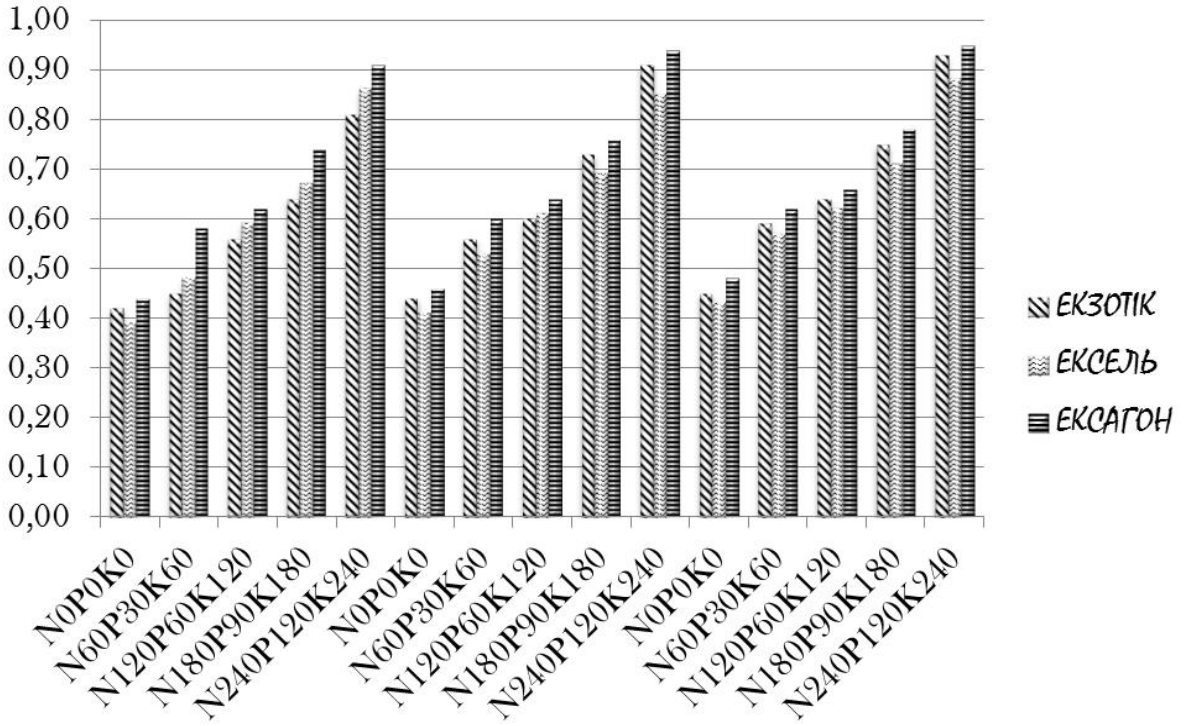
Figure 2. The influence of fertilizer system on the formation of winter rapeseed hybrids yields

Seed quality of winter rape hybrids depending on sowing dates and mineral fertilizer rates. 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 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 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 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% . Rapeseed plants of the winter 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 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.

The analysis of qualitative indicators of winter rapeseed allowed to build a histogram (Fig. 3) of the content of erucic acid in percent depending on the influence of the studied factors.

Thus, the results showed 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.



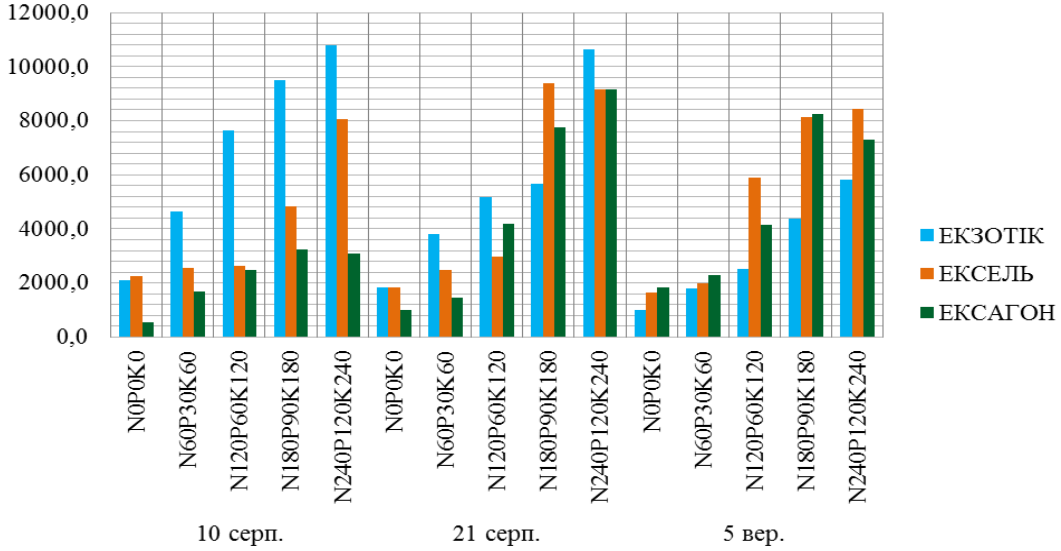
Source: made by the author on the basis of his own research

Figure. 3. The content of erucic acid in the seeds of winter rape, depending on the elements of technology (average for 2012-2015)

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.

Economic and energy evaluation of elements of winter raps growing technology. Economic evaluation of winter rapeseed cultivation depending on the elements of technology. The technological map of winter rape cultivation developed at Vinnytsia National Agrarian University was used to calculate the production costs. Prices for winter rape were used according to the exchange data of the Ukrainian market and amounted to UAH 5,500 / t (average value of prices as of August 15, 2013-2015) of commercial seeds. The specified cost of seeds was used to calculate the main indicators of economic efficiency. Economically advantageous in the hybrid Exotic was the option with maximum fertilizer, ie with the introduction of $N_{240}P_{120}K_{240}$ when sowing crops on August 10. Thus, the maximum cost of production was 22550.0 UAH, production costs - 11744.8 UAH / ha, the cost of 1 ton of seeds - 2864.6 UAH, net profit per 1 ha - 10805.2 UAH. and the level of profitability - 92%. In the Excel hybrid, the best option in terms of product cost was the introduction of $N_{240}P_{120}K_{240}$ - UAH 20,900. for the second sowing period on August 21. The largest value of the level of profitability is 88% and net profit is UAH 9,395.1. was obtained during the same sowing period, but when applying $N_{180}P_{90}K_{180}$. In the Exagon hybrid, the best option was also the introduction of $N_{240}P_{120}K_{240}$ for the second sowing period on August 21. A comparative assessment of the economic efficiency of the three studied hybrids showed that the maximum cost of production - 22550 UAH. was obtained during the cultivation of the hybrid Exotic for the first sowing period on August 10 at maximum fertilization.

The minimum value of the cost is UAH 2,864.6. per 1 ton of seeds, the largest net profit (Fig. 4) - 10805.2 UAH / ha and the level of profitability - 92% was obtained in the same option.

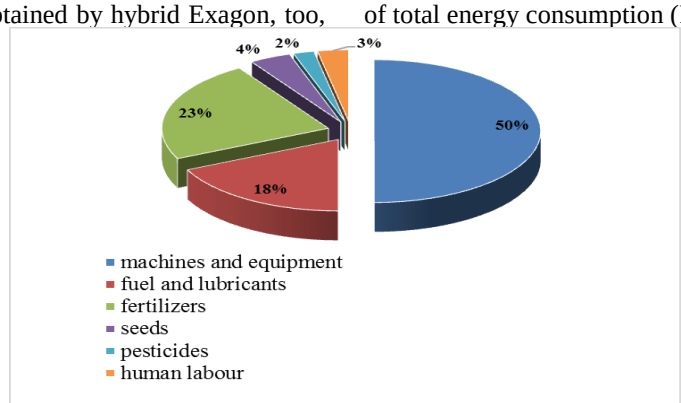


Source: made by the author on the basis of his own research

Figure. 4. Net profit from 1 ha (UAH) when growing winter rape hybrids depending on the elements of technology (average for 2012-2015)

Energy efficiency of winter rape growing depending on the elements of technology. Among the three studied hybrids, the highest value of energy intensity of 77900 MJ was obtained by hybrid Exotic for the first sowing period on August 10 with the introduction of $N_{240}P_{120}K_{240}$, with the maximum energy efficiency - 2.34 was obtained by hybrid Exagon, too, for the first term without . The lowest value of this coefficient of 1.48 was obtained in the hybrid Exotic also during the first sowing period, but in the variant with maximum fertilizer.

During the calculations it was proved that energy consumption fluctuations directly depend on the items of total energy consumption (Fig. 5).



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

Figure. 5. Indicators of the share of energy consumption by articles of the technological process of growing winter oilseed rape,%
(average for 2012-2015)

The maximum energy consumption was accounted for by machinery and equipment - 50%. The following indicators of energy consumption were - 23% fertilizer, 18% fuel and lubricants. In the total energy costs in the technology of growing winter rape, the lowest values are for seeds - 4%, live labor - 3% and pesticides - 2%.

Conclusions. In the article the scientific task on substantiation of processes of formation of productivity of hybrids of winter rape in the conditions of the Right - bank Forest - steppe of Ukraine by selection of optimum term of sowing, carrying out of system of fertilizer at optimum level, use of hybrids of different groups of maturity is experimentally investigated, theoretically generalized and solved. The dependence of conditions of growth, development and formation of reproductive organs in increasing the yield and seed quality of winter rape hybrids has been established. As a result of studying these measures, the theoretical and practical bases of winter rape growing technology have been developed.

1. Giving a general description of weather conditions that have developed over the years of research, it should be noted that September 2012 was abnormal for a small amount of precipitation, which was only 11.0 mm, March 2013, when in the third decade fell monthly precipitation, September 2013 for an excessive amount of precipitation, which amounted to 121.8 mm at a rate of 46.0 mm, and in May 2014, also for the amount of precipitation, which was equal to 134.6 mm at an average long-term rate of 63.0 mm.

2. The best conditions for the synthesis of organic matter, which forms the productivity of plants, were created under the influence of the fertilizer rate $N_{240}P_{120}K_{240}$ and the sowing period inherent in the maturity group of the hybrid. Analysis of the formation of structural elements of winter rapeseed yield showed that the largest values of structural elements of the crop

were formed by the hybrid Excel during the second sowing period on August 21.

3. The most significant influence on the formation of winter rapeseed productivity had sowing dates, while a hybrid reaction to this indicator was observed. Thus, on average over the years of research, the maximum yield was achieved by medium-ripe hybrid Exotic for the first sowing period with the introduction of 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.

4. Evaluation of the acid number in hybrids showed that its value increased with each subsequent sowing period, and all experimental variants had a low value (not more than 1.45 KOH / g), which allows the use of oil of these plants for food purposes. 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 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%. Rapeseed plants of the winter hybrid Exagon formed the highest protein values during the third sowing period on September 5 - from 19.33 to 22.35%.

5. The total oil yield depended on the yield, so this figure in hybrids increased with increasing fertilizer rate, reaching maximum values in the version 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 for the hybrid Exagon - 1.71 t / ha for the second sowing period.

6. Economically advantageous in the hybrid Exotic proved to be an option due to the maximum fertilizer, ie the introduction of $N_{240}P_{120}K_{240}$ when sowing crops on August 10. Thus, the maximum cost of production was 22550.0 UAH, production costs - 11744.8 UAH / ha, the cost of 1 ton of seeds - 2864.6 UAH, net profit per 1 ha - 10805.2 UAH. and the level of profitability - 92%. In the Excel hybrid, the best option in terms of product cost was the introduction of $N_{240}P_{120}K_{240}$ - UAH 20,900. for the second sowing period on August 21. The largest value of the level of profitability is 88% and net profit is UAH 9,395.1. was obtained during the same sowing period, but when applying $N_{180}P_{90}K_{180}$. In the Exagon hybrid, the best option was the introduction of $N_{240}P_{120}K_{240}$ for the second sowing period on August 21.

7. The highest value of energy consumption of 77900 MJ was obtained by hybrid Exotic for the first sowing period on August 10 with the introduction of $N_{240}P_{120}K_{240}$, with the maximum energy efficiency - 2.34 was obtained by hybrid Exagon for the first sowing period, but in the application without application. The lowest value of this coefficient of 1.48 was obtained in the hybrid Exotic for the first sowing period, but in the variant with maximum fertilization.

Production recommendations. In the conditions of the Right-Bank Forest-Steppe of Ukraine to obtain the maximum yield of winter rapeseed (3.8-4.10 t / ha) with a high total oil yield (1.76-1.85 t / ha) and the level of profitability , 0%) agro-formation of various forms of ownership is recommended:

- to grow a medium-ripe hybrid of winter rape Exotic, which is characterized by higher yields compared to the mid-late hybrids Excel and Exagon by 0.30 t / ha;

- sow in the second (August 10) and third (August 21) decades of August, which increases the assimilation surface area, the duration of the period of photosynthetic activity of crops and seed yield by 0.240-0.199 t / ha;

- fertilization of winter oilseed rape should be carried out in three terms with the norm $N_{240}P_{120}K_{240}$, which provides seed yield at the level of 3.80-4.10 t / ha, total oil yield 1.76-1.85 t / ha and resistance to major harmful factors.

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