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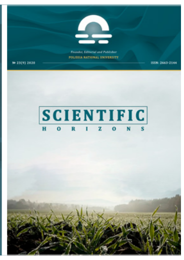

Control of segetal vegetation in the agrocenosis of common buckwheat

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Abstract. The aim of the study was to determine the effectiveness of herbicides in controlling segetal vegetation in the agrocenosis of common buckwheat (*Fagopyrum esculentum* Moench.) while considering their influence on crop condition and yield formation. The methodology involved a field experiment conducted at the Educational and Research Field of Polissia National University during 2021-2025, which included five variants of herbicide control, namely the use of the graminicide Norvel Extra alone and in combination with the preparations Horizon, Tsukron+, and Helianthex. Herbicide effectiveness was assessed through quantitative weed

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composition at three observation periods, and yield was measured according to standard agronomic procedures with an untreated control. The study found that the structure of weed infestation was dominated by grass species, accounting for 77.2% of the total weed population. The application of Norvel Extra alone ensured a technical efficiency of 77.1%, whereas its combinations with Horizon, Tsukron+, and Helianthex provided weed control ranging from 88.5% to 95.5%. A strong correlation was observed between yield preservation and weed suppression, with yield retention levels of 23.5-42.6% compared to the control. The results indicated that the highest performance was achieved when Tsukron+ and Helianthex were combined with the graminicide, due to their selective activity against both grass and broadleaf species. The practical value of the study lies in the potential use of its results by agronomists, crop consultants, and agricultural producers to optimise buckwheat herbicide management systems and improve crop productivity under Forest-Steppe conditions in Ukraine

Keywords: crops; weeds; herbicide; efficiency; yield; protection technologies

INTRODUCTION

Buckwheat (*Fagopyrum esculentum* Moench.) is one of the leading cereal crops with significant nutritional, melliferous, and agroecological importance. Although its share in global crop production remains limited, this crop is an essential component of Ukraine's national food security. Increasing buckwheat yield and ensuring the stability of its production are strategic objectives for the agricultural sector, given the reduction in sown areas and low profitability across most regions. Buckwheat cultivation also performs an ecological function, improving soil structure, promoting the accumulation of organic matter, and serving as a valuable preceding crop for other species. One of the key factors in enhancing buckwheat productivity is the effective control of weeds, which significantly affect plant growth, development, and yield. Therefore, the search for optimal herbicides for buckwheat agrocenoses remains a relevant research direction.

Recent studies have demonstrated significant changes in approaches to buckwheat cultivation technology, particularly concerning the use of herbicides and biological preparations. According to V. Moisiienko *et al.* (2023), yield improvement in buckwheat directly depends on balanced nutrition and foliar feeding, yet weed competition remains a crucial limiting factor even under optimal fertilisation. Research by Q. Wang *et al.* (2024) confirmed that optimising herbicide types and concentrations is a key element in increasing the intensity of buckwheat cultivation without compromising grain quality. Ukrainian researchers have also focused considerable attention on agronomic factors affecting buckwheat productivity. Yu. Mashchenko and I. Semeniaka (2018) established that the correct selection of preceding crops, adherence to crop rotation, and technological discipline are critical for achieving stable yields. O. Vavrynovych and O. Kachmar (2019) noted that changes in the species composition of buckwheat weed flora depend not only on soil fertility but also on the fertilisation system, which influences weed germination dynamics during the growing season.

International research in recent years has concentrated on issues of herbicide resistance and the search for environmentally safe methods of weed management. T.A. Gaines *et al.* (2020) outlined the principal biochemical mechanisms underlying the evolution of weed resistance to herbicidal active substances, highlighting the need for developing new compounds to maintain agro-technological efficiency. Similar conclusions were drawn by T. Randell-Singleton *et al.* (2025), who determined that herbicide selection for buckwheat must be based on an assessment of selectivity to avoid phytotoxic effects on the crop. Y. Vieites-Álvarez *et al.* (2024) demonstrated that different genotypes of common (*Fagopyrum esculentum*) and Tartary buckwheat (*Fagopyrum tataricum*) exhibit varying abilities to exert allelopathic suppression of weeds, opening prospects for biological weed management.

A significant contribution to the study of varietal characteristics of buckwheat was made by P. Karazhbei *et al.* (2022), who focused on the creation of high-yielding and adaptive varieties resistant to abiotic stresses. Meanwhile, H. Debski *et al.* (2018) found that certain herbicides, including glyphosate and fluazifop-P-butyl, can alter the flavonoid content in buckwheat plants, which requires careful management to avoid negative impacts on product quality.

Thus, the current level of scientific research confirms that effective weed management in buckwheat crops remains a complex and multifaceted challenge. Alongside breeding and agronomic measures, improving herbicide control systems is an essential area for ensuring environmental safety, biodiversity conservation, and yield enhancement. Therefore, the aim of this study was to determine the effectiveness of herbicides for controlling segetal vegetation in the agrocenosis of common buckwheat (*Fagopyrum esculentum* Moench.) while considering their influence on crop development and productivity.

MATERIALS AND METHODS

Field studies were carried out during 2021-2025 at the Educational and Research Field of Polissia National University, located 20 km north of Zhytomyr, in the village of Velyka Horbasha, Zhytomyr District, Zhytomyr Region.

The soil at the experimental site was predominantly sandy loam, sod-podzolic, characterised by the following parameters: humus content (according to Tyurin and Kononova, DSTU 7828:2015, 2016) – 1.07-1.22%; easily hydrolysable nitrogen (according to Kornfield, DSTU 7863:2015, 2016) – 56-67 mg/kg of soil; available phosphorus (according to Chirikov, DSTU 4115:2002, 2003) – 107-175 mg/kg of soil; exchangeable potassium (according to Chirikov, DSTU 4115:2002, 2003) – 74-105 mg/kg of soil; and soil pH – 5.6-6.5. Weather conditions during the research period slightly deviated from long-term averages but did not have a significant influence on the development of buckwheat.

Buckwheat in the experiment was cultivated according to the conventional soil tillage technology. The preceding crop was winter wheat. After harvesting the predecessor, stubble cultivation was performed to a depth of 7-10 cm. Once weed seedlings and volunteer wheat appeared, deep ploughing was conducted to a depth of 23 cm. In spring, moisture preservation and pre-sowing cultivation were carried out. Buckwheat sowing took place from the third decade of May to the first decade of June using the variety Syn 3/02. The seeding rate was 2.8 million grains per hectare, and sowing was conducted with an SZ-3.6 seed drill. Certified seed material treated with a fungicidal preparation was used. During sowing, fertiliser NPK 10:26:26 was applied at a rate of 80 kg/ha. The studied herbicides were applied using a backpack sprayer at the 12-14 BBCH growth stage with a working fluid rate of 200 L/ha. During the growing season, pest control measures were taken when necessary, particularly against aphids. Throughout the research period, the application of fungicides was not required, as no significant signs of disease were observed in buckwheat plants. The species composition of weeds present in the buckwheat agrocenosis was determined using the Weed Identifier Atlas (Veselovsky *et al.*, 1988). The evaluation of herbicide effectiveness against weeds was conducted according to the following experimental design:

1. Weedy control (treatment with water);
2. Norvel Extra, EC (active ingredient: quizalofop-P-ethyl 125 g/L) – 1.0 L/ha;
3. Horizon, EC (active ingredients: phenmedipham – 91 g/L, desmedipham – 71 g/L, and ethofumesate – 112 g/L) – 0.7 L/ha, followed after 10 days by Norvel Extra, EC, 1.0 L/ha;
4. Tsukron+, SL (active ingredient: clopyralid 300 g/L) – 0.2 L/ha, followed after 10 days by Norvel Extra, EC, 1.0 L/ha;
5. Helianthex, SC (active ingredient: halauxifen-methyl 68.5 g/L) – 0.04 L/ha, followed after 10 days by Norvel Extra, EC, 1.0 L/ha.

The size of each experimental plot was 50 m², with four replications and a one-row sequential layout. Weed infestation assessments in buckwheat crops were performed three times: the first – before herbicide application, the second – 30 days after application, and the third – prior to harvest. Herbicide efficacy was calculated on the 30th day after treatment, using the initial weed density as a control. The calculation of herbicide efficiency employed a correction formula relative to the control. Buckwheat yield was determined for each treatment variant in accordance with the methodology described by S. Tribel (2001). The authors adhered to the standards of the Convention on Biological Diversity (1992) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1979).

RESULTS AND DISCUSSION

Since buckwheat is one of the main grain crops in Ukraine, improving its cultivation techniques enables producers to increase productivity per hectare. In modern technological maps for buckwheat cultivation, the protection section mainly focuses on controlling certain pest species and grass weeds, while information on disease management is almost absent. A similar situation applies to the control of broadleaf weeds, as there are no registered herbicides for their effective suppression. Therefore, the present study aimed to investigate the possibility of herbicidal control of both broadleaf and grass weed species in buckwheat crops. As a result of assessing the weed infestation within the buckwheat phytocenosis, it was found that the majority of segetal plants belonged to grass species, which accounted for more than 70% of the total (Fig. 1).

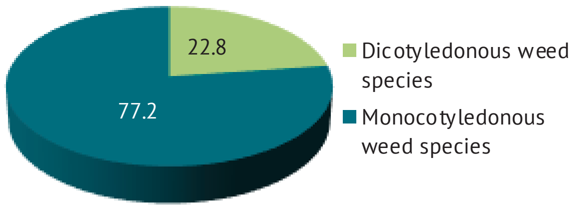

***Figure 1**. Ratio of monocotyledonous and dicotyledonous weed species in common buckwheat crops, 2021-2025*
***Source:** developed by the authors*

The most numerous weed species in buckwheat crops were green foxtail (*Setaria viridis*), yellow foxtail (*Setaria pumila*), barnyard grass (*Echinochloa crus-galli* L.), and witchgrass (*Panicum capillare* L.). Among the broadleaf weeds, the following species were identified: common lambsquarters (*Chenopodium album* L.), wild mustard (*Sinapis arvensis* L.), creeping thistle (*Cirsium arvense* L.), black-bindweed (*Polygonum convolvulus* L.), and spotted lady's thumb (*Persicaria maculosa* Gray), among others (Fig. 2).

As a result of applying the studied preparations in buckwheat crops, a high level of effectiveness was observed in controlling unwanted vegetation. The initial weed infestation of the buckwheat stands averaged 65.4 plants per m² (Table 1).

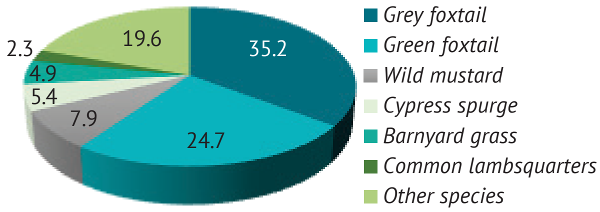

***Figure 2**. Structure of weed infestation in common buckwheat crops, 2021-2025*
***Source:** developed by the authors*

***Table 1**. Effect of herbicides on weed infestation in common buckwheat crops (2021-2025)*

Experimental variant	Number of monocotyledonous and dicotyledonous weed species, pcs/m²			Technical efficiency, %
	initial	30 days after treatment	before harvest	
Weedy control (water treatment)	65.5	74.9	78.0	–
Norvel Extra, EC, 1.0 L/ha	65.2	17.1	19.5	77.1
Horizon, EC, 0.7 L/ha, followed after 10 days by Norvel Extra, EC, 1.0 L/ha	63.9	8.4	9.3	88.5
Tsukron+, SL, 0.2 L/ha, followed after 10 days by Norvel Extra, EC, 1.0 L/ha	66.2	3.4	5.0	95.5
Helianthex, SC, 0.04 L/ha, followed after 10 days by Norvel Extra, EC, 1.0 L/ha	66.1	4.2	5.5	94.4
$LSD_{0.5}$	0.06	0.1	0.1	–

***Source:** developed by the authors*

In the control variant, the number of weeds increased to 74.9 plants per m² on the 30th day after the first observation and reached 78.0 plants per m² before harvesting. The application of the graminicide Norvel Extra at a rate of 1.0 L/ha provided almost complete control of grass-type segetal species; however, some dicotyledonous weeds remained, resulting in an overall efficiency of 77.1% compared to the control. In the treatment with Horizon (0.7 L/ha) followed after 10 days by Norvel Extra (1.0 L/ha), the technical efficiency reached 88.5%. The use of Tsukron+ and Helianthex, followed by the graminicide application, demonstrated the highest weed suppression, achieving 95.5% and 94.4% effectiveness, respectively. Due to the reduced weed pressure on the buckwheat agrocenosis, a significant increase in crop yield indicators was observed (Table 2).

***Table 2**. Effect of post-emergence herbicides on the yield of common buckwheat (2021-2025)*

Experimental variant	Application rate, L/ha	Yield, t/ha	Yield preserved	% relative to weedy control
Weedy control (water treatment)	–	1.15	–	–
Norvel Extra, EC, 1.0 L/ha	1.0	1.42	0.27	23.5
Horizon, EC, 0.7 L/ha, followed after 10 days by Norvel Extra, EC, 1.0 L/ha	0.7 + 1.0	1.50	0.35	30.4
Tsukron+, SL, 0.2 L/ha, followed after 10 days by Norvel Extra, EC, 1.0 L/ha	0.2 + 1.0	1.64	0.49	42.6
Helianthex, SC, 0.04 L/ha, followed after 10 days by Norvel Extra, EC, 1.0 L/ha	0.04 + 1.0	1.61	0.46	40.0
$LSD_{0.5}$	–	0.01	0.01	–

***Source:** developed by the authors*

In the control variant, this indicator was the lowest, amounting to 1.15 t/ha. The other experimental variants demonstrated significantly higher yield values. The application of the graminicide Norvel Extra at a rate of 1.0 L/ha resulted in yield preservation of 0.27 t/ha, corresponding to 23.5% compared to the control. A slightly higher buckwheat yield of 1.50 t/ha was obtained in the treatment involving Horizon followed after 10 days by Norvel Extra, providing a yield increase of 30.4%. The highest yield values – 1.64 t/ha and 1.61 t/ha – were recorded in the variants where Tsukron+ and Helianthex were followed by Norvel Extra, respectively, allowing yield preservation at 42.6% and 40.0% compared to the weedy control. This study contributes to the development of plant protection technologies by proposing effective solutions for weed management and yield enhancement in buckwheat cultivation.

The results of the present research demonstrated high herbicidal control efficiency against segetal vegetation in the agrocenosis of common buckwheat, which is consistent with findings from previous studies emphasising the crucial role of technological optimisation in improving crop productivity. In the study by I. Tkalich *et al.* (2019), it was shown that the growth intensity and yield of buckwheat significantly depended on the application of rational agrotechnical practices, among which timely weed control played a decisive role. The authors noted that in areas with high weed infestation, yield losses exceeded 40%, which aligns with the current results indicating the adverse effect of segetal vegetation on yield formation.

According to Z. Hrytsaienko and A. Datsenko (2014), the use of biological preparations contributed to increasing buckwheat productivity by stimulating growth processes and enhancing the crop's competitive ability against weeds. The results obtained in this experiment confirm the effectiveness of an integrated approach, where herbicidal control is combined with optimal plant nutrition and biostimulation, ensuring yield preservation of up to 40-42%. These findings highlight the necessity of comprehensive management of the phytosanitary condition of the buckwheat agrocenosis to achieve sustainable economic efficiency.

A comparison with the study by V. Onychko *et al.* (2015) revealed that the interaction between sowing rate, fertilisation level, and herbicide control determines the final crop yield. In their research, the optimal plant density and fertiliser application promoted the formation of a more developed leaf surface, enabling buckwheat to compete more effectively with weeds. A similar pattern was observed in the present experiment: under conditions of reduced weed pressure and sufficient nutrient supply, buckwheat showed an increased nutrient uptake efficiency and a higher level of photosynthetic activity.

At the same time, V. Khomina and O. Pastukh (2016) emphasised the importance of agroecological factors in buckwheat cultivation under mixed cropping systems, where weed control is achieved through mutual suppression between crops. The current results partially align with their conclusions, as in both cases the key factor was the reduction of competition for light and nutrients. However, herbicide application in this study provided a faster and more predictable effect, which offers a practical advantage under production conditions.

Particular attention should be given to the findings of I. Straholis *et al.* (2019), who highlighted the response of different buckwheat varieties to the combined use of biological preparations and mineral fertilisers. The authors established that the resistance of varieties to stress conditions, including weed competition, increased due to balanced nutrition. A similar phenomenon was observed in the present study: yield improvement in the herbicide-treated variants was accompanied by enhanced growth parameters, confirming the importance of an integrated crop management approach.

The results of R. Tobiasz-Salach *et al.* (2018) demonstrated that foliar fertilisation of buckwheat affects not only yield quantity but also the chemical composition of the grain. This aspect is significant in the context of herbicide application, as improved weed control efficiency must coincide with the preservation of the biochemical quality of the produce. In the present study, no negative impact of herbicides on crop productivity was detected, confirming the safety of the recommended herbicide combinations.

Similar results were reported by A. Słomka *et al.* (2017), who described the positive effects of biostimulants on buckwheat seed productivity. The authors showed that hormonal regulation in flowers promoted fertilisation and seed formation, partially compensating for losses caused by weed competition. In this study, herbicide application also contributed to an increase in the total number of seeds per plant, indirectly confirming the importance of reducing biotic stress to realise the crop's yield potential. The findings of A. Płażek *et al.* (2019) are also noteworthy, as they demonstrated the effect of high temperatures on buckwheat embryogenesis. Their research indicated that under stressful conditions, ovule development disturbances and reduced seed germination may occur. The results obtained in the present study indicate that effective herbicidal control not only improves the phytosanitary condition of the agrocenosis but also indirectly mitigates environmental stress effects by reducing competition, which enhances reproductive organ formation.

Therefore, the findings confirm that herbicidal control of segetal vegetation in the buckwheat agrocenosis is a crucial element of modern cultivation technology. Its efficiency depends on integration with the fertilisation system, varietal characteristics, and soil biological activity level. The consistency of these results with the conclusions of contemporary researchers supports the scientific and practical reliability of the findings, while the observed differences highlight the need for further testing of new herbicide combinations under various climatic conditions to ensure stable yield improvement in buckwheat cultivation.

CONCLUSIONS

Under the conditions of the Educational and Research Field of Polissia National University, the agrocenosis of common buckwheat was predominantly infested with grass weed species. The proportion of monocotyledonous weeds accounted for 77.2% of the total undesirable vegetation. The dominant representatives of the grass flora were grey foxtail (*Setaria pumila*), green foxtail (*Setaria viridis*), and barnyard grass (*Echinochloa crus-galli*). Among dicotyledonous weeds, the most common were wild mustard (*Sinapis arvensis*), cypress spurge (*Euphorbia virgata*), and common lambsquarters (*Chenopodium album*). The application of all tested herbicides resulted in a significant reduction of weed pressure within the buckwheat agrocenosis. In the variant where the graminicide Norvel Extra was applied at a rate of 1.0 L/ha, almost complete control of grass weeds (98.9%) was achieved, allowing for yield preservation of 23.5%. The treatment combining Horizon with a subsequent application of Norvel Extra provided control over both grass and broadleaf weeds at 88.5%, resulting in a 30.4% yield increase compared to the control.

The most effective treatments were those combining Tsukron+ and Helianthex with Norvel Extra applied 10 days later. The technical efficiency in these variants reached 95.5% and 94.4%, respectively, relative to the initial weed infestation, while yield increased by 42.6% and 40.0%. The results of this research confirm the high efficiency of herbicidal control of segetal vegetation in buckwheat agrocenoses and highlight the potential for further studies aimed at identifying herbicides with diverse mechanisms of action to ensure sustainable and environmentally safe weed management in buckwheat cultivation.

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CONFLICT OF INTEREST

None.

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Контроль сегетальної рослинності в агроценозі гречки посівної

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Анотація. Метою дослідження було визначення ефективності гербіцидів для контролю сегетальної рослинності в агроценозі гречки посівної (*Fagopyrum esculentum* Moench.) з урахуванням їх впливу на стан культури та формування врожайності. Методологія роботи передбачала закладання польового досліду на навчально-дослідному полі Поліського національного університету протягом 2021-2025 рр., де оцінювали п’ять варіантів гербіцидного контролю, включаючи використання граміциду Норвел екстра окремо та в комбінації з препаратами Горизонт, Цукрон+ і Геліантекс. Ефективність гербіцидів визначали за динамікою кількісного складу бур’янів у трьох обліках, а врожайність встановлювали за стандартною методикою з урахуванням контрольного варіанта. У результаті дослідження було виявлено, що у структурі забур’яненості посівів гречки переважали злакові види, частка яких становила 77,2 %. Було встановлено, що застосування лише граміциду Норвел екстра забезпечувало 77,1 % технічної ефективності, тоді як його поєднання з препаратами Горизонт, Цукрон+ і Геліантекс сприяло контролю 88,5-95,5 % бур’янів. Було проаналізовано залежність урожайності гречки від рівня забур’яненості та відзначено збереження врожаю на рівні 23,5-42,6 % порівняно з контролем. Було узагальнено, що найвищу результативність забезпечували варіанти з використанням Цукрон+ і Геліантекс у поєднанні з граміцидом, що зумовлено їх вибірковою дією на широколисті й злакові види. Практична цінність роботи полягає у можливості використання результатів агрономами, консультантами та виробниками сільськогосподарської продукції для оптимізації системи гербіцидного захисту гречки та підвищення її врожайності в умовах Лісостепу України

Ключові слова: посіви; бур’ян; гербіцид; ефективність; урожайність; технології захисту