UDC 633.853.494
DOI https://doi.org/10.32782/2226-0099.2025.145.1.14

THE INFLUENCE OF WEATHER CONDITIONS ON THE FORMATION OF WINTER RAPESEED (BRASSICA NAPUS L.) YIELD IN THE FOREST-STEPPE OF THE RIGHT BANK

Zabarnyi O.S. *– Candidate of Agricultural Sciences,*
Doctoral candidate,
Institute of Agroecology and Environmental Management
orcid.org/0009-0007-3337-9386
Pelekh L.V. *– Candidate of Agricultural Sciences,*
Senior Lecturer at the Department of Agriculture, Soil Science and Agrochemistry,
Vinnytsia National Agrarian University
orcid.org/0000-0003-0967-2121

Winter rapeseed is a promising and economically attractive crop that can be successfully grown in virtually all soil and climate zones of Ukraine. Modern winter rapeseed cultivation technologies have their own characteristics, which may vary depending on the conditions and growing area. Therefore, determining the impact of weather factors on the formation of winter rapeseed hybrid yields in the conditions of the right-bank forest-steppe is an extremely important issue and requires in-depth field research, taking into account the selection of sowing dates and rates.

As a result of three years of research, the impact of weather factors on the seed productivity of winter rapeseed hybrids has been identified. Several critical periods in the cultivation of winter rapeseed were identified: the germination period (August-September) and the flowering and seed filling period (May-June). In the first case, plant density was at risk, while in the second case, pod formation and the weight of 1,000 seeds were at risk.

According to observations, the amount of precipitation during the seed formation and filling period varied significantly depending on the year. In 2019, 323.3 mm of precipitation fell in May-June, in 2020 – 193.9 mm, and in 2021 – 231.4 mm. These figures exceeded the long-term average by 182.3, 52.9, and 90.4 mm, respectively.

The reduction in the sowing rate to 200 thousand pieces/ha of similar seeds contributed to a significant shortfall in the winter rapeseed harvest. At the same time, the Pancher hybrid produced only 3.62 t/ha of seeds under optimal date and 2.94 t/ha under late sowing date. Under similar growing conditions, the Fencer hybrid produced seed yields of 3.87 and 3.27 t/ha, respectively.

Sowing winter rapeseed at the optimal date with a rate of 500 thousand pieces/ha of similar seeds allowed the most effective realization of the biological potential of hybrids for productivity formation. Under these growing conditions, the Pancher hybrid yielded an average of 4.37 t/ha over the years of research, while the Fencer hybrid yielded 4.55 t/ha of seeds.

Key words: *precipitation, air temperature, sowing rate, sowing date, yield.*

Забарний О.С., Пелех Л.В. Вплив погодних факторів на формування врожаю насіння ріпаку озимого (Brassica napus L.) в умовах Лісостепу Правобережного

Ріпак озимий є досить перспективною та економічно привабливою культурою, що може з успіхом вирощуватися практично у всіх ґрунтово-кліматичних зонах України. Сучасні технології вирощування ріпаку озимого мають свої особливості, вони можуть відрізнятися залежно від умов та зони вирощування. Тому визначення впливу погодних факторів на формування врожаю насіння гібридів ріпаку озимого в умовах Лісостепу правобережного є надзвичайно важливим питанням і потребує проведення поглиблених польових досліджень з урахуванням підбору строків та норм висіву.

У результаті трирічних досліджень виявлено вплив погодних факторів на формування насіннєвої продуктивності гібридів ріпаку озимого. Виявлено декілька найбільш критичних періодів у вирощуванні ріпаку озимого: це період сходів (серпень-вересень) та період цвітіння і наливу насіння (травень-червень). У першому випадку під загрозою була густота стояння рослин, тоді як у другому – закладка стручків та маса 1000 насінин.

Згідно спостережень, кількість опадів у період формування та наливу насіння суттєво відрізнялась у залежності від року. Так у 2019 році за період травень – червень випало 323,3 мм, у 2020 році – 193,9 мм, у 2021 році – 231,4 мм. Ці показники перевищували середню багаторічну норму, відповідно, на 182,3; 52,9 та 90,4 мм.

Зниження норми висіву до 200 тис. шт./га схожих насінин сприяло суттєвому недобору врожаю насіння ріпаку озимого. При цьому гібрид Панчер сформував лише 3,62 т/га насіння за оптимальних і 2,94 т/га за пізніх строків сівби. За аналогічних умов вирощування гібрид Фенцер сформував урожай насіння на рівні 3,87 та 3,27 т/га, відповідно.

Висів ріпаку озимого в оптимальні строки з нормою 500 тис. шт./га схожих насінин дозволив найбільш ефективно реалізувати біологічний потенціал гібридів для формування продуктивності. За таких умов вирощування гібриду Панчер було отримано, у середньому за роки досліджень, 4,37 т/га, тоді як гібрид Фенцер забезпечив формування 4,55 т/га насіння.

Ключові слова: *сума опадів, температура повітря, норма висіву, строки сівби урожайність.*

Formulation of the problem. The issue of food security in Ukraine and worldwide is becoming increasingly relevant. One possible solution to the food problem is to expand the area under winter rapeseed cultivation. It is well known that the versatility of rapeseed allows it to be widely used in the food, industrial and many other sectors of the economy.

Important issues in the cultivation of winter rapeseed are the choice of sowing dates and sowing rates. However, all these factors are technologically controllable, while problems related to weather conditions can be reduced by selecting high-quality hybrids recommended for a specific growing area.

Analysis of recent research and publications. The high profitability of the agricultural sector is ensured by growing economically viable crops using modern innovative technologies. Among oilseeds, rapeseed (*Brassica napus L.)* ranks second in the world and Ukraine, as the unique biological and chemical properties of its seeds determine its wide prospects for use in many sectors of the national economy [1].

As is well known, climate change is a global threat to the development of the agro-industrial complex, natural ecological systems, the economy and humanity as a whole. The threatening nature of this issue for agriculture can be confirmed by analysing climate change model forecasts for several decades ahead, which, according to the authors, are not very optimistic [2, 3].

Climatic resources play an important role in agriculture. In Ukraine, they vary according to the geographical location of the territories. Instability in agricultural production is primarily due to climatic conditions. Recently, there has been a trend towards an increase in the average annual temperature, which is one of the key meteorological factors in crop formation [4].

The indicator of the compatibility of the biological characteristics of a crop in combination with agricultural technology and climatic conditions determines the productivity of these crops. The highest productivity can be achieved when the plant fully utilises the potential of climatic resources [5].

The cultivation of winter rapeseed in conditions of climate change is an extremely important issue, which is why it has been studied by a number of foreign and domestic scientists [6-8].

The cultivation of winter rapeseed in Ukraine is environmentally safe, as it does not require the use of pesticides and other chemical protection agents. Rapeseed oil is particularly valuable because of its beneficial effects on health. It contains various fatty acids, vitamins and microelements. It is known that rapeseed oil producers are working

to expand exports, which will contribute to raising the country's international status and increasing its income [9].

The main criterion for the leadership of winter rapeseed among other agricultural crops is the creation of a large number of new hybrids that do not contain erucic acid in oil and have a minimum of glucosinolates in rapeseed meal. Rapeseed oil is considered one of the most valuable in the world in terms of its nutritional qualities. Often, winter rapeseed cultivation technology has its own characteristics depending on the region of cultivation, which raises many questions about the scientific justification of its individual elements [10].

Rapeseed and its processed products, in particular oil, are in high demand worldwide and occupy a large export niche. The largest areas of rapeseed cultivation are concentrated in China, India, the United States and Canada. In Ukraine, winter rapeseed is grown in most regions of the country, but it has proven itself best in Vinnytsia, Poltava, Kherson, Zhytomyr, Kyiv, Kharkiv, Odesa, and others. The area under winter rapeseed cultivation is growing every year, because even in unstable climatic conditions, winter rapeseed can provide a good harvest [11].

In Ukraine, winter rapeseed is most often used as a technical crop for the purpose of obtaining seeds and, accordingly, oil from it. In some regions, rapeseed is grown for green fodder for animals and green manure. In addition, it is an excellent honey plant [12].

Practice shows that growing winter rapeseed in the forest-steppe and steppe zones in dry and very dry years has significant advantages over grain crops. For the most part, rapeseed goes through the reproductive development phase somewhat earlier and thus avoids drought, the probability of which is very high in the subsequent period [13, 14].

Winter rapeseed is characterised by its cold resistance and undemanding heat requirements. Seeds can germinate at temperatures as low as 1-3 °C, but the optimum temperature is considered to be between 15-18 °C. Under such conditions and with sufficient moisture, seedlings begin to appear as early as the fifth day after sowing. A drop in temperature of several degrees leads to a delay in emergence of up to 8-10 days, and a lack of moisture delays emergence to 15-18 days. The growing season of winter rapeseed in autumn lasts until the average daily temperature drops to 5 °C. One month after emergence, a rosette of 5-9 leaves forms. During this period, rapeseed can withstand frosts down to -8 °C [15].

It is well known that winter rapeseed is a demanding crop in terms of wintering conditions. The best conditions for it are a mild winter with sufficient rainfall in autumn, a gradual onset of frost and stable snow cover. Unfortunately, such conditions are not typical for all regions of Ukraine where winter rapeseed is grown [16].

Due to the variability of weather conditions and frequent moisture deficits, obtaining a high yield of winter rapeseed is quite a difficult task. Only a professional approach to the technological aspects of cultivation can ensure high production profitability [17].

Ukrainian scientists note that the most suitable regions for winter rapeseed cultivation are the central, eastern and western areas of the Forest-Steppe, Polissya, and the Northern Steppe. In addition, there are regions that are less suitable, including Transcarpathia and the Southern Steppe [18].

As is well known, winter rapeseed is very demanding in terms of moisture supply, as it requires almost twice as much moisture as cereals, and its transpiration coefficient is between 500 and 750 units. To obtain a guaranteed high yield, it is necessary to have at least 600-800 mm of precipitation per year. The lower limit at which it is still profitable

to grow winter rapeseed is 400-500 mm of precipitation per year. The moisture requirements of winter rapeseed during the growing season vary greatly. Scientists note that the most critical needs of winter rapeseed are during the budding, flowering and seed filling phases [19].

Scientists note that due to global warming and critical lack of precipitation during various periods of vegetation, winter rapeseed requires differentiation of cultivation technology elements [20].

Many scientists note that air temperature and moisture availability have the most significant impact on winter rapeseed productivity [21, 22]. Other scientists add that, in addition to temperature and moisture, important factors affecting yield are solar radiation and the degree of its absorption by crops, soil fertility, the level of agricultural technology, varietal characteristics of plants, and the photosynthetic potential of crops [23, 24].

The productivity of winter crops depends on a number of abiotic factors, among which meteorological conditions play a major role. Analysing a significant number of studies, given the diversity of soil and climatic conditions, it can be noted that this issue is still relevant and requires clarification for specific regions. Climatic conditions are the main factor determining the average yield of field crops [25].

The purpose of the study was to determine the effect of average daily air temperature and precipitation on the formation of winter rapeseed hybrid seed yield.

Materials and methods of research. Field studies with winter rapeseed hybrids were conducted in the Vinnytsia region. The climate of the study site is temperate continental, characterised by mild winters and warm, humid summers.

The soils of the experimental field are grey forest soils. They have a light, medium-loamy granulometric composition. The humus content in the soil is 2.2%. The phosphorus content in the soil is 19.5 mg-eq per 100 g of soil, and potassium is 9.6 mg-eq per 100 g of soil. Hydrolytic acidity is within 4.6, and the sum of absorbed bases is 15.2 mg-eq per 100 g of soil.

Field studies were conducted with two different winter rapeseed hybrids, originally developed by BASF. Both hybrids are included in the State Register of Plant Varieties Suitable for Distribution in Ukraine in 2015.

Pancher is an early-maturing winter rapeseed variety. It is characterised by high stable yields, good winter hardiness, drought resistance, and high oil content in the seeds. The hybrid is characterised by rapid development in the autumn and resistance to lodging.

Fencer is a late-maturing winter rapeseed hybrid. It is characterised by excellent winter hardiness and high oil content. The hybrid has rapid autumn development, which allows it to be sown late. It is quite resistant to lodging and pod cracking at high fertiliser doses.

The experiment involved sowing winter rapeseed hybrids at the optimal time (15 August) and late (30 August). Rapeseed hybrids were sown at rates of 500, 400, 300 and 200 thousand viable seeds per hectare.

Field studies were conducted in accordance with generally accepted methods, and statistical processing of yield data was performed using the method of variance analysis [26].

Presentation of the main research material. It was noted that the average daily air temperature and precipitation during the years of the study differed slightly from the long-term average data (Table 1).

Table 1

Hydrothermal conditions during the years of research

Month	Average daily air temperature, °C				Precipitation, mm			
	18/19	19/20	20/21	*ALD	18/19	19/20	20/21	*ALD
August	22.4	21.5	22.7	19.4	32.9	52.8	5.4	55.0
September	16.6	16.4	18.5	14.1	63.6	41.7	57.7	61.0
October	11.0	11.1	14.1	8.1	56.3	22.1	103.1	35.0
November	2.5	7.6	5.1	1.7	54.4	28.2	12.9	37.0
December	-0.4	2,7	2.2	-2.8	55.8	19.4	76.7	35.0
January	-2.5	0.4	-0.4	-3.8	74.1	10.3	41.1	28.0
February	2.6	3.1	-1.2	-2.7	34.6	60.5	49.3	33.0
March	6.2	6.5	3.1	1.9	30.2	32.7	57.3	32.0
April	11.0	9.9	8.0	14.7	34.0	32.0	38.4	40.0
May	16.4	13.7	15.0	18.2	232.6	108.0	138.5	54.0
June	22.5	21.3	20.6	20.0	90.7	85.9	92.9	87.0
July	20.5	22.1	23.3	19.4	36.8	54.9	122.9	73.0
Year:	**10.7**	**11.4**	**10.9**	**8.2**	**796.0**	**548.5**	**796.2**	**570.0**

**Note – average long-term data*

The sowing period and emergence of seedlings are important stages in the cultivation of winter rapeseed. Quite often, due to insufficient rainfall, some of the seeds may not germinate, while others may form patchy seedlings.

The amount of precipitation in August 2018 was 32.9 mm, which was 40.2% below normal. The average daily air temperature during this period was 3.0 °C above the long-term average. In 2019 and 2020, the average daily air temperature during the sowing period (August) was also above normal, by 2.1 and 3.3 °C, respectively. With long-term averages of 55.0 mm, precipitation in 2019 was 52.8 mm and only 5.4 mm in 2022.

The total amount of precipitation from August to November inclusive was 207.2 mm in 2018, 144.8 mm in 2019, and 179.1 mm in 2020.

According to observations, the amount of precipitation during the winter months was as follows: 164.5 mm in 18/19, 90.2 mm in 19/20, and only 167.1 mm in 20/21. The average daily air temperature in these months (December-February) exceeded the long-term average and was -0.1 ºC in 18/19, 2.07 ºC in 19/20 and 0.2 ºC in 20/21, while the long-term average was -3.1 ºC. Therefore, no particular problems with freezing and death of winter rapeseed plants were observed.

During three years of research, the temperature regime in March significantly exceeded the long-term average. This allowed winter rapeseed plants to fully resume their vegetation in the third decade of the month. The amount of moisture received during this period varied. In March 2019, precipitation amounted to 30.2 mm, while in 2020 it was 2.5 mm higher. These figures were close to the long-term average (32.0 mm). However, it should be noted that in March 2021, precipitation exceeded the norm by 79% and amounted to 57.3 mm.

The third decade of March and April in the forest-steppe of the right bank are marked by the intensive growth and development of winter rapeseed plants. At this time, the phases of development change quite rapidly: stemming, leaf mass growth, primary and secondary flower stalks are formed, and rapeseed plants reach budding.

The average daily temperatures in April over the three years ranged from 8.0 to 11.0 ºC, which is slightly below the long-term average (14.7 ºC), while precipitation for this month in 2019 and 2020 was 15-20% below normal. Only in 2021 did the amount of precipitation for this month come close to the long-term average, reaching 38.4 mm.

The period from May to June inclusive is important for the formation of winter rapeseed yield indicators, as this is when the flowering and seed filling phases occur. Therefore, it is very important at this time to monitor and protect rapeseed plants from diseases and pests.

It should be noted that the temperature regime during these months in the years of research was close to the long-term average, while the amount of precipitation differed significantly. In 2019, 323.3 mm of precipitation fell in May–June, in 2020 – 193.9 mm, and in 2021 – 231.4 mm. The long-term average was 141.0 mm.

As a rule, in the Vinnytsia region, winter rapeseed is harvested in July. Early-maturing hybrids are harvested in the first ten days of July, while mid- and late-maturing hybrids are harvested starting in the second ten days. The weather conditions in July during the years of the study were favourable for seed harvesting.

Analysing the yield data obtained over the years of research, it should be noted that weather conditions had a significant impact on the productivity of winter rapeseed crops. The most favourable year for seed formation in winter rapeseed hybrids was 2019 (Table 2). In the variants with optimal sowing date, the rapeseed yield was 3.98-4.77 t/ha for the Pancher hybrid and 4.23-4.91 t/ha for the Fencer hybrid. Slightly lower seed yield indicators were observed in the variants of the experiment with late sowing date. Thus, for the Pancher hybrid, they ranged from 3.38 to 4.51 t/ha, while for the Fencer hybrid, they ranged from 3.68 to 4.69 t/ha.

Hot and dry conditions during flowering and seed filling (May-June) in 2020 had a negative impact on winter rapeseed yields. It was the lowest in three years of research. At the same time, the yield indicators for the Pancher hybrid at optimal sowing date were in the range of 3.00-3.81 t/ha, while at late sowing date they decreased to 2.15-3.53 t/ha. In winter rapeseed of the Fencer hybrid, the seed yield was 3.15-3.95 t/ha in variants with optimal sowing date and 2.68-3.76 t/ha in variants with late sowing date.

The yield of winter rapeseed in 2021 was as follows: under optimal sowing date, the Pancher hybrid yielded 3.87-4.53 t/ha of seeds, while under late sowing date, it yielded 3.28-4.31 t/ha. Slightly higher crop yields were observed when growing the Fencer hybrid. Under optimal sowing date, the hybrid yielded 4.23-4.80 t/ha of seeds, while under late sowing date, it yielded 3.45-4.64 t/ha.

On average, over the years of research, it has been established that growing winter rapeseed hybrids with a sowing rate of 500 thousand seeds per hectare of similar seeds allows for the highest seed yield. Thus, in variants with optimal sowing date, the yield of the Pancher hybrid was 4.37 t/ha, while in variants with late sowing date, it was 4.12 t/ha. Growing the Fencer hybrid with optimal sowing date and a sowing rate of 500 thousand seeds/ha of similar seeds yielded 4.55 t/ha of seeds. With late sowing date, the yield of the hybrid decreased to 4.36 t/ha.

On average, the least productive option was growing winter rapeseed hybrids at late sowing date and a sowing rate of 200 thousand seeds/ha of similar seeds. Under these conditions, the yield of the Pancher hybrid was 2.94 t/ha, and that of the Fencer hybrid was 3.27 t/ha.

Calculations of the impact of the studied factors on the formation of winter rapeseed seed productivity showed that factor C (sowing rate) had the greatest impact, accounting for 32.7% (Fig. 1).

Table 2

Yield of winter rapeseed hybrids depending on sowing dates and sowing rates, t/ha

Hybrid (Factor A)	Sowing date (Factor B)	Sowing rate (Factor C)	Yield, t/ha			
			2019	2020	2021	Average
Pancher	Optimal sowing date	500,000 pcs/ha	4.77	3.81	4.53	4.37
		400,000 pcs/ha	4.63	3.62	4.42	4.22
		300,000 pcs/ha	4.57	3.56	4.36	4.16
		200,000 pcs/ha	3.98	3.00	3.87	3.62
	Late sowing date	500,000 pcs/ha	4.51	3.53	4.31	4.12
		400,000 pcs/ha	4.33	3.31	4.20	3.95
		300,000 pcs/ha	4.08	3.03	4.02	3.71
		200,000 pcs/ha	3.38	2.15	3.28	2.94
Fencer	Optimal sowing date	500,000 pcs/ha	4.91	3.95	4.80	4.55
		400,000 pcs/ha	4.78	3.83	4.68	4.43
		300,000 pcs/ha	4.71	3.77	4.60	4.36
		200,000 pcs/ha	4.23	3.15	4.23	3.87
	Late sowing date	500,000 pcs/ha	4.69	3.76	4.64	4,36
		400,000 pcs/ha	4.55	3.63	4.47	4.22
		300,000 pcs/ha	4.36	3.42	4.22	4.00
		200,000 pcs/ha	3.68	2.68	3.45	3.27
LSD_{05} (average for 2019-2021), т/га: A – 0.04, B – 0.04, C – 0.05, ABC – 0.10						

The next most influential factor was factor B (sowing date) – 9.4%. The least influence on the formation of seed productivity of winter rapeseed crops was from factor A (hybrid), which accounted for only 4.0%. Other unaccounted factors, including weather conditions, had a significant impact on seed productivity, accounting for 53.9%.

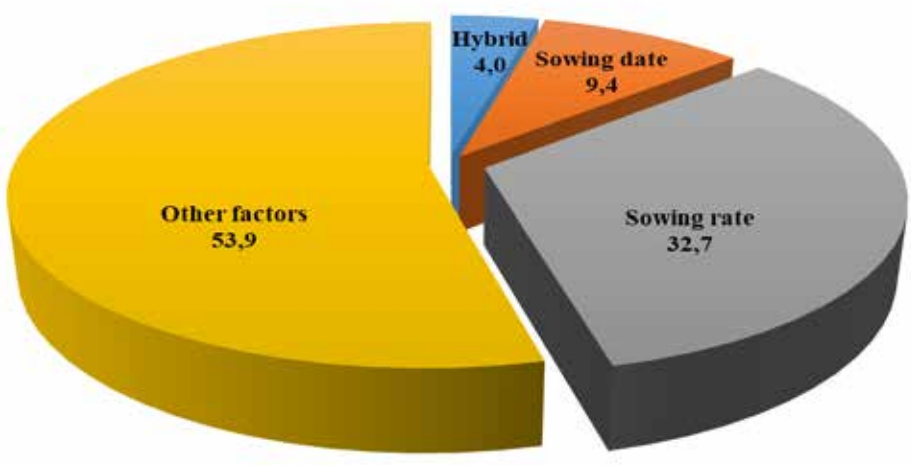

Fig. 1. Weight of factors influencing seed productivity of winter rapeseed

Conclusions and suggestions. According to observations, precipitation for the period 2018-2019 amounted to 796.0 mm, in 2019-2020 – 548.5 mm, while in 2020-2021 it was 796.2 mm, which made it possible to form, in variants with optimal sowing date and a sowing rate of 500 thousand pieces/ha of similar seeds, the yield of the Pancher hybrid at the level of 4.77; 3.81 and 4.53 t/ha of seeds. The seed yield of the Fencer hybrid, under similar growing conditions, was 4.91, 3.95 and 4.80 t/ha, respectively.

REFERENCES:

1. Raboanatahiry N., Li H., Yu L., Li M. Rapeseed (Brassica napus): Processing, Utilization, and Genetic Improvement. *Agronomy.* 2021. 11(9). 1776. https://doi.org/10.3390/agronomy11091776
2. Польовий В.М., Лукащук Л.Я., Лук'яник М.М. Вплив змін клімату на розвиток рослинництва в умовах Західного регіону. Вісник аграрної науки. 2019, № 9 (798). С. 29–34. DOI: https://doi.org/10.31073/agrovisnyk201909-04
3. Stocker T.F., Qin D., Plattner G.-K. et al. IPCC, 2013: Climate Change: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 2013. 1535 p. https://doi.org/10.1017/cbo9781107415324.023
4. Бондарчук І.Л., Дремов А.І., Красько Я.В. Особливості перезимівлі ріпаку озимого в умовах північно-східного Лісостепу України. Міжнародна науково-практична конференція «Гончарівські читання». (Суми, 24–25 травня 2018 р.). 2018. С. 109.
5. Палапа Н.В., Дем'янюк О.С., Нагорнюк О.М. Продовольча безпека України: стан та актуальні питання сьогодення. Агроекологічний журнал. 2022. № 2. С. 34–45. DOI: https://doi.org/10.33730/2077-4893.2.2022.263314
6. Домарацький Є.О., Базалій В.В., Домарацький О.О. Продуктивність ріпаку озимого залежно від азотного живлення та рістрегулюючих препаратів за умов кліматичних змін. Вісник аграрної науки Причорномор´я. 2019. Вип. 1. С. 53–62. (DOI: 10.31521/2313-092X/2019-1(101)-8)
7. Ray, D.R.; Gerber, J.S.; MacDonald, G.K.; West, P.C. Climate Variation Explains a Third of Global Crop Yield Variability. Nat. Commun. 2015. Vol. 6. P. 1–9.
8. Scealy, R.; Newth, D.; Gunasekera, D.; Finnigan, J. Effects of Variation in the Grains Sector Response of Climate Change: An Integrated Assessment. Econ. Pap. J. Appl. Econ. Policy. 2012. Vol. 31. P. 327–336.
9. Шуліка Б., Гузь-Москаленко А. Вплив кліматичних змін на географічні умови вирощування ріпаку (на прикладі Харківської області). Проблеми безперервної географічної освіти і картографії. 2022. Вип.35. С. 39–45. DOI: 10.26565/2075-1893-2022-35-05
10. Волощук О. П., Сендецький В. М., Мельничук Т. В., Сендецький І. В. Продуктивність ріпаку озимого за застосування регулятора росту вермийодіс та різних норм висіву. Передгірне та гірське землеробство і тваринництво. 2022. Вип. 71 (2). С. 67–84. DOI: 10.32636/01308521.2022-(71)-2-5
11. Гадзало Я.М. Гладій М.В., Саблук П.Т. Аграрний потенціал України. Київ: Аграрна наука, 2016. 332 с.
12. Забарний О.С., Дем'янюк О.С. Оцінка стану та перспективи розвитку ріпаківництва в Україні і світі. Агроекологічний журнал № 2. 2023. С. 83–90. DOI: https://doi.org/10.33730/2077-4893.2.2023.283700
13. Забарний О.С. Забарна Т.А. Особливості догляду за посівами ріпаку озимого у весняний період. Сільське господарство та лісівництво. 2024. Вип. № 1 (32). С. 50–61. DOI: 10.37128/2707-5826-2024-1-5
14. Гайдаш В.Д. Ріпак – культура великих можливостей / В.Д. Гайдаш, Г.Т. Дем'янчук, Г.М. Ковальчук. Ужгород : Карпати, 1999. 69 с.

15. Гауе О. Озимий ріпак: потужне повернення значущої культури. Пропозиція. Київ. 2013. № 7. С. 76–77.

16. Адаменко Т. Агрокліматичні умови вирощування ріпаку в Україні. Агроном. 2006. № 2. С. 95–96.

17. Matsera O. Comparative evaluation of quality properties of winter rapeseed depending on the level of fertilizers and sowing date. Сільське господарство та лісівництво. 2020. № 1 (16). С. 108–118. DOI: 10.37128/2707-5826-2020-1-8.

18. Лихочвор В. В., Проць Р. Р. Ріпак. Українські технології. Львів : НВФ, 2005. 88 с.

19. Рекомендації з насінництва нових сортів ріпаку озимого і ярого селекції ННЦ «Інститут землеробства НААН» / Є.В. Заїка, О.М. Дрозд, В.В. Кондратюк, Т.М. Пивовар. Вінниця: ТОВ «ТВОРИ», 2020. 28 с.

20. Безкоровайний В. М., Мойсієнко В. В. Формування врожайності та якості насіння ріпаку озимого залежно від гібридів і способів сівби в умовах Лісостепу правобережного. Український журнал природничих наук 2024. № 9. С. 169–178. DOI https://doi.org/10.32782/naturaljournal.9.2024.17

21. Zhang, S. J., Wang, H. Z. Adaptation to Climate Change of Chinese OSR Production. Chin. J. Oil Crop Sci. 2012. Vol. 34. P. 114–122.

22. He, Y.Q., Leng, B.F., Feng, Z.C. The Impact of Climate Factors on OSR Production in Hubei, China by Using Translog Production Function. Res. Sci. 2015. Vol. 37. P. 1465–1473.

23. Екологоорієнтовані підходи відновлення техногенно забруднених територій і створення сталих екосистем : колективна монографія / за заг. ред. Т. О. Чайки. Полтава : ПП Астрая, 2022. 452 с.

24. Ляшенко Г. В., Данілова Н. В. Практикум з мікрокліматології : навчальний посібник. Одеса : ТЕС, 2016. 220 с.

25. Зубов О. Р., Зубова Л. Г., Славгородська Ю. В. Оцінка впливу метеорологічних факторів на врожайність озимих культур в умовах північної частини Луганської області. Вісник Полтавської державної аграрної академії. № 2. 2012. С. 14–20.

26. Єщенко В. О., Копитко П. Г., Опришко В. П., Костогриз П. В. Основи наукових досліджень в агрономії. К.: Дія, 2005. 288 с.

Дата першого надходження рукопису до видання: 23.09.2025
Дата прийнятого до друку рукопису після рецензування: 30.10.2025
Дата публікації: 05.12.2025