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Determination of biochemical indicators of winter rape seeds under different growing conditions

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Purpose. To determine the biochemical indicators of seed quality of winter rape varieties grown under different conditions. **Methods.** During the research, the following methods were used: laboratory, calculation and statistical, to prepare conclusions – analysis and synthesis. **Results.** According to the results of laboratory studies, biochemical indicators of the quality of seeds of winter rape varieties, grown in different conditions, were established, namely: the content of oil, "crude protein" and glucosinolates. Meteorological conditions during the vegetation period of plants of the corresponding soil and climate zone have a significant influence on the quality indicators of seeds. Based on the results of the research, it was established that in 2022, compared to 2020, the biochemical indicators of winter rapeseed were higher. The increase in yield by 1.6 t/ha in the Steppe zone, 1.1 t/ha – Forest-Steppe, 1.4 t/ha – Polissia ensured an increase in oil content by 2.4% – Steppe, 6.6% – Forest-Steppe, 6.7% – Polissia and oil collection per hectare by 0.74 t/ha – Steppe and Polissia, 0.62 t/ha – Forest-Steppe. For the content of "crude protein", a decrease in the index was observed, namely: by 3.1% in the Steppe zone, 5.8% in the Forest-Steppe and 5.0% in the Polissia in 2022 compared to 2020. Meteorological conditions of the research years in the corresponding soil and climatic zones had an influence on the content of glucosinolates. For the Steppe and Forest-Steppe zones, the indicators were identical and amounted to 0.7%, 0.8% (Polissia), while in 2021, for the Steppe and Polissia zones, the content of glucosinolates in rapeseed was 0.8% and 0.9% more, compared to the indicators obtained in other years of research. **Conclusions.** It was established that, on average, for 2020–2022, the total oil content in seeds of rape was 46.2% – Steppe, 47.5% – Forest-Steppe, 47.8% – Polissia; "crude protein" content – 19.6% – Steppe, 18.4% – Forest-Steppe, 17.9% – Polissia; the content of glucosinolates was 0.7% in the Steppe and Forest-Steppe zones, 0.8% in the Polissia; oil collection in the Steppe zone 1.31 t/ha, Forest-Steppe – 1.16 t/ha, Polissia – 1.33 t/ha; protein collection per hectare is 0.54 t/ha in Steppe, 0.44 t/ha in Forest-Steppe and 0.48% in Polissia. Growing conditions over the years of research in the corresponding zone affect the formation of biochemical indicators of winter rapeseed.

Keywords: *winter rapeseed; oil content; "crude protein"; glucosinolates; oil collection; protein collection.*

Introduction

The main tasks of winter and spring rapeseed breeding are the creation of high-yielding, large-seeded varieties, hybrids of different types in terms of oil content and composition with wide plasticity to meteorological and agroecological factors [1].

The main economic and valuable indicators of plant varieties are their productivity and quality of marketable products, which in turn depends on a number of factors. In Ukraine, the average yield of winter rapeseed varieties is 1.73 t/ha, and in some farms 3.0–3.5 t/ha [2], while for the countries of the European Union this indicator is somewhat higher and is 3.5–4.0 t/ha and even more [3–5].

The formation of yield and quality of commercial products is influenced by a large number of factors, both uncontrollable – weather factors (solar radiation, temperature, precipitation) and controlled – agrotechnical measures (varieties, agricultural machinery, fertilizers, protection system). Taking into account the factors that have a positive and negative effect on the harvest, it is possible to purposefully use controlled and create optimal conditions for the growth and development of plants [5–8].

The most important agrotechnical measures are the terms, methods of sowing and the norms of seed sowing. Whereas agrotechnical measures have an important influence on the density of plant stands per unit area, their growth and development in the autumn period, damage by diseases, overwintering and, as a result, productivity [5, 6].

Sowing dates directly affect the overwintering condition of winter rapeseed crops, which plants are very demanding on growing conditions, especially on overwintering conditions [6, 7].

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In order to obtain a yield of winter rape at the level of 3.5–4.0 t/ha, plants use 150–180 kg/ha of nitrogen, 60–80 kg/ha of phosphorus and 120–150 kg/ha of potassium, and only 15–25% of the required amount comes from the soil [9]. Studies of the effect of mineral fertilizers on winter rapeseed indicate that it responds well to the introduction of phosphorus-potassium and complete formulations [10, 11]

In general, soil and climatic conditions of Ukraine are favorable for the normal growth and development of winter rapeseed plants and meet its biological requirements [12].

However, the cultivation of rapeseed requires strict adherence to the elements of technology. Since, due to a violation of the accuracy of sowing or a decrease in the norm of mineral fertilizers, the minimization of protection, compliance with the harvesting deadlines lead to a loss of about 30–50% of the potential yield, which in turn increases the cost of a ton of products produced [13].

Biochemical indicators of seed quality are economically valuable indicators of winter rapeseed along with the yield. Its seeds contain 30-50% oil of exceptional caloric content and energy yield. Weather conditions have a significant influence on the yield as well as on the oil content and its quality. The accumulation of oil in rape seeds occurs when plants are supplied with moisture during the period of pod formation and with an increase in air temperatures during the seed ripening period with sufficient moisture supply [5, 14].

Among oil crops, rapeseed has advantages in the food market and ranks third in the world oil market after palm and soybean oils, due to the content of about 35–45% of low-drying oil, with an iodine value of 101, 20–26% protein and 17–18% carbohydrates [15].

Rape seeds also contain thioglycosides (glucosinolates), the compounds that break down during hydrolysis to form isothiocyanates, substances that have toxic properties and can irritate the mucous membranes, respiratory organs, and even affect the activity of the thyroid gland [1].

The main indicator of winter rapeseed oil quality is the presence of erucic acid. When using rapeseed oil for food purposes, the presence of erucic acid is undesirable, as it has a negative effect on the cardiovascular system and the liver, which limits the use of oil for human consumption, and meal for feeding animals. However, for technical purposes, oil with a high erucic acid content is suitable due to its higher caloric content compared to other fatty acids, whose carbon chain is shorter. Rapeseed oil with a high content of erucic acid is used for the production of biodiesel fuel [1, 5, 16].

Unique biological and chemical properties of rapeseed oil provide the possibility of its use not only for food, but also for technical purposes. It is the composition and ratio of fatty acids in rapeseed oil that determine the direction of its use [15]. Rapeseed varieties that do not contain erucic acid and the content of glucosinolates in their seeds does not exceed 18–25 μmol/g are in demand on the market [13]. In terms of qualitative indicators, rapeseed must meet the national standard of Ukraine «Rapeseed for industrial processing. Technical conditions: Ukrainian State Standard 4966:2008» [17]. According to USS 4966:2008, rapeseed is divided into three classes according to the content of erucic acid and glucosinolates; for the highest class, the content of erucic acid should not exceed 1.5%, glucosinolates should not exceed 20 μmol/g [17].

Therefore, taking into account the influence of meteorological conditions during research in the relevant growing zones on the formation of biochemical indicators of commercial products of winter rapeseed, the problem of the formation of economic and valuable indicators is relevant and requires further study.

The purpose of the research is to investigate the biochemical parameters of seed quality of winter rapeseed varieties grown under different conditions.

Materials and methods

We studied 20 varieties of winter rapeseed included in the State Register of plant varieties suitable for distribution in Ukraine: ‘GEORGE’, ‘Jeremy’, ‘Sapsan’, ‘ELMSTAR’, ‘ES LEVEL CL’, ‘Crome’, ‘SY FLORETTA’, ‘SY JULIETTA’, ‘PX133’, ‘COLUMBIA’, ‘ES VITO’, ‘Drone’, ‘Duplo’, ‘RGT QUIZZ’, ‘NIZZA CL’, ‘TYRION’, ‘PX135’, ‘PT297’, ‘Duke’, ‘Crocodile’. All varieties were grown in the following points of research, which represented the corresponding soil and climatic zones: Lviv branch (village of Bilyi Kamin, Lviv region), Rivne branch (Verkhivsk village, Rivne district, Rivne region), Ternopil branch (Plotycha village, Ternopil district, Ternopil region), Khmelnytskyi branch (Khmelnytskyi city), Kirovohrad branch (Novoselytsia village, Blahovishchenskyi district, Kirovohrad region), Dnipropetrovsk branch (Semenivka village, Krynychanskyi district, Dnipropetrovsk region). Laboratory studies were carried out in the laboratory of quality indicators of plant varieties UIPVE in accordance with the Methodology for the qualification examination of plant varieties on suitability for distribution in Ukraine. Methods for determining the quality indicators of crop production [26]. The oil content and «crude protein» in the seeds were determined by express method using an Instalab 700 infrared grain analyzer (DICKEY-john, USA). The collection of vegetable oil and protein per hectare was calculated by the formulas:

A = Y × DR × F (a)
A = Y × DR × CP (b)

where: A (a) – oil collection; A (b) – protein collection; Y – yield (t/ha) at standard humidity; DR – dry residue; F – the proportion of fat in seeds, %; CP – the proportion of «crude protein» in seeds, %.

Results and discussion

Depending on the soil and climate zones and the conditions that developed during the years of the study, the yield of winter rapeseed in the Steppe zone was from 2.4 t/ha (2020) to 4.0 t/ha (2022), in the Forest-Steppe zone – from 2.3 t/ha (2020) to 3.4 t/ha (2022) and in the Polissia zone – from 2.4 t/ha to 3.8 t/ha (2022). Compared to 2020, in 2022 the yield increased by 1.6 t/ha in the Steppe zone, by 1.1 t/ha in the Forest-Steppe and by 1.4 t/ha in Polissia. On average, for 2020–2022, the yield of winter rape in the Steppe zone was 3.2 t/ha, in the Forest-Steppe – 2.8 t/ha, and in Polissia – 3.1 t/ha (Fig. 1).

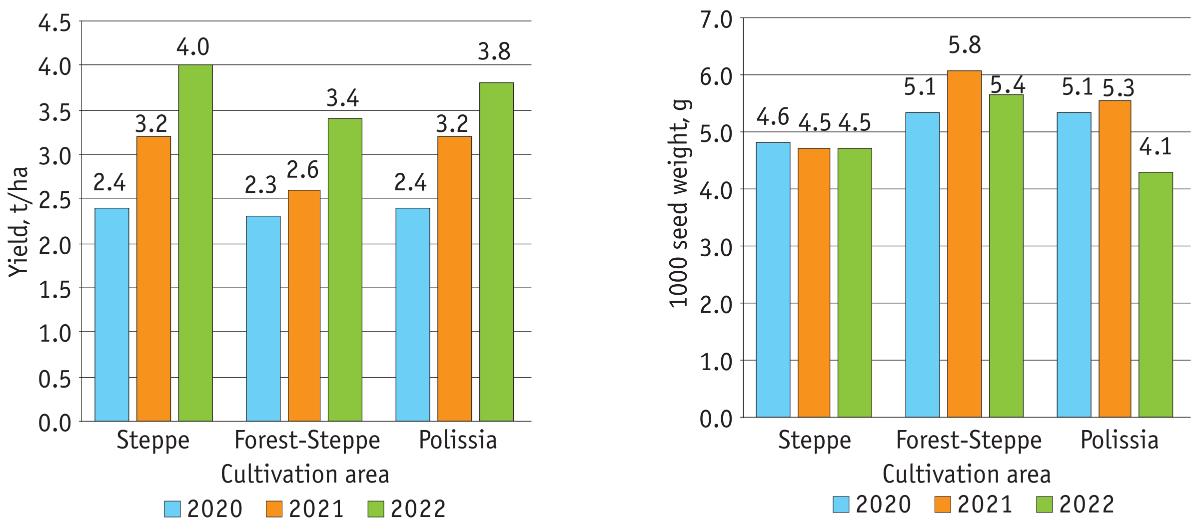

Fig. 1. Yield and 1000 seed weight depending on the soil and climate zone on average for 2020–2022

According to the index of 1000 seed weight of winter rapeseed, the highest values were obtained on average for varieties grown in the Forest-Steppe zone – 5.4 g, lower values were characteristic of the Polissia zone – 4.8 g and the Steppe zone – 4.5 g. Experimental samples from the Steppe zone had the same 1000 seed weight throughout all years of research. In the Forest-Steppe zone, this indicator changed from 5.1 g in 2020 to 5.8 g in 2021, and in the Polissia zone – from 4.1 g in 2022 to 5.3 g in 2021. In 2022 In 2018, a decrease in 1000 seed weight compared to 2021 was observed by 0.4 g for plants from the Forest-Steppe zone, and by 1.2 g for varieties growing in Polissia.

The oil content in the seeds of winter rape varieties during 2020–2022 ranged from 43.4% to 52.5%, depending on the soil and climate zone, the year of testing and the month of the study. Analyzing the obtained data in terms of years and research points, it can be seen that the lowest oil content was in the samples from the Rivne branch of UIPVE – 43.4% in 2020, the Kirovohrad branch of UIPVE – 45.8% in 2021, and the Dnipropetrovsk branch of UIPVE – 47.3% in 2022. The highest values were in samples from the Kirovohrad branch of the UIPVE in 2020 – 46.0%, the Rivne branch of the UIPVE in 2021 – 47.8%, the Lviv branch of the UIPVE in 2022 – 52.5% (Table 1). The lowest values were obtained in 2020 in samples from all branches except Kirovohrad, where the lower oil content in 2021 was 45.8%. In 2022, the highest oil content was observed in experimental samples of winter rapeseed obtained from all branches, in comparison with the 2020. Thus, oil content of the Dnipropetrovsk branch of the UIPVE increased by 3.0%, the Kirovohrad branch – 1.9%, the Ternopil branch – 7.9%, the Khmelnytskyi branch – 5.3%, the Rivne branch – 6.6%, and the Lviv branch of the

UIPVE – by 6.7%. According to the classifier of quality indicators of botanical taxa, which varieties were examined for suitability for distribution [27], winter rapeseed samples had an average (40.1–45.0%) oil content in the seeds, which is typical for the Dnipropetrovsk, Ternopil and Rivne branches of the UIPVE in 2020, high (45.1–50.0%) – Kirovohrad (2020–2022), Khmelnytskyi (2020–2021), Lviv (2020–2021), Dnipropetrovsk (2021–2022), Ternopil and Rivne branches of the UIPVE in 2021, very high (> 50.0%) in the Ternopil, Khmelnytskyi, Rivne and Lviv branches of the UIPVE in 2022.

The content of «crude protein» in the seeds of winter rape in 2020 was significantly lower than in 2022. Depending on the soil and climate zone, year and branch of the UIPVE, the content of «crude protein» ranged from 13.9% to 22.5% (Table 1).

Table 1

Oil and «crude protein» content depending on growing conditions, average for 2020–2022

Branches of UIPVE	Oil content, %			«Crude protein» content, %		
	2020	2021	2022	2020	2021	2022
Dnipropetrovsk	44.3	46.0	47.3	22.5	18.7	17.7
Kirovohrad	46.0	45.8	47.9	19.6	20.4	18.3
Ternopil	43.7	46.3	51.6	22.3	20.3	14.7
Khmelnytskyi	45.6	46.4	50.9	18.6	19.6	14.6
Rivne	43.4	47.8	50.0	22.0	18.2	16.4
Lviv	45.8	47.2	52.5	18.4	18.2	13.9
$LSD_{0.05}$	1.61	1.08	2.92	2.71	1.42	2.56

Over the years of research, a high content of «crude protein» in the seeds of winter rape was obtained in the experimental samples of the Dnipropetrovsk branch of the UIPVE – 22.5% in 2020, Kirovograd branch in 2021 – 20.4% and 2022 – 18.3%. Significantly lower values were in samples from the Lviv branch of the UIPVE in 2020 – 18.4%, in 2021 – 18.2% and in 2022 – 13.9%. Also in 2021, 18.2% «crude protein» were in samples from the Rivne branch of the UIPVE. Compared to 2020, «crude protein» content of winter rapeseed varieties decreased in 2022 by 4.8% in the Dnipropetrovsk branch of the UIPVE, 1.3% in Kirovohrad, 7.6% in Ternopil, 4.0% in Khmelnytskyi, 5.6% in Rivne and 4.5% in the Lviv branch of UIPVE.

The average oil content for 2020–2022 was: in the Steppe zone – 46.2%, Forest-Steppe – 47.5%, Polissia – 47.8%. In 2020, in samples of winter rapeseed obtained from branches representing all soil and climatic zones, oil content was at the same level with the highest values in the Steppe zone – 45.2% and the lowest in Polissia – 44.6%. In 2021, oil content in the Steppe zone practically did not change, compared to 2020 it increased by 0.7% and amounted to 45.9%. Starting from 2021, oil content increased significantly in the Forest-Steppe zones by 1.7% and Polissia – by 2.9%. In 2022, the growth of this indicator was monitored much better, since in the Forest-Steppe zone oil content increased by 6.6% compared to 2020 and by 4.9% compared to 2021, in the Polissia zone by 6.7% until 2020 and 3.8% – 2021 in the Steppe zone by 2.4% by 2020 and 1.7% by 2021. The maximum values of oil content (51.3%) were obtained in 2022 from plants, grown in the Forest-Steppe and Polissia zones (Fig. 2).

The maximum content of «crude protein» in seeds of winter rape in 2020 and 2022 was typical for the Steppe zone – 21.1% and 18.0%, respectively. In 2021, in the Forest-Steppe zone, the indicated figure was 20.0%. The minimum content of «crude protein» in

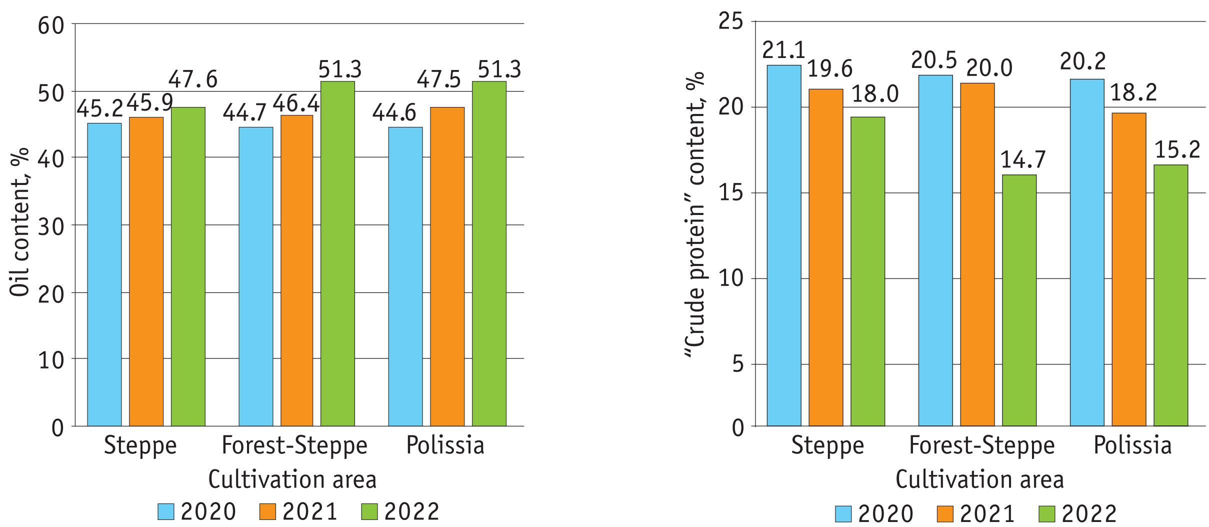

Fig. 2. The content of oil and "crude protein" depending on the soil, climate zone and the years of the study

winter rape seeds was obtained in 2020–2021 for Polissia branches – 20.2% and 18.2%, in 2022 in the Forest-Steppe zone – 14.7%.

During 2020–2022 the content of «crude protein» in rape seeds on average for the Steppe zone was 19.6%, for the Forest-Steppe – 18.4%, in Polissia – 17.9%. The highest rate of «crude protein» content in rapeseed was obtained in the Forest-Steppe and Polissia zones, which was 5.8% and 5.0%, while in the Steppe zone it was only 3.1%.

According to the index of oil content, the highest values were obtained for the following varieties: 'Jeremy' – 47.9% (Forest-Steppe), 'SY FLORETTA' – 47.2% (Steppe), 47.9% (Forest-Steppe), 'GEORGE' – 49.5% (Polissia), 'PX135' – 48.8% (Polissia), 'PT297' – 47.6% (Steppe), 48.5% (Forest-Steppe), 48.9% (Polissia), 'Duke' – 47.9%. The lowest values of oil content in 'COLUMBIA' varieties – 45.3% (Steppe), 45.7% (Forest-Steppe), 47.1% (Polissia), 'PX133' – 45.1% (Steppe), 46.2% (Forest-Steppe) and 'Sapsan' – 45.1% (Steppe), 46.4% (Forest-Steppe).

The varieties 'SY FLORETTA', 'GEORGE' and 'PT297' were the best among the studied varieties of winter rape in terms of oil content, the varieties 'COLUMBIA' and 'Sapsan' were of the least quality. Since winter rape belongs to oil crops and the main quality indicator is the oil content in the seeds, it can be concluded that according to this indicator, the highest results can be obtained in the soil and climate zone of Polissia.

On average, the lowest content of «crude protein» was observed in varieties 'RGT QUIZZ' – 18.2% (Steppe), 'ELMSTAR' – 17.7% (Forest-Steppe), 'SY FLORETTA' – 17.9% (Forest-Steppe), 16.7% (Polissia), 'GEORGE' – 16.5% (Polissia), 'PT297' – 18.3% (Steppe), 17.9% (Forest-Steppe). The highest values were in plants of the variety 'NIZZA CL' – 19.8% (Forest-Steppe), 18.6% (Polissia), 'COLUMBIA' – 19.8% (Forest-Steppe), 18.5% (Polissia), 'PX133' – 20.9% (Steppe), 19.9% (Polissia) and 'Sapsan' – 21.4% (Steppe), 19.8% (Polissia).

According to the obtained results, varieties 'PX133' and 'Sapsan' are the best in terms of the content of «crude protein», varieties 'PT297' and 'SY FLORETTA' are of the least quality (Table 2).

Table 2

The content of oil and "crude protein" in winter rapeseed varieties, depending on the soil and climate zone, on average for 2020–2022

Variety	"Crude protein" content, %			Oil content, %		
	Cultivating area					
	Steppe	Forest-Steppe	Polissia	Steppe	Forest-Steppe	Polissia
'NIZZA CL'	19.9	19.8	18.6	46.1	46.5	47.2
'RGT QUIZZ'	18.2	18.5	18.1	47.0	47.3	47.6
'ELMSTAR'	18.4	17.7	17.8	46.5	47.8	47.7
'Jeremy'	19.8	18.3	17.5	46.0	47.9	47.7
'Crome'	19.6	19.0	17.5	46.6	47.2	48.0
'TYRION'	19.4	18.2	18.0	46.0	47.7	48.0
'COLUMBIA'	20.2	19.8	18.5	45.3	45.7	47.1
'SY FLORETTA'	18.9	17.9	16.7	47.2	47.9	48.6
'GEORGE'	19.3	18.2	16.5	46.4	47.8	49.5
'SY JULIETTA'	19.4	18.7	17.9	46.4	47.1	48.0
'PX135'	18.9	18.1	16.9	46.6	47.7	48.8
'PT297'	18.3	17.9	17.3	47.6	48.5	48.9
'PX133'	20.9	19.9	18.3	45.1	46.2	47.7
'Sapsan'	21.4	18.8	19.8	45.1	46.7	46.4
'ES VITO'	19.9	18.9	18.2	45.8	47.0	47.2
'Duke'	18.7	18.0	17.0	46.9	47.9	48.4
'Drone'	18.8	18.1	17.9	46.7	47.4	47.7
'Duplo'	19.0	18.4	17.6	46.8	47.6	48.4
'Crocodile'	19.8	19.1	17.6	46.0	46.8	47.7
'ES LEVEL CL'	19.8	19.4	18.2	45.9	46.5	47.5
$LSD_{0.05}$	0.55	0.45	0.50	0.44	0.46	0.47

The content of glucosinolates is one of the main indicators that determine the direction of rapeseed use. The content of glucosinolates in rapeseed is from 0.5 to 1.0%, depending on the year and point of study. According to the results of our research, in 2020 it was observed that the value of the studied indicator was 0.7% and was at the same level for five branches. Only in the experimental samples from the Rivne branch of the UIPVE, this indicator was 0.8%. Whereas in 2021, the content of glucosinolates in rapeseed increased in experimental samples from branches: Kirovohrad and Dnipropetrovsk by 0.1%, Ternopil by 0.2%, Lviv by 0.3%. Lower values of the indicator were obtained in the experimental samples from the Khmelnytskyi branch by 0.2% and remained unchanged in the samples from the Rivne branch of the UIPVE.

In 2021, the content of glucosinolates was higher compared to other years. In the samples from the Lviv and Ternopil branches of the UIPVE the maximum values were 1.0% and 0.9%, respectively. In 2022, there was a decrease in the content of glucosinolates in samples from the Dnipropetrovsk and Rivne branches of the UIPVE by 0.1%, from the Kirovohrad, Ternopil and Lviv branches of the UIPVE by 0.2%, only in samples from the Khmelnytskyi branch it increased by 0.2% (Table 3).

Table 3

The content of glucosinolates in winter rapeseed depending on the conditions of the soil and climate zone on average for 2020–2022, %

Branches of UIPVE	2020	2021	2022
Dnipropetrovsk	0.7	0.8	0.7
Kirovohrad	0.7	0.8	0.6
Ternopil	0.7	0.9	0.7
Khmelnytskyi	0.7	0.5	0.7
Rivne	0.8	0.8	0.7
Lviv	0.7	1.0	0.8
$LSD_{0.05}$	0.06	0.24	0.09

On average, for 2020–2022, the content of glucosinolates in winter rapeseed was 0.7% in the Steppe and Forest-Steppe zones, 0.8% in Polissia. The testing year had a pronounced influence on this indicator, since in 2020 and 2022 the values were identical, while in 2021 in the Steppe and Polissia zones the values were higher compared to other years (Fig. 3).

According to the classifier of quality indicators of botanical taxa, which varieties undergo examination for suitability for distribution [27] winter rapeseed samples on average have medium (15–20 µmol/g, 0.6–0.8%) and high (20–30 µmol/g, 0.8–1.3%) content of glucosinolates. The lower the content of glucosinolates in rapeseed, the more valuable it is.

Taking into account that the lower the content of glucosinolates in rapeseed, the better it is, varieties ‘PX133’, ‘PX135’ and ‘Drone’ were the best according to this indicator (Fig. 4). The analysis of the content of

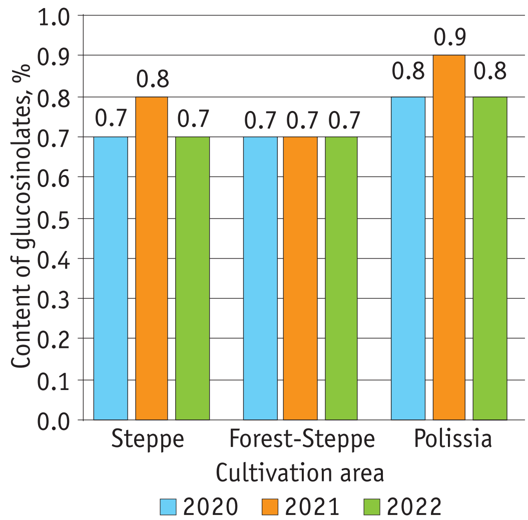

Fig. 3. Content of glucosinolates in samples of winter rapeseed from different soil and climatic zones for 2020–2022

glucosinolates in the seeds of winter rape varieties showed that the highest values were obtained in ‘ELMSTAR’ – 0.9% (Steppe), 1.0% (Forest-Steppe, Polissia), slightly lower values were in the varieties ‘SY FLORETTA’ and ‘ES VITO’ – 0.8% (Steppe, Forest Steppe) 0.9% (Forest). The lowest values of the content of glucosinolates were in the varieties ‘PX133’ – 0.6% (Steppe, Forest-Steppe), 0.7% (Polissia), ‘PX135’ and ‘Drone’ – 0.7% (Steppe, Polissia), 0.6% (Forest-Steppe).

Depending on the year and point of research, oil collection per hectare is from 0.70 t/ha to 2.06 t/ha. The collection of oil depends on the yield of the variety and the oil content of the seeds. Considering these indicators and their gradual growth during the studied years, the values of oil collection are higher in 2022.

During the studied years, the lowest oil collection were in samples from the Khmelnytskyi branch of the UIPVE: 0.70 t/ha in 2020, 0.73 t/ha – 2021 and 1.28 t/ha – 2022.

The highest values were in the samples from the Lviv branch of the UIPVE in 2020 – 1.12 t/ha, Kirovograd in 2021 and 2022 – 1.61 t/ha and 2.06 t/ha, respectively (Table 4). Comparing the results, it can be seen that in the samples from the Dnipropetrovsk branch of the UIPVE, oil collection increased by 0.28 t/ha, Kirovohrad – 1.19 t/ha, Ternopil – 0.66 t/ha, Khmelnytskyi – 0.58 t/ha, Rivne – 1.0 t/ha and the Lviv branch of UIPVE by 0.48 t/ha in 2022 compared to 2020.

Table 4

Average values of oil and protein collection depending on the year and month of cultivation, t/ha

Branches of UIPVE	Oil collection			Protein collection		
	2020	2021	2022	2020	2021	2022
Dnipropetrovsk	1.01	1.00	1.29	0.51	0.41	0.48
Kirovohrad	0.87	1.61	2.06	0.37	0.71	0.79
Ternopil	1.08	1.41	1.74	0.55	0.62	0.50
Khmelnytskyi	0.70	0.73	1.28	0.29	0.31	0.37
Rivne	0.78	1.57	1.78	0.39	0.60	0.58
Lviv	1.12	1.12	1.60	0.45	0.43	0.43
$LSD_{0.05}$	0.24	0.49	0.43	0.14	0.22	0.21

During the studied years, the collection of protein per hectare ranges from 0.29 to 0.79 t/ha. Like the oil collection, the protein collection is the lowest in the samples from the Khmelnytskyi branch of the UIPVE – 0.29 t/ha in 2020, 0.31 t/ha in 2021, 0.37 t/ha in 2022. This is explained by the low yield level of samples from this branch.

The highest values in the samples of the Ternopil branch of the UIPVE were 0.55 t/ha in 2020 and Kirovohrad branch – 0.71 t/ha in 2021 and 0.79 t/ha in 2022. On average for 2020–2022 the collection of protein depending on the research point was as follows: Dnipropetrovsk branch of UIPVE – 0.47 t/ha, Kirovohrad – 0.62 t/ha, Ternopil – 0.55 t/ha, Khmelnytskyi – 0.32 t/ha, Rivne – 0.52 t/ha and the Lviv branch of UIPVE – 0.43 t/ha.

On average, during 2020–2022, oil collection was: in the Steppe zone, 1.31 t/ha, Forest-Steppe – 1.16 t/ha, Polissia – 1.33 t/ha. Thus, in the Steppe and Polissia zones, the value of oil collection was at the same level. Depending on the year of the study, oil collection in the Steppe zone was 0.94–1.68 t/ha, in the Forest-Steppe zone – 0.89–1.51 t/ha, and 0.95–1.69 t/ha in the Polissia zone. Compared to 2020, in 2022 the value of oil collection increased by 0.74 t/ha in the Steppe and Polissia zone, and by 0.62 t/ha in the Forest-Steppe (Fig. 5).

Protein collection per hectare in the studied years averaged 0.54 t/ha in the Steppe zone, 0.44 t/ha in the Forest-Steppe, and 0.48% in the Polissia. In the Steppe soil-climatic zone, there was an increase in the value of protein collection in 2022 compared to 2020 and was 0.63 t/ha, which was the highest. In the Forest-Steppe and Polissia zones, the results obtained during the studied years did not change too sharply; this is due to the fact that the yield was lower in 2020 and much higher in 2022, and the «crude protein» content, on the contrary, was higher in 2020 and much lower in 2022. The direct influence of soil-climatic zones and meteorological conditions during years of research on the indicator of yield and «crude protein» content led to the equalization of protein collection values in these soil-climatic zones. In the Forest-Steppe zone, the value was at the same level – 0.42–0.46 t/ha.

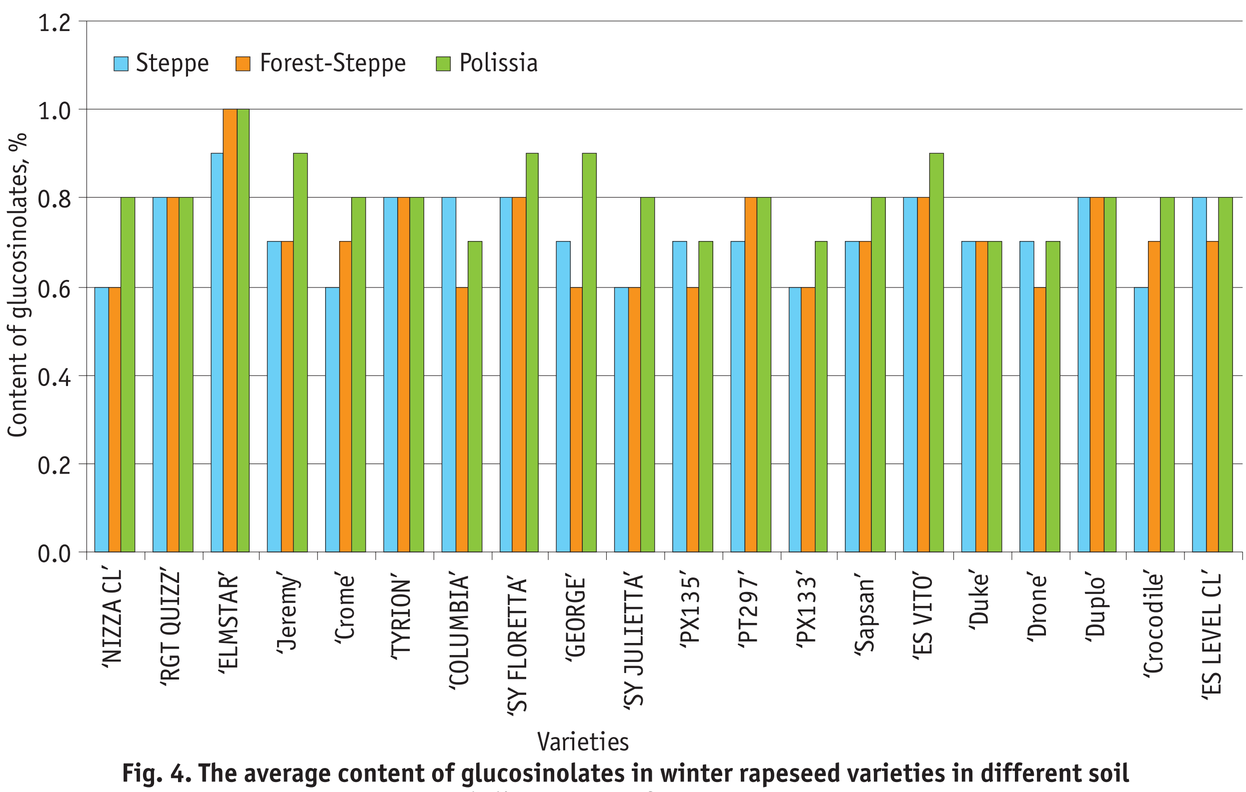

Fig. 4. The average content of glucosinolates in winter rapeseed varieties in different soil and climate zones for 2020–2022

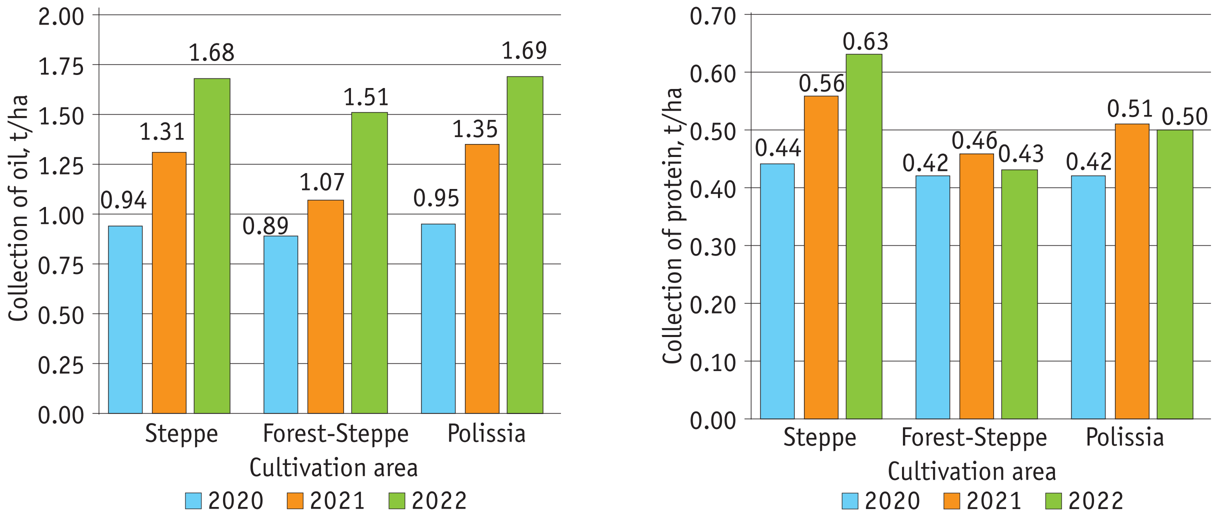

Fig. 5. Collection of oil and protein in winter rapeseed samples in different soil and climatic zones for 2020–2022

In the Polissia zone in 2021–2022, the collection of protein per hectare increased compared to 2020 and amounted to 0.51–0.50 t/ha. In the Forest-Steppe and Polissia zones, the studied winter rapeseed samples had a higher protein collection in 2021 – 0.46 t/ha and 0.51 t/ha.

The yield of oil in the Steppe zone was 1.31 t/ha, in the Forest-Steppe – 1.16 t/ha, and in Polissia – 1.33 t/ha.

Protein collection per hectare in the years of research averaged 0.54 t/ha in the Steppe zone, 0.44 t/ha in the Forest-Steppe, and 0.48% in Polissia.

Conclusions

Biochemical indicators of the quality of seeds of winter rape depend on the growing conditions in the corresponding soil and climatic zones.

High oil content in experimental seed samples was ensured by meteorological conditions during the vegetation period of winter rape in 2022 in all branches, which made it possible to obtain the largest increase – by 7.9% compared to 2020.

The meteorological conditions in the years of research had a direct impact on the formation of biochemical indicators of the quality of commercial products of winter rape varieties, so the indicator of the content of «crude protein» in winter rape seeds was the highest in 2020 and significantly decreased in 2022, to 7.6%.

It was determined that, on average, during the research years (2020–2022), the oil content in winter rape seeds was 46.2% in the Steppe zone, 47.5% in the Forest- Steppe, and 47.8% in Polissia.

The average indicators for the content of «crude protein» were 19.6% in the varieties grown in the Steppe zone, 18.4% in the Forest-Steppe, 17.9% in Polissia.

The share of glucosinolates for experimental samples of winter rape seeds was 0.7% in the Steppe and Forest-Steppe zones, 0.8% in Polissia.

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Мета. Визначити біохімічні показники якості вирощуваного у різних умовах насіння сортів ріпаку озимого. **Методи.** У процесі досліджень використовували лабораторний, розрахунковий і статистичний методи, для підготовки висновків – аналізу та синтезу. **Результати**. За результатами лабораторних досліджень визначили біохімічні показники якості вирощуваного в різних умовах насіння сортів ріпаку озимого типу розвитку, а саме: вміст олії, «сирого протеїну» та глюкозинолатів. Значний вплив на показники якості насіння мають метеорологічні умови впродовж вегетаційного періоду рослин відповідної ґрунтово-кліматичної зони. Встановлено, що у 2022 р. біохімічні показники насіння ріпаку озимого були вищими ніж у 2020 р. Зростання урожайності на 1,6 т/га у зоні Степу, 1,1 т/га – Лісостепу, 1,4 т/га – Полісся забезпечило підвищення вмісту олії на 2,4, 6,6 та 6,7% відповідно. Збори олії з гектара збільшилися на 0,74 т/га у зонах Степу та Полісся, 0,62 т/га – Лісостепу. У 2022 р., порівнюючи з 2020, спостерігали зниження показника «сирого протеїну»: на 3,1% у зоні Степу, 5,8% – Лісостепу та 5,0% – Полісся. На вміст глюкозинолатів впливали умови років досліджень у відповідних ґрунтово-кліматичних зонах. Степ і Лісостеп мали ідентичні показники – 0,7%, Полісся – 0,8%, тоді як у 2021 р. для зони Степу та Полісся вміст глюкозинолатів у насінні ріпаку був на 0,8 та 0,9% більшим, порівнюючи з показниками, отриманими в інші роки досліджень. **Висновки.** Встановлено, що в середньому за 2020–2022 рр. загальний вміст олії в насінні ріпаку становив 46,2% (Степ), 47,5% (Лісостеп) і 47,8% (Полісся); вміст «сирого протеїну» – 19,6% (Степ), 18,4% (Лісостеп) і 17,9% (Полісся); вміст глюкозинолатів – 0,7% (Степ та Лісостеп) і 0,8% (Полісся). Збір олії в зоні Степу мав показник 1,31 т/га, Лісостепу – 1,16 т/га, Полісся – 1,33 т/га. Збір білка з гектара становив 0,54 т/га для Степу, 0,44 т/га – Лісостепу та 0,48 т/га – Полісся. Умови вирощування за роки досліджень у відповідній зоні впливають на формування біохімічних показників насіння ріпаку озимого.

Ключові слова: *ріпак озимий; вміст олії; «сирий протеїн»; глюкозинолати; збір олії; збір білка.*

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