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SPECIES COMPOSITION OF SEGETAL VEGETATION IN WINTER RYE PHYTOCOENOSES IN THE FOREST-STEPPE OF UKRAINE

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Abstract. *Winter rye is an important food and fodder crop. Its grain is used to make bakery flour, animal feed, and in the production of alcohol, starch and malt. Rye products are rich in nutrients essential for the human body, such as carbohydrates, proteins, fats and minerals. Bread made from rye flour contains vitamins B1, B2, PP and E, which provide 30 to 50% of the daily energy requirement, up to 40% of the protein requirement, up to 60% of B vitamins and up to 80% of vitamin E. The article discusses the problem of weed infestation of winter rye crops, which is becoming increasingly important for agricultural production in*

the context of climate change. Weed infestation of agrocenoses causes significant economic losses, as weeds not only extract nutrients from the soil, but also deteriorate the quality and volume of the crop. In this study, an ecological and geographical approach was used to identify the main weed species that infest winter rye crops. In particular, the most common were Convolvulus arvensis L . (20 %), Sonchus arvensis L. (17 %) and Centaurea cyanus (All.) Dost. (16 %). The study found that exceeding the economic threshold of harmfulness, especially in the case of perennial weeds, leads to a yield loss of 3.5 kg/ha on average for each weed species. The results show that the level of weed infestation significantly affects rye grain yields, and 18.7% of the yield variation can be explained by these changes. In order to maintain the stability of agroecosystems, it is necessary to implement environmentally safe protection systems, including organisational, economic, agronomic and biological methods of weed control. The article emphasises the importance of integrating modern technologies, in particular precision farming methods, to minimise the negative impact of weeds and other pests on the productivity of winter rye. Further research involves improving weed control methods, as well as analysing the impact of different protection systems on the stability and productivity of winter rye crops. The results of the study are valuable for agronomists and scientists involved in the development of effective weed management strategies in the context of sustainable development of the agricultural sector aimed at preserving and increasing yields.

***Ключові слова**: winter rye, weed species composition, weed infestation, agrocenosis, harmfulness.*

Introduction. Winter rye is one of the most valuable food and fodder crops. The grain is used for the production of bakery flour, as feed for farm animals, as

well as for the production of alcohol, starch and malt [1]. Products derived from grain contain nutrients necessary for the human body: carbohydrates, proteins, fats, and minerals. Baked bread contains vitamins B1, B2, PP, E, which help people to get 30 to 50 per cent of the energy they need for life, up to 40 per cent of their protein needs, up to 60 per cent of B vitamins, and up to 80 per cent of vitamin E [2].

Winter rye is a valuable crop due to its high resistance to cold weather and ability to produce stable yields even in low temperatures. It is characterised by a deep root system, which facilitates the absorption of nutrients from the lower soil layers and improves soil structure. Rye is also highly competitive with weeds, which reduces the need for chemical plant protection products. In addition, rye grain is rich in vitamins, minerals and fibre, making it important for healthy eating and use in dietary products [1, 3].

Segetal vegetation is a significant competitor for cultivated plants. In the phytocoenoses of winter rye, especially in the Forest-Steppe of Ukraine, segetal vegetation forms various interactions that affect the yield and quality of products. The relevance of studying the composition of such communities is due to the need to increase the efficiency of agricultural production by optimising the phytocoenotic environment. The forest-steppe, as a unique natural region with a moderately humid climate, contributes to the formation of specific vegetation characterised by a high diversity of species. The study of the species composition of segetal communities allows us to assess the competitive potential of different weed species and develop measures for their control [4].

Studying the relationship between weeds and winter rye is important for increasing the resistance of agrocenoses to stress factors. In addition, the assessment of the prevalence of segetal flora in the Forest-Steppe is important for

the conservation of biodiversity in agricultural landscapes [5, 6]. Modern methods of phytosociology allow for a detailed analysis of the structural and functional characteristics of plant communities. The results of such studies serve as the basis for environmentally sound weed control methods. In addition, they help to adapt rye cultivation technologies to environmental conditions and climate change. In this regard, determining the species composition of segetal vegetation is an important step in optimising winter rye agroecosystems.

Analysis of recent research and publications. Foreign and domestic scientists are actively researching the spread of segetal vegetation in winter rye agrocenoses. A significant contribution to the development of this topic was made by such scientists as M. R. Ryan, S. B. Mirsky, D. A. Mortensen, O. I. Savchuk, V. V. Gurel, N. A. Koshitska, G. M. Kochyk and others [7, 8, 9]. At the same time, the species composition of the weed component and its harmfulness in winter rye crops remain insufficiently investigated and require further study.

Today, about 30,000 weed species are known, of which more than 1,800 cause serious economic losses annually. At the same time, most agricultural crops have to compete with about 200 weed species [10, 11]. Weed losses can reach 10–70 % of the crop [12, 13], so weed control is a technological and economic necessity in winter rye cultivation. Thus, an important task is to conduct a phytocoenotic analysis of weed communities, determine their species composition and level of harmfulness. Accordingly, the aim of our study was to investigate the species composition and harmfulness of segetal vegetation in winter rye agrocenoses in the forest-steppe of Ukraine.

Material and Methods. The field trials were conducted in 2022–2024 at Bel-Agro 3 LLC, Berdychiv district, Zhytomyr region, and Agrolan Podillya LLC, Koziatyn district, Vinnytsia region. The predecessor of winter rye is soya.

The technology of winter rye cultivation included seed treatment with a mixture of the biological product Agat-25K, PA with a consumption rate of 0.04 kg/t and the plant growth regulator Ekostim-1, RK (0.05 l/t). In the tillering phase (21st stage of development), foliar feeding was carried out with EKOSTIM-1, RK (0.05 l/ha), and in the tube stage (31st stage), crops were sprayed with the biological preparation Agat-25K, PA (0.03 kg/ha), which helped to reduce the development of fungal diseases and increase crop productivity.

To protect against weeds and destroy the soil crust, double harrowing of winter rye was used. The weather conditions of 2022–2024 were characterised as susceptible to winter rye cultivation and were distinguished by uneven temperature and precipitation during the growing season, which contributed to obtaining reliable data.

To determine the actual weed infestation of winter rye crops, the eyeball and quantitative methods were used. The eyeball method was used to determine the dominant weed species. The degree of weed infestation was determined by the scale of O. I. Maltsev (Table 1).

Table 1. Scale for visual assessment of weediness

Coverage of soil surface with weeds, points	Degree of surface coverage, %.	Number of weeds, pcs./m^2	Crop dominance
1	<1	<3	Full
2	<5	3–5	High
3	5–20	6–15	Weakened
4	21–50	16–30	Medium
5	51–70	31–75	Weak
6	71–100	<5	Absent, continuous clogging

The quantitative method was used to determine the number of weed plants on the survey plots (50x50 cm). An accounting frame was used, provided that one of the crop rows was diagonally aligned with it [14]. Next, the number of weeds on

the plot was counted, and the number of cultivated plants was determined, which was taken as 100%. The weediness score was determined according to the scale given in Table 2.

Table 2. Scale for determining the degree of weediness of winter rye crops

Weediness		Weeds, pcs/m^2
score	**degree**	
1	Weak	<2
2–3	Noticeable	2–5
4–5	Medium	6–8
6–7	High	9–11
8–9	Very high	>11

Statistical processing of the obtained experimental data was carried out by the method of analysis of variance using the applied computer programs Microsoft Excel and Statistica 10.

Results. Weeds have a complex negative impact on the growth and development of winter rye for several reasons. They shade the crop, reduce soil temperature, actively absorb water and nutrients, and contribute to the formation of pest and disease foci [8]. Weeds use moisture in dry years, when its lack becomes a decisive factor for the yield of winter rye, is particularly harmful.

Different types of weeds affect the crop in different ways, and this impact is determined by their harmfulness, which leads to lower yields and poorer grain quality. The species composition of weeds varies depending on the cultivation technology, including tillage methods, crop rotation, fertilisers and plant protection products.

During the study of winter rye agrocenoses, 13 weed species belonging to different biological groups and classes were identified. Annual weeds are represented by such biological groups as ephemerals, early spring, late spring and overwintering species.

Ephemerals are represented by only one species – *Stellaria media* (L.) Vill. Spring early weeds occur in small numbers, including: *Fallopia convolvulus* L., *Sinapis arvensis* L. and *Fumaria officinalis* L. The peculiarity of *Sinapis arvensis* L. is the ability of its seeds to germinate in autumn, although the main seedlings appear in spring. Even unripe seeds retain germination, and the seedlings themselves are resistant to frost (down to –3.8 ℃). Among spring late weeds, the most harmful are *Chenopodium album* L., *Setaria glauca* L., *Amaranthus retroflexus* L.

Some researchers refer to *Chenopodium album* L. as an early spring weed, as its germination period can vary from March to October. Flowering begins in July and lasts until September, fruiting from August to October, and productivity reaches up to 1,000,000 nuts. Mature seeds have a higher germination rate in dry years, while immature seeds do not germinate at all. Seeds can remain viable in the soil for up to 38 years.

Winter rye crops were dominated by overwintering weed species such as *Centaurea cyanus* (All.) Dost., *Capsella bursa-pastoris* L., *Papaver rhoeas* L., *Tripleurospermum maritimum* L. The most harmful species is *Capsella bursa-pastoris* L. because it blooms from spring to autumn, develops 2–3 generations, has spring and winter forms. Fertility reaches 274 thousand seeds. It remains viable for up to 35 years. Perennial weeds are represented by three species: *Taraxacum officinale* Wigg., *Convolvulus arvensis* L., *Sonchus arvensis* L. The peculiarity of the distribution of *Convolvulus arvensis* L. is that the plant curls up very quickly and becomes visible only after the flowers appear. The maximum fertility is 9800 seeds, and their viability is up to 50 years. The structure of the species composition of weed populations in the agrocenoses of winter rye of the Forest-Steppe of Ukraine is presented: *Centaurea cyanus* (All.) Dost.), *Tripleurospermum*

maritimum L., *Convolvulus arvensis* L., *Chenopodium album* L., *Stellaria media* (L.) Vill., *Sonchus arvensis* L., *Papaver rhoeas* L., *Sinapis ararvensis* L. (Figs. 1, 2).

***Centaurea cyanus* (All.) Dost.**

***Tripleurospermum maritimum* L.**

***Convolvulus arvensis* L.**

***Chenopodium album* L.**

***Stellaria media* (L.) Vill.**

***Sonchus arvensis* L.**

***Papaver rhoeas* L.**

***Sinapis ararvensis* L.**

Fig. 1. Species composition of weeds in winter rye agrocenoses in the forest-steppe of Ukraine

Numerous species in the agrocenoses of winter rye were: *Convolvulus arvensis* L. (20 %), *Sonchus arvensis* L. (17 %) and *Centaurea cyanus* (All.) Dost. (16 %). However, these weeds germinate in spring under the cover of well-developed winter rye, so they are unable to form a significant competitive mass.

The percentage of other weeds varied from 5 to 14 %. The smallest share was accounted for by *Sinapis ararvensis* L. (5 %) and *Papaver rhoeas* L. (7 %).

An important reserve for increasing the yield of winter rye is the protection of crops from weeds. When there is a lack of weed control measures, grain producers lose 10–35 % of their crops, and these losses increase by 1.5–2 times in heavily weeded areas. Reduced grain yields and deterioration in grain quality are the result of competition between weeds and crops for water, light and nutrients.

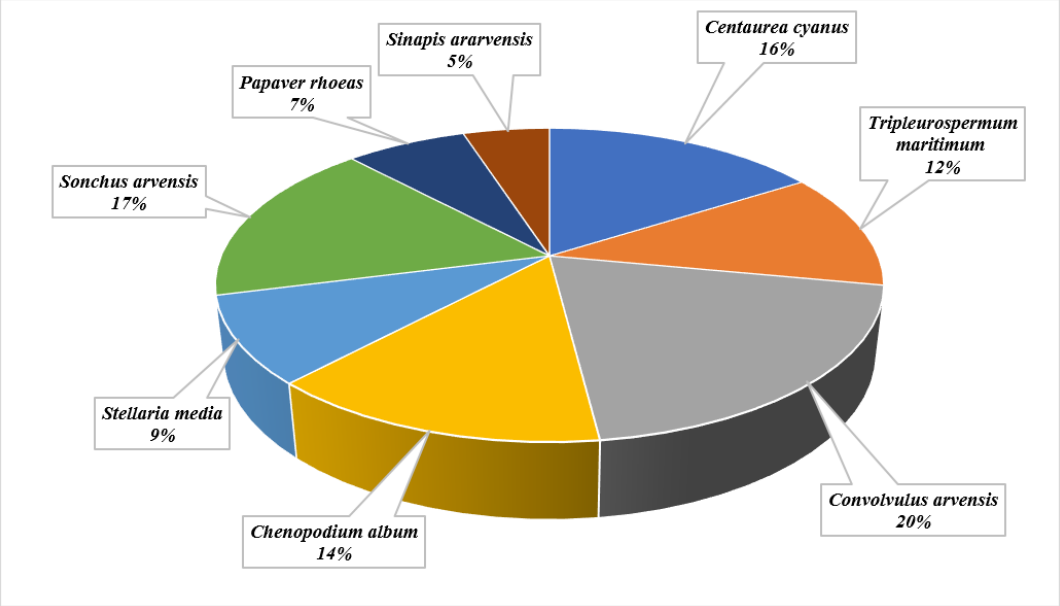

Fig. 2. Structure of weed species composition in winter rye agrocenoses in the Forest-Steppe of Ukraine, 2022–2024

According to the results of the experiment, the density of weeds in the experimental plots was 13.3 pcs./m^2, the presented amount in terms of the degree of weediness is 1 point (Table 3).

Table 3. Weed infestation of winter rye crops before harvesting, 2022–2024

Type	Quantity, pcs./m^2	Contamination score
Amaranthus retroflexus L.	0,4	1
Capsella bursa-pastoris L.	0,2	1
Centaurea cyanus (All.) Dost.	2,6	2
Chenopodium album L.	0,9	1
Convolvulus arvensis L.	1,3	1
Fallopia convolvulus L.	0,7	1
Fumaria officinalis L.	0,3	1
Papaver rhoeas L.	0,8	1
Setaria glauca L.	0,2	1
Sinapis ararvensis L.	0,8	1
Sonchus arvensis L.	1,5	1

Stellaria media (L.) Vill.	2,4	2
Taraxacum officinale Wigg.	0,3	1
Tripleurospermum maritimum L.	0,9	1
Разом	13,3	
HIP_{05}	*1,23*	

Other types of weeds were few in number, their number ranged from 0.1 to 0.9 plants per m^2.

It is worth noting that the level of weed infestation of winter rye crops significantly depended on the weather conditions of the growing season, in particular on the amount of productive moisture. Under conditions of unstable moisture in 2022–2024, all types of weeds, both annual and perennial, showed moderate growth and development. At the same time, weeds remained in the lower tier of crops and were well suppressed by winter rye plants, which reduced their danger to the crop. Correlation and regression analysis revealed a close inverse relationship between the level of grain yield and the number of weeds in winter rye crops (Table 4).

Table 4. Influence of weediness on grain yield of winter rye

	r	Rxy	Dxy
winter rye	-0,75	0,036	18,7

R – correlation coefficient; Rxy – regression coefficient; Dxy – determination coefficient.

Thus, as the level of weed infestation increases, there is a direct correlation with a decrease in yield (r= -0.75). When the number of weeds exceeds the economic threshold of harmfulness, according to the regression coefficient, grain yield decreases by 3.5 kg/ha per weed species. The coefficient of determination (Dxy) shows the proportion (%) of the change in winter rye grain yield that

depends on the weediness of the crops. Thus, 18.7 % of grain yield fluctuations can be explained by changes in weed infestation.

Conclusion. Climate change significantly disrupts the processes of self-regulation in winter rye agrocenoses, which leads to an increase in the level of weeds and disruption of ecological balance, resulting in significant losses of grain yields of this crop. The application of an ecological and geographical approach allowed us to determine the species composition of weeds in winter rye crops, taking into account their habitats. Among the numerous weed species in the agrocenoses of winter rye, the following dominated: *Convolvulus arvensis* L. (20 %), *Sonchus arvensis* L. (17 %) and *Centaurea cyanus* (All.) Dost. (16 %). Studies have shown that when the economic threshold of harmfulness is exceeded, especially for perennial weeds, grain yields decrease by 3.5 kg/ha per weed species. Thus, 18.7 % of grain yield fluctuations are associated with changes in the level of weed infestation. The main prerequisite for increasing the productivity and quality of winter rye grain products, as well as reducing biological contamination of agroecosystems by harmful organisms, is the development and improvement of environmentally safe protection systems based on a rational combination of organisational and economic, agrotechnical, immunological, biological and other methods, taking into account the environmental situation and cultivation technologies. Prospects for further research will focus on improving and substantiating environmentally friendly systems of winter rye protection against the spread of segetal vegetation.

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