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**COMPARATIVE EVALUATION OF
QUALITY PROPERTIES OF
WINTER RAPESEED DEPENDING
ON THE LEVEL OF FERTILIZERS
AND SOWING DATE**

O. O. MATSERA,*assistant at the chair of agriculture, soil
science and agrochemistry**Vinnitsia National Agrarian University*

It is made the comparison estimation of winter rapeseed quality properties depending on the fertilization level and sowing date in this article. The literature on the research problem is elaborated; there are presented the study importance and relevance of growing technology elements influence on the quality properties of winter rapeseed seeds. It is analyzed the results of sowing periods and different rates of mineral fertilizers influence on the quality indicators of winter rapeseed seeds under the conditions of Right-Bank Forest-Steppe in Ukraine. Significant influence of the studied elements of technology on the main indicators of seed quality was noted; it was found that the change in the yield level obtained by the hybrids led to a change in the oil quality indices.

Four the most important oil quality indicators were analyzed in this article. They are: acid value, glucosinolates amount, oil and protein contents. They were affected by different fertilizer rates and sowing dates, which were the experiment conditions. So, the lowest acid value – 1.08 provided hybrid Excel, when fertilizer rate was $N_{240}P_{120}K_{24}$; when sowing dates were analyzed, the lowest indicator – 1.24 was obtained by Exagon hybrid in the first sowing date – 10th of Aug. the correlation between acid value and rapeseed yield was negative and oscillated from $r = -0.9327$ to $r = -0.9843$; the magnitude of the approximation reliability oscillated in the range of $R^2 = 0.87 - 0.97$, which evidence the strong dependence between indicators. The lowest content of glucosinolates – 12.51 $\mu\text{mol} / \text{g}$ had Excel hybrid under the conditions without fertilizers; when sowing dates were analyzed, the lowest indicator 15.06 $\mu\text{mol} / \text{g}$ was obtained by Exagon hybrid in the first sowing date – 10th of Aug. The highest oil content had Excel hybrid – 46.27%, it was obtained in variant of $N_{240}P_{120}K_{240}$. The protein content of each hybrid was increasing with fertilizer rates expansion. So, the highest indicator of it was obtained in the variant where $N_{240}P_{120}K_{240}$ was used and it was Exagon – 22.10%. The highest protein content – 21.13% was obtained by Excel hybrid in the second sowing date – the 21st of Aug. when sowing dates were analyzed, and the highest oil content – 46.75% were obtained by Excel hybrid in the third sowing date – 5th of Sept.

Key words: *winter rapeseed, sowing dates, fertilizers, acid value, glucosinolates amount, oil and protein contents.*

Tabl. 3. Fig. 6. Lit. 13.

Formulation of the problem. Everybody knows rapeseed is very important agricultural plant which provides seeds are enriched of protein and oil. Oilseed rape

is the most important cultivated crop grown for vegetable oil in temperate climates and the second leading source of vegetable oil in the world. Meteorological conditions in autumn no less, than the fertilizers rates have a major effect on oilseed rape yield and quality and determine the sowing dates, which are one of the growing technology elements that influence on the yield and its quality too.

The last investigations and publications analysis. A lot of researchers devoted their investigations to the problem of rapeseed yield and quality improvement all over the world. So Beres J., Becka D., Tomasek J., Vasak J. [1] studied the effect of autumn nitrogen fertilization on winter oilseed rape growth and yield parameters and research results confirmed a statistically important effect of autumn fertilization on growth of the above-ground biomass and roots. Statistically important effect on seed yield was confirmed, too. But fertilization effects on the oil content and one thousand seeds' weight were statistically insignificant.

From the other side Jankowski, K.J.; Sokólski, M.; Szatkowski, A. [2], were conducted a 3-year field experiment in north-eastern (NE) Poland to determine the influence of the autumn application of foliar macronutrient and micronutrient fertilizers on the growth and development of winter oilseed rape plants, nutrient accumulation, overwintering success, yield components, yield, nutritional value, and feed value of seeds confirmed that the application of foliar macronutrient and micronutrient fertilizers in autumn increased seed yield (by 0.25 Mg ha⁻¹), contributed to a significant increase in the crude fat content of seeds (by 1.3–7.4 g kg⁻¹ dry matter (DM)), increased the content of oleic acid, decreased the concentration of linoleic acid, and increased the content of glucosinolates.

Gugała, M., Sikorska, A., Zarzecka, K. [3] also showed that the foliar feeding applied reduced the feed value of winter rape seeds. On treatments (2, 4), where only amino acids were used or additionally in combination with sulphur and boron, the increase in the GLS concentration was the largest. Regardless of the type of foliar fertilization used, the Monolit variety contained the lowest concentration of these compounds. The content of glucosinolates in winter rape seeds increased with increasing water stress occurring before the harvest.

Rozhgar Mustafa Ahmed [4] was conducted a field experiment to evaluate the effect of planting dates (2 Feb. and 27 Feb. /2017) and application of nitrogen and phosphorus fertilization (0 N: 0 P, 60 kg/ha N: 30 kg/ha P and 90 Kg/ha N: 60 kg/ha P to oil percent and unsaturated fatty acid analysis composition of two rapeseed cultivars (Sherally and Dunkild). The results demonstrate that late planting date significantly decrease Linolenic acid and Oleic acid. Oil percent and unsaturated fatty acids were significantly responded due to application of nitrogen and phosphorus fertilizer, the treatment 60 N: 30 P produced maximum value for each fatty acids α -Linolenic acid, Linolenic acid and Oleic acid.

Jarecki W., Buczek J., Bobrecka-Jamro D. [5] were evaluated the response of winter oilseed rape cv. SY Alister F1 to diverse foliar fertilization. Mária Vicianová, Ladislav Ducsay, Pavel Ryant and others [6] were devoted their research to the effect

of phosphorus (P) and nitrogen (N) application on yield, oil and fatty acids content (especially oleic acid, linoleic acid and linolenic acid) in rapeseed. Emilie Poisson, Jacques Trouverie, S. Brunel-Muguet and others [7] were working on the problem of seed yield components and seed quality of oilseed rape. Edmund T. Tetteh, Jason P. de Koff and others [8] were studied the effect of winter canola cultivar on seed yield, oil, and protein content.

Conditions and methods of research. The field experiment on study the comparison between qualitative indexes of winter rapeseed cultivars depending the sowing dates and fertilization was conducted in conditions of VNAU research plots. The soil of the experimental area is favorable for the use of mechanized soil tillage, sowing and harvesting of crops, namely characterized by the following agrochemical parameters: the humus content in the arable layer (according to Tyurin) is 2.16%, the reaction of soil solution is pH of 5.6 salt extract. 5.8, hydrolytic acidity – 2.3-2.7 mg. – eq. per 100 g of soil, the sum of the absorbed bases is 15 mg. – eq. per 100 g of soil, the degree of saturation of the basics – 79-88%. The soil contains 81-89 mg of nitrogen available for plants (Cornfield) (81-89 mg per 1 kg of soil), mobile phosphorus and exchangeable potassium (Chirikov) 205-251 and 83-90 mg per 1 kg of soil, respectively.

The area of the accounting site – 50 m²; repeated in the experiment three times; placement of options systematically in one tier. The agro-technological measures conducted, apart from those studied in the experiment, are recommended for the cultivation area. The scheme of the experiment was as follows: sowing period (factor A) – 10th, 21nd August and 5th September; mineral nutrition background (factor B) – N₀P₀K₀ (control); N₆₀P₃₀K₆₀; N₁₂₀P₆₀K₁₂₀; N₁₈₀P₉₀K₁₈₀; N₂₄₀P₁₂₀K₂₄₀; rapeseed hybrids (factor C) – Exotic, Excel, Exagon [9]. Testing and conducting of experiments, key observations and records were carried out according to B. O. Dospekhov's "Field Experience Methodology" [10].

Results and discussion. Rapeseed seeds for industrial processing must meet certain technical requirements. High-grade rapeseed seeds, to wit, intended for nutritional purposes, must contain a mass fraction of erucic acid in the oil of not more than 1.5% and not more than 20.0 μmol / g of glucosinolates. Restrictive standards for harvested rapeseed indicate that the acidity of the oil in the seed should be no more than 3.5 mg KOH / g and the basic rates for rapeseed that are harvested and supplied set oil content of 36% dry matter.

The main quality indicators that are used to characterize the degree of freshness fat belongs acid value, which is regulated by standards for all types of dietary fats. This is the 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 value and the ether number [11].

The acid value conditionally indicates the amount of free fatty acids that have not reacted with glycerol. Free fatty acids impair the taste of vegetable oil and accelerate its clotting. Oils used in the food industry should have a low acid value. On

the figure 1 showed the influence of fertilizers rates on changes of acid value in different winter rapeseed hybrids.

The results show that the amount of fertilizers rates considerably influence on the acid value in the figure 1. The highest value was obtained by winter rapeseed hybrid Exotic under conditions of fertilizer absence – 1.52, the lowest – 1.08, by hybrid Excel, when fertilizer rate was $N_{240}P_{120}K_{24}$. The similar dependence is evidencing for every hybrids: with the increasing of fertilizers rates, the acid value becomes lower. This information allows approving that the fertilizer rates considerably effect on the acid value.

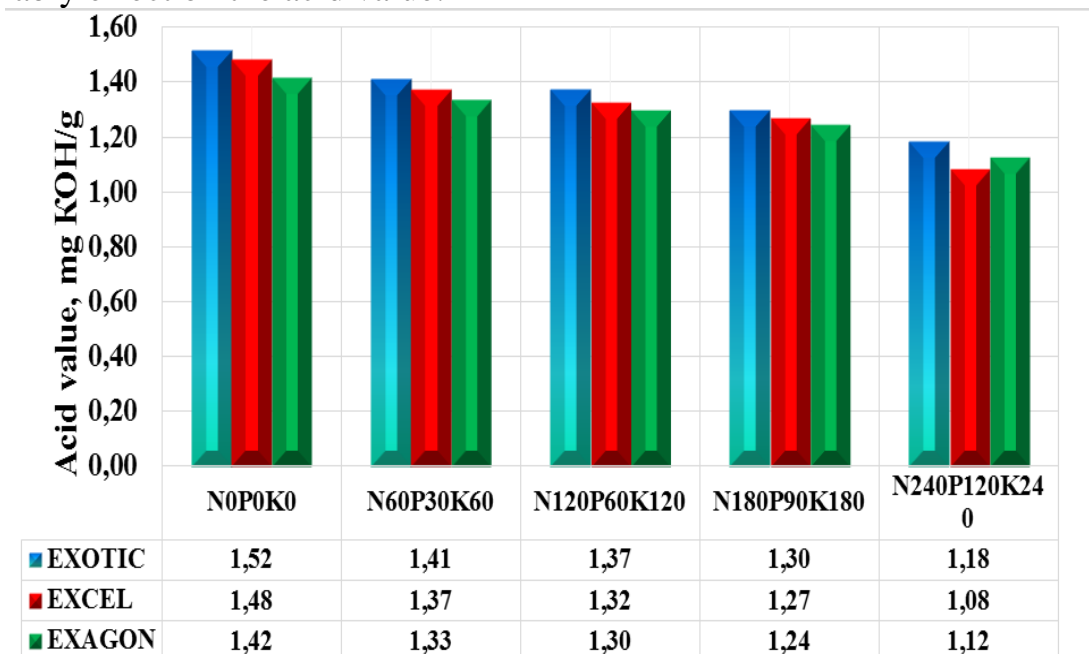


Fig. 1. The acid value of winter rapeseed depending on the fertilization

Source: made by the author based on own research

To make sure that the sowing dates have effect on this index was build the fig.2.

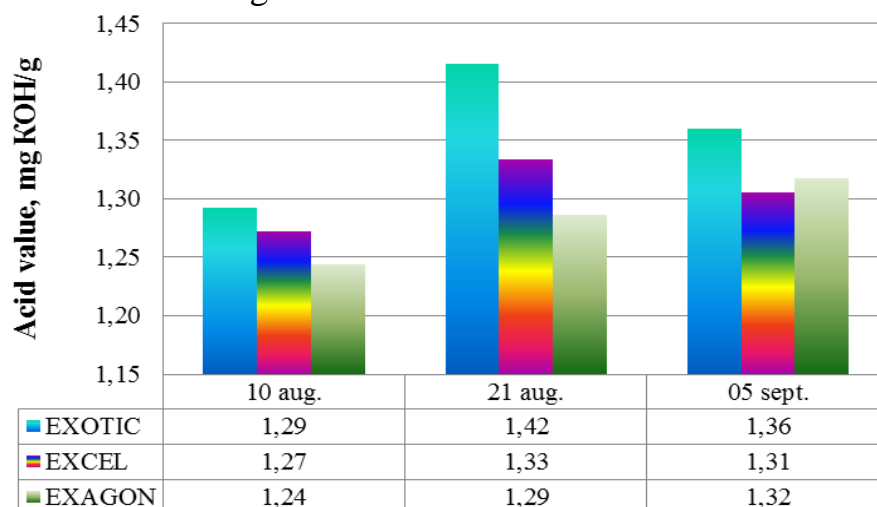


Fig. 2. The acid value of winter rapeseed depending on the sowing dates

Source: made by the author based on own research

This figure shows that the sowing dates considerably influenced the acid value of winter rapeseed hybrids. So the lowest indexes were obtained in the first sowing date – 10th of August: the Exotic – 1.29, Excel – 1.27 and the Exagon – 1.24, besides there weren't significantly difference between hybrids indexes, as shown. The highest index – 1.42 was obtained in the second sowing term – 21st of August by Exotic hybrid, which was caused, on our mind, by the weather conditions and biological peculiarities of hybrid. There isn't so fully dependence between the sowing dates and acid value, as was shown in figure 1, but we can make a conclusion that biological peculiarities of hybrids no less than the sowing dates and fertilizers, are influencing the acid value of them.

To prove the received results were made the correlation and regression analysis between rapeseed yield and acid value. And correlation was negative, which means that there is the opposite connection: as higher is one variable, so lower is meaning of another variable, namely negative correlation means that the increasing of one variable leads another to reduction (Fig. 3-5).

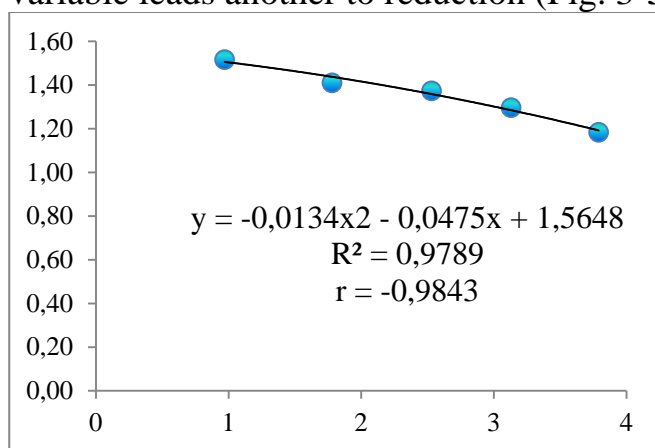


Fig. 3. Exotic correlation

Source: made by the author based on own research

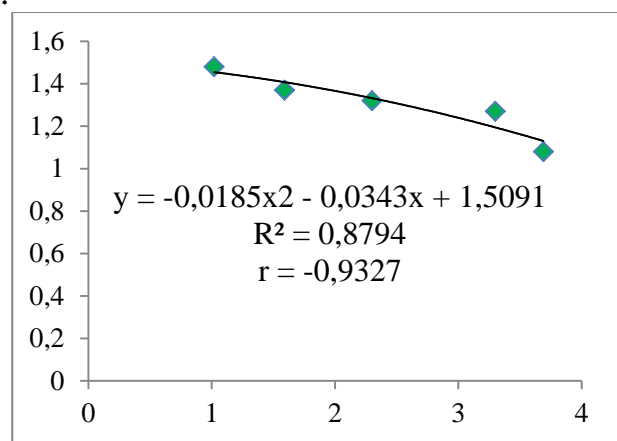


Fig. 4. Excel correlation

Source: made by the author based on own research

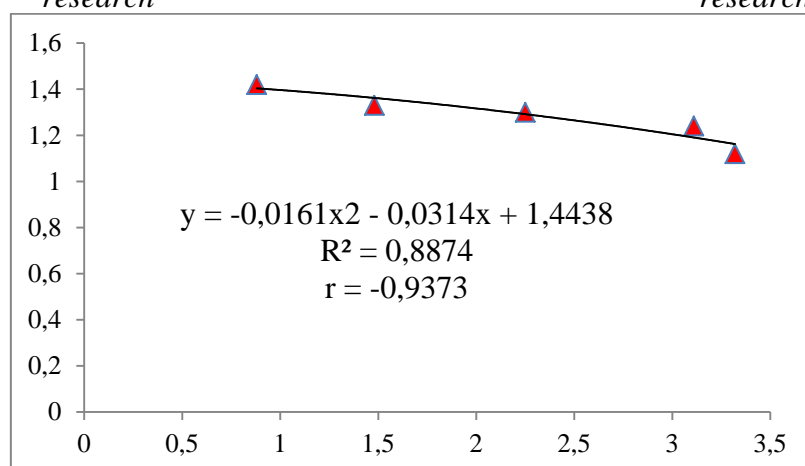


Fig. 5. Exagon correlation

Source: made by the author based on own research

Glucosinolates are secondary metabolites synthesized by plants. They contain sulfur groups and are present in numerous species belonging to Brassicaceae family. Chemically, glucosinolates are composed of thiohydroximate-O-sulfonate group linked to glucose, and an alkyl, aralkyl, or indolyl side chain [12, 13].

To find out the fullest information about rapeseed oil quality it is necessary to estimate the content of glucosinolates in the seeds. The influence of fertilizers rates on glucosinolates content in rapeseed seeds is shown on the figure 6. The results show that lowest content – 12.51 $\mu\text{mol} / \text{g}$ had Excel hybrid under the conditions without fertilizers, and another two hybrids had lowest indicators in the same variant.

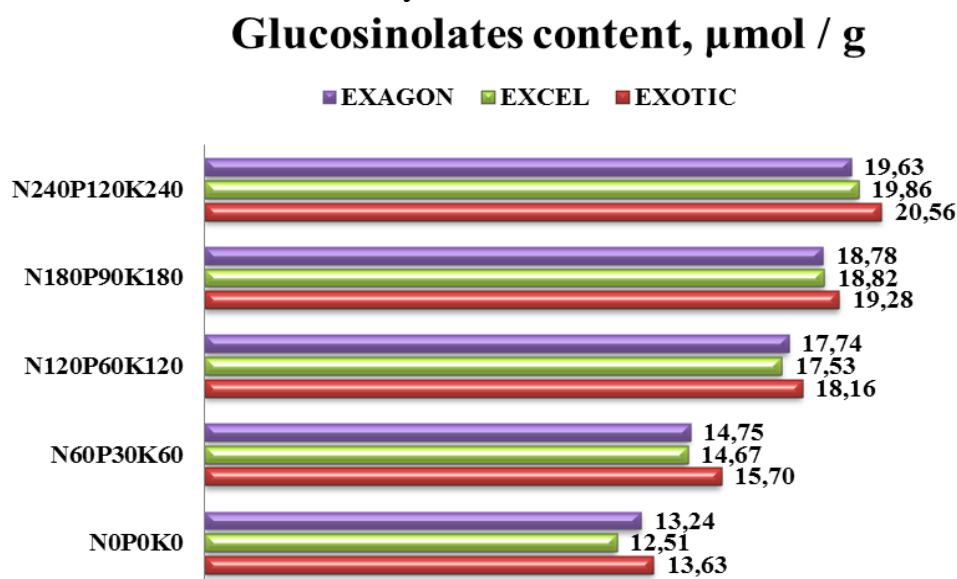


Fig. 6. Glucosinolates content depending on the fertilizer rates

Source: made by the author based on own research

So the fertilizer rates considerably influence on the glucosinolates content in rapeseed seed: the increasing of the rate leads to increasing of glucosinolates content.

The sowing dates also effected on the glucosinolates content, but there weren't legible dependence (Tabl. 1).

Table 1

The effect of sowing dates on the glucosinolates content in winter rapeseed hybrids

Hybrid	Sowing date	Glucosinolates content, $\mu\text{mol} / \text{g}$
Exotic	10 th of August	17,33
	21 st of August	18,60
	05 th of September	16,47
Excel	10 th of August	15,48
	21 st of August	17,69
	05 th of September	16,86
Exagon	10 th of August	15,06
	21 st of August	16,97
	05 th of September	18,46

Source: made by the author based on own research

The lowest indicator of Exotic hybrid was obtained in the third sowing date – the fifth of September – 16.47 $\mu\text{mol} / \text{g}$, of Excel – in the first sowing date – the tenth of August – 15.48 $\mu\text{mol} / \text{g}$ and of Exagon – in the first sowing date too (10th of August) – 15.06 $\mu\text{mol} / \text{g}$, this indicator was the lowest through the experiment.

One of the main indicators of the quality of winter rape seeds is the oil and protein content (Table 2). It is known that oil and protein accumulate in rapeseed from the moment of fertilization to full maturity, at the same time, seed substitutes, such as lipids and starch, and protein are formed from carbohydrates that are synthesized during photosynthesis in green parts of plants from carbon dioxide and water.

Table 2

Oil and protein content of rapeseed hybrids depending on the fertilizer rates

Hybrid	Fertilizer rate	Oil content, %	Protein content, %
Exotic	N ₀ P ₀ K ₀	46,03	18,57
	N ₆₀ P ₃₀ K ₆₀	45,47	19,36
	N ₁₂₀ P ₆₀ K ₁₂₀	45,07	20,41
	N ₁₈₀ P ₉₀ K ₁₈₀	44,90	21,07
	N ₂₄₀ P ₁₂₀ K ₂₄₀	44,90	22,09
Excel	N ₀ P ₀ K ₀	45,72	18,61
	N ₆₀ P ₃₀ K ₆₀	46,05	19,37
	N ₁₂₀ P ₆₀ K ₁₂₀	45,71	20,33
	N ₁₈₀ P ₉₀ K ₁₈₀	45,91	21,27
	N ₂₄₀ P ₁₂₀ K ₂₄₀	46,27	21,91
Exagon	N ₀ P ₀ K ₀	46,08	18,63
	N ₆₀ P ₃₀ K ₆₀	46,23	19,58
	N ₁₂₀ P ₆₀ K ₁₂₀	45,32	20,64
	N ₁₈₀ P ₉₀ K ₁₈₀	45,58	21,77
	N ₂₄₀ P ₁₂₀ K ₂₄₀	45,35	22,10

Source: made by the author based on own research

The highest oil content of Exotic hybrid – 46.03% was obtained in the variant without fertilizers, the lowest – 44.90% when were used N₁₈₀P₉₀K₁₈₀ and N₂₄₀P₁₂₀K₂₄₀, but the highest oil content of Excel hybrid – 46.27% was obtained in variant of N₂₄₀P₁₂₀K₂₄₀, the lowest – 45.71% – in the variant were N₁₂₀P₆₀K₁₂₀ used and there were insignificant difference between indicator of variant without fertilizers – 45.72%. The biggest oil content of Exagon hybrid – 46.23% showed variant where N₆₀P₃₀K₆₀ was applied, the lowest – 45.32% in the variant of N₁₂₀P₆₀K₁₂₀ was used.

The protein content of each hybrid was increasing with fertilizer rates expansion. So, the highest indicators of it were obtained in the variants where N₂₄₀P₁₂₀K₂₄₀ was used: Exotic – 22.09%, Excel – 21.91% and Exagon – 22.10%; the lowest, respectively in the variants without fertilizers: Exotic – 18.57%, Excel – 18.61% and Exagon – 18.63%.

The effect of sowing dates on the protein and oil contents is shown in the (Tabl. 3). The highest protein content – 21.13% was obtained by Excel hybrid in the second sowing date – the 21st of August, the lowest – 19.64% – by Exotic hybrid in the third

Table 3

Oil and protein content of rapeseed hybrids depending on the sowing dates

Hybrid	Sowing date	Oil content, %	Protein content, %
Exotic	10 th of August	20,44	45,05
	21 st of August	20,82	45,87
	05 th of September	19,64	44,90
Excel	10 th of August	20,34	44,81
	21 st of August	21,13	46,23
	05 th of September	19,42	46,75
Exagon	10 th of August	20,17	46,17
	21 st of August	20,43	45,17
	05 th of September	21,03	45,80

Source: made by the author based on own research

sowing date – the fifth of September. The highest oil content – 46.75% were obtained by Excel hybrid in the third sowing date (5th of September), the lowest – 44.81% – by the same hybrid, but in the first sowing date – the tenth of August.

Conclusions. The main aim of the investigation was to estimate the quality oil indicators of winter rapeseed hybrids according to their reaction and ability on weighty growing technology elements. The hybrid, which showed the worst results, was Exotic, with only one exception, when sowing dates influence on the oil and protein contents were analyzed, the Excel was worse. And the leader was Excel hybrid, which shown the greatest results in acid value, glucosinolates amount, and oil and protein contents, which allows to recommend it to cultivated under conditions of our region.

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АНОТАЦІЯ

ПОРІВНЯЛЬНА ОЦІНКА ЯКІСНИХ ВЛАСТИВОСТЕЙ ОЗИМОГО РІПАКУ В ЗАЛЕЖНОСТІ ВІД РІВНЯ УДОБРЕННЯ І ДАТИ ПОСІВУ

Проведена порівняльна оцінка якісних властивостей озимого ріпаку в залежності від рівня удобрення та дати посіву в даній статті. Опрацьовано літературу з проблеми дослідження; представлено дослідження значущості та актуальності впливу елементів технології вирощування на якісні властивості насіння озимого ріпаку.

Проаналізовано результати посівних періодів і різних показників впливу мінеральних добрив на якісні показники насіння озимого ріпаку в умовах Правобережного Лісостепу в Україні. Відзначено значний вплив вивчених

елементів технології на основні показники якості насіння; було виявлено, що зміна рівня врожайності, отриманого гібридами, призвело до зміни показників якості олії.

У цій статті були проаналізовані чотири найбільш важливі показники якості олії. До них відносяться: кислотне число, кількість глюкозинолатів, вміст олії і білка. На них впливали різні норми внесення добрив і строки посіву, які були умовами експерименту. Так, найнижче кислотне значення - 1,08 було отримано у гібрида Excel, коли норма добрива була $N_{240}P_{120}K_{240}$; при аналізі дат посіву найнижчий показник - 1,24 було отримано гібридом Eragon в першу дату посіву - 10 серпня. Кореляція між кислотним значенням і врожайністю ріпаку була негативною і коливалася від $r = -0,9327$ до $r = -0,9843$; величина достовірності апроксимації коливалася в діапазоні $R^2 = 0,87 - 0,97$, що свідчить про сильну залежність між показниками. Найменший вміст глюкозинолатів - 12,51 мкмоль / г було у гібрида Excel в умовах без добрив; при аналізі строків сівби найменший показник 15,06 мкмоль / г був отриманий гібридом Eragon в перший строк сівби - 10 серпня. Найбільший вміст олії було у гібрида Excel - 46,27%, воно було отримано у варіанті $N_{240}P_{120}K_{240}$. Вміст білка в кожному гібриді збільшувався зі збільшенням норми внесення добрив. Так, найвищий показник був отриманий у варіанті, де використовувався $N_{240}P_{120}K_{240}$ і це був Eragon - 22,10%. Найвищий вміст білка - 21,13% було отримано гібридом Excel за другої дати сівби - 21 серпня, коли були проаналізовані дати висіву, а саме високий вміст олії - 46,75% було отримано гібридом Excel в третю дату посіву - 5-го вересня.

Ключові слова: ріпак озимий, строки сівби, удобрення, кислотність, кількість глюкозинолатів, вміст олії і білка.

Табл. 3. Рис. 6. Літ. 13.

АННОТАЦИЯ

СРАВНИТЕЛЬНАЯ ОЦЕНКА КАЧЕСТВЕННЫХ СВОЙСТВ ОЗИМОГО РАПСА В ЗАВИСИМОСТИ ОТ УРОВНЯ УДОБРЕНИЙ И ДАТЫ ПОСЕВА

Проведена сравнительная оценка качественных свойств озимого рапса в зависимости от уровня удобрения и даты посева в данной статье. Разработана литература по проблеме исследования; представлено исследование значимости и актуальности влияния элементов технологии выращивания на качественные свойства семян озимого рапса. Проанализированы результаты посевных периодов и различных показателей влияния минеральных удобрений на качественные показатели семян озимого рапса в условиях Правобережной Лесостепи в Украине. Отмечено значительное влияние изученных элементов технологии на основные показатели качества семян; было обнаружено, что изменение уровня урожайности, полученного гибридами, привело к изменению показателей качества масла.

В этой статье были проанализированы четыре наиболее важных показателя качества масла. К ним относятся: кислотность, количество глюкозинолатов, содержание масла и белка. На них влияли разные нормы внесения удобрений и сроки посева, которые были условиями эксперимента. Так, самое низкое кислотное значение – 1,08 было получено у гибрида Excel, когда норма удобрения была $N_{240}P_{120}K_{240}$; при анализе дат посева самый низкий показатель – 1,24 был получен гибридом Exagon в первую дату посева – 10 августа. Корреляция между кислотным значением и урожайностью рапса была отрицательной и колебалась от $r = -0,9327$ до $r = -0,9843$; Величина достоверности аппроксимации колебалась в диапазоне $R^2 = 0,87 - 0,97$, что свидетельствует о сильной зависимости между показателями. Наименьшее содержание глюкозинолатов – 12,51 мкмоль / г было у гибрида Excel в условиях без удобрений; при анализе сроков сева наименьший показатель 15,1 мкмоль / г был получен гибридом Exagon в первый срок сева – 10 августа. Наибольшее содержание масла было у гибрида Excel – 46,27%, оно было получено в варианте $N_{240}P_{120}K_{240}$. Содержание белка в каждом гибриде увеличивалось с увеличением нормы внесения удобрений. Так, самый высокий показатель был получен в варианте, где использовался $N_{240}P_{120}K_{240}$ и это был Exagon – 22,10%. Самое высокое содержание белка – 21,13% было получено гибридом Excel во второй дате сева – 21 августа, когда были проанализированы даты высева, а самое высокое содержание масла – 46,75% было получено гибридом Excel в третью дату посева – 5-го сентября.

Ключевые слова: рапс озимый, сроки сева, удобрения, кислотность, количество глюкозинолатов, содержание масла и белка.

Табл. 3. Рис. 6. Лит. 13.

Інформація про автора

Мацера Ольга Олегівна – асистент кафедри землеробства, ґрунтознавства та агрохімії Вінницького національного аграрного університету (21008, м. Вінниця, вул. Сонячна, 5. e-mail: matsera.olga.vnau@gmail.com).

Мацера Ольга Олеговна – асистент кафедри земледелия, почвоведения и агрохимии Винницкого национального аграрного университета (21008, г. Винница, ул. Солнечная, 5. e-mail: matsera.olga.vnau@gmail.com).

Matsera Olha – assistant at the chair of Cultivation, Soil Science and Agrochemistry, Vinnytsia National Agrarian University (21008, Vinnytsia, Sonniachna St., 5. e-mail: matsera.olga.vnau@gmail.com).