**UDC 632.954:633.15 (477.44)**
**DOI:** 10.37128/2707-5826-2025-4-12

# ASSESSMENT OF WEED INFESTATION OF CORN CROPS DEPENDING ON HERBICIDE PROTECTION IN THE VINNYTSIA REGION

***NINA RUDSKA***, *candidate of Agricultural Sciences, Associate Professor,*
***OLEG KOLISNYK***, *candidate of Agricultural Sciences, Associate Professor, Vinnytsia National Agrarian University*

*This article presents the results of research aimed at improving the key elements of weed control in corn crops. Optimal tank mixtures and combinations of modern pre-emergence and post-emergence herbicides were identified.*

*It was established that a mixed type of weed infestation is formed in the maize agrocenosis, with late spring weeds dominating the structure and accounting for 70,6%. The share of overwintering species was significantly lower (12,8%), followed by early spring weeds (7,6%) and ephemeral species (5,2%). The proportion of perennial weeds was insignificant and represented by root-suckering species (2,1%), rhizomatous species (0,8%), fibrous-rooted species (0,6%), and tap-rooted species (0,4%). The highest emergence of weed seedlings was observed during the period from May 30 to June 20. The highest technical efficiency of weed control (97,5–99,7%) was achieved by combining pre-emergence and post-emergence herbicides in the following system: Frontier Optima (1,2 l/ha (applied before sowing) + Stellar – 1,25 l /ha in combination with the adjuvant Metolat – 1,25 l /ha (applied at the crop emergence stage).*

*To limit weed development, the most effective were protection systems that combined soil and foliar action, in particular: Stellar – 0,8 l/ha* **+** *Frontier Optima (0,8 l /ha + Metolat adjuvant – 0,8 l /ha, as well as Kelvin Plus – 0,3 kg/ha* **+** *Frontier Optima (***–** *0,8 l /ha in combination with the adjuvant Hasten – 1,0 l /ha***.** *The highest grain yield of maize–8,02–7,85 t/ha–was obtained with the combined use of soil-applied and post-emergence herbicides***:** *Frontier Optima (pre-sowing) + Kelvin Plus with the adjuvant Hasten (post-emergence) and Double Try (pre-sowing) + Stellar with the adjuvant Metolat (post-emergence)***.** *Under these treatments, the preserved yield amounted to 3,62–3,79 t/ha, whereas in the control it was 4,23 t/ha***.** *Among the mixtures of post-emergence herbicides, the treatment : Frontier Optima* **+** *Stellar + Metolat was distinguished, providing a yield of 7,69 t/ha***.** *With the autonomous application of Stellar and Kelvin Plus, grain yield reached 7,49 t/ha and 7,69 t/ha***,** *respectively.*

***Keywords:*** *corn, weed infestation of crops, green mass, soil and protective herbicides, technical efficiency, 1000-seed weight, yield.*

***Table 4. Fig 1. Lit. 15.***

**Introduction.** Corn is one of the major cereal crops in the world. It ranks first in terms of gross grain yield and is second only to wheat in terms of area sown. Corn is used as a major crop for food, feed, and industrial purposes, playing a significant role in global agricultural production. The area under maize cultivation exceeds 140 million hectares, which is approximately 20% of the total area allocated to cereal crops. At the same time, gross maize grain production accounts for about 30% of total world grain production. This crop is used not only for food and feed, but also for the production of bioethanol and electricity. Its versatility and high productivity make maize a strategically important crop for ensuring food security and supporting the development of the agro-industrial sector [4, 7].

Corn, as one of the most high-yielding crops in modern agriculture, is characterized by high competitiveness due to its versatile use, stable demand, and significant export potential. However, its productivity can be substantially reduced by infestation of crops with segetal (weed) vegetation. Competition for light, water, and nutrients between cultivated plants and weeds can lead to a decrease in maize yield by 50–60% [2].

In the corn agrocenosis, weed density control is one of the limiting factors for achieving high grain yield and quality. The implementation of an integrated crop protection system, which combines agronomic, chemical, and biological methods, ensures effective weed management. Herbicides occupy a significant role in this system, as their selective action against weeds allows for the preservation of the cultivated crop and optimization of its growth and development conditions.

However, the main requirement is the use of low safety class preparations (III–IV classes), which reduces their negative impact on the ecosystem, microflora and human health. For corn, herbicides with high selectivity, short half-life and low phytotoxicity are recommended [10].

Therefore, the relevance of a modern approach to agroecosystem management, aimed at reducing the negative impact of herbicides on the natural environment and increasing the efficiency of their use, is increasing. Optimization of herbicide application rates and the creation of tank mixtures allows reducing chemical loads and contributes to the preservation of fertility and biologization of the agrocenosis.

In addition, such measures are aimed at improving the competitiveness of crops, which is an important aspect of low-impact farming systems. This is an approach that takes into account the interaction of components of agrocenoses adapted to climate change and modern challenges in the field of sustainable agriculture.

**Analysis of recent research and publications.** In Ukraine, the problem of weeds in agriculture is extremely urgent. Annual crop losses due to weed infestation of crops, in particular, a decrease in gross grain yields, can reach millions of tons, which causes significant economic losses. Weeds not only significantly reduce crop yields, but also negatively affect the quality of products, deplete soils and reduce their fertility.

Weeds are a significant threat to crops, as they compete intensively with them for basic resources – moisture, nutrients and light. In the first half of the growing season, weeds are characterized by high intensity of growth and development, as a result of which they absorb a significant amount of soil moisture. This leads to a shortage of available water for cultivated plants, especially during critical growth phases in the summer months – July and August, which negatively affects the formation of crops, in particular corn. Highly developed above-ground organs of weeds create significant shading of crops, which leads to a decrease in the intensity of photosynthesis in cultivated plants due to the limitation of carbon dioxide absorption. Additional shading causes a decrease in soil temperature by 1,5–4,0 °C, which, in turn, slows down the growth and development of the crop. Weeds are also characterized by a powerful and deeply penetrating root system, which provides more efficient absorption of nutrients and moisture from deeper soil layers, limiting their availability to crops. The combined effect of these factors leads to a significant decrease in the yield of cultivated plants [3, 5].

Weeds can cause significant damage to crops by competing for nutrients. The strong root systems of some weeds, such as common oats, creeping wheatgrass, and field thistle, enable them to absorb significantly more nutrients from the soil, significantly reducing their availability to crops. In the process of competition, weeds can extract 2–3 times more nutrients from the soil than cultivated plants, making it difficult for them to provide full mineral nutrition. According to research, with 100–150 weeds per 1 m², up to 100 kg/ha of nitrogen, 40–50 kg/ha of phosphorus and up to 120 kg/ha of potassium can be lost from the soil. At the same time, corn absorbs more than 400 kg/ha of nutrients from the soil to form a grain yield of 100 c/ha [6].

In corn crops, a wide range of weeds is formed that actively compete with the crop. Due to the morphological features of corn, it does not create favorable conditions for the development of highly specialized weeds, but among all the diversity, the most harmful are species whose biological cycle coincides with the main phases of crop development. The structure of the weed group is dominated by annual cereal species – *Echinochloa crus-galli* and *Setaria glauca*, as well as annual dicotyledons – *Chenopodium album, Amaranthus retroflexus, Barbarea vulgaris, Galium aparine*. Of the perennial dicotyledonous weeds, the most common are *Cirsium arvense* and *Convolvulus arvensis* [5].

Weeds are strong competitors for limited soil moisture because they are characterized by a high transpiration coefficient. For example, the formation of 1 kg of dry matter requires 800–900 L of water in *Chenopodium album*, up to 1000 L in *Avena fatua*, *Thlaspi arvense*, and *Cirsium arvense*, and 1180–1683 L in *Elytrigia repens*. In contrast, corn requires only 250–300 L of water to produce 1 kg of dry matter [8].

Competition between weeds and crops significantly reduces corn yield. Total grain yield losses in the presence of weeds, depending on soil and climatic conditions and the level of weed infestation of crops, can be 25–40%, and in some cases up to 70–80%. The impact of individual weed species is different: the constant presence of one *Cirsium arvense* L. plant per 1 m² during the growing season causes a decrease in corn yield by 1 c/ha; *Setaria pumila* – by 0,50 c/ha; weed infestation of crops with *Amaranthus retroflexus* L and *Chenopodium album* L. leads to yield losses of 0,50–0,60 c/ha [8, 10].

Perennial weeds, in particular *Cirsium arvense* and *Convolvulus arvensis*, create significant competition for moisture, nutrients and light. With a high degree of weed infestation, corn yield can be reduced by 50–55%. In the case of accumulation of weed mass of more than 5 kg/m² in the Forest-Steppe zone, corn may not form generative organs at all, in particular ears. Weeds, especially perennial species, are characterized by high resource efficiency, significantly limiting their availability to cultivated plants. In addition, they are able to slow down the growth and development of corn, which negatively affects the formation of the crop and grain quality.

According to the results of the research, the leaf area of weeds in the phase of formation of the third leaf of corn can reach 1329,7 $cm^2/m^2$, which is 2,8 times higher than the leaf surface of cultivated plants. This indicates a significant competitive advantage of weeds in the early stages of corn organogenesis, as a result of which plant growth is suppressed and their productivity level is reduced. In this regard, the timely application of effective weed control measures, in particular chemical and mechanical protection, is a necessary condition for ensuring normal growth and development of corn and the formation of high productivity [9].

In addition, as the leaf surface increases, weeds form more powerful defense systems, in particular, they accumulate reserves of energy stored in organic matter; synthesize protein compounds and enzyme systems capable of inactivating and destroying the active ingredients of herbicides; and also form a layer of epicuticular hairs, which complicates the penetration of active ingredients into the tissues and vascular systems of plants.

A significant proportion of weed species exhibit inhibitory properties due to their ability to release biologically active substances into the soil–namely allelopathic compounds–that negatively affect the growth and development of cultivated plants. In particular, it has been established that *Elytrigia repens*, *Acroptilon repens* (L.) DC., as well as various species of Artemisia, significantly suppress the growth and development of most agricultural crops [10].

According to Ivashchenko O. O. et al. [2] it was found that weeds, compared to field crops, germinate earlier, are characterized by more intensive growth, higher drought and frost resistance, survive the winter better and have a high reproduction rate. The same researchers determined that the soil contains a significant number of seeds of various weed species, which are able to maintain viability for many years and even decades, without losing germination. In addition, it is known that weeds are reserves of many pests and pathogens of agricultural crops.

In modern agriculture, especially under conditions of intensification of production, traditional agrotechnical measures of weed control often turn out to be insufficiently effective. In this regard, chemical methods of crop protection are increasingly used, in particular the use of herbicides. According to V.S. Zuza, in areas without the use of herbicides, the density of the weed component is 116–144 pcs./$m^2$, while the use of herbicides provides a reduction in the number and fresh weight of weeds by 76–90% [1].

The rational use of herbicides determines the importance of a balanced approach to modern agricultural technologies. Their use contributes to a significant increase in the efficiency of weed control and provides economic benefits, in particular, reducing the cost of mechanical tillage and saving fuel and lubricants. At the same time, in order to maintain ecological balance, the use of herbicides should be carried out strictly in accordance with scientifically based recommendations, which allows limiting their negative impact on the natural environment.

To protect corn crops from weeds, both pre-emergence soil-acting herbicides and post-emergence herbicides are applied. It is advisable to select plant protection products with a wide spectrum of action, targeting both monocotyledonous (grasses) and dicotyledonous (broadleaf) weeds. Pre-emergence (soil) herbicides are applied before the emergence of corn seedlings and are aimed at preventing weed germination and early growth. The most commonly used soil herbicides include: Harness, k. e. (1,5–3,0 l/ha); Trofi 90 EC, k. e. (2,0–2,5 l/ha); Dual Gold 960 EC (1,0–1,6 l/ha); Adengo 465 SC, KS (0,35–0,5 l/ha); Frontier Optima, KE (0,8–1,4 l/ha); Acenit-A 880, k. e. (2–2,5 l/ha); Primextra TZ Gold 500 SC, k. s. (4,0–4,5 l/ha); +Primekstra Gold 720 SC, k. s. (2,5–3,5 l/ha). The last two drugs can be used not only in the pre-emergence period, but also in the phase of crop development with three to five leaves [11].

In the 1–7 leaf phase, against annual and perennial cereal and dicotyledonous corn weeds, it is recommended to use the herbicides Basis 75, VG + Surfactant Trend (20–25 g/ha + 0,2 l/ha); Titus 25, v. g. + Surfactant Trend (40–50 g/ha + 0.2 l/ha); MaisTer 62 WG, v. g. (150 g/ha), etc [12].

When the crop reaches the 3–10 leaf stage, when annual cereal weeds and perennial cereal wild plants dominate the crop, Milagro 040 SC, c. s. are effective. (1,0–1,25 l/ha); Milano, KC (1,0–1,25 l/ha); Samson Extra 6 OD, o. d. (0,75–1,0 l/ha).

In the corn agrocenosis, the use of herbicides in tank mixtures can significantly increase their effectiveness. When herbicides are used in combined mixtures, they can act more synergistically, that is, enhance each other's effects. This makes it possible to obtain better results even at reduced doses.

However, herbicides can have a negative impact on corn plants. It has been found that dicamba and dichlorophenoxyacetic acid can disrupt the balance of natural plant hormones – auxins, cytokinins and gibberellins. Hormonal imbalance leads to uncontrolled cell division, damage to chloroplasts, cell membranes and vascular tissues of the plant.

The active ingredient mesotrione, widely used in corn cultivation, inhibits the synthesis of carotenoids, pigments essential for the proper functioning and stability of chlorophyll in plants. Mesotrione is effective against both monocotyledonous and dicotyledonous weeds**,** reducing their density in crops and creating optimal conditions for the growth and development of the main crop. However, exceeding the recommended application rates or applying the herbicide under unfavorable environmental conditions may result in phytotoxic effects on cultivated plants, leading to slowed growth or even complete cessation of development due to disruption of photosynthetic processes [12].

Thus, although the use of herbicides may cause a temporary phytotoxic effect on corn plants, the correct selection of the hybrid and adherence to the optimal timing of drug application are crucial, which makes it possible to reduce their negative impact on the formation of corn productivity.

Therefore, protecting corn crops from weeds by using chemicals is the most effective and reliable way to reduce crop losses.

**The purpose of this article** is to develop and optimize a system of weed control measures in corn crops for grain.

**Analysis of recent research and publications.** The research was conducted in corn crops under the conditions of the Educational and Scientific Institute of Agrotechnology and Environmental Management of the Vinnytsia Region using generally accepted methods in herbology [13].

*Accounting and observations*. In addition to the sowing date (last decade of April), the onset of the following phenological phases of plant development was noted: seedlings; phases 3–5 and 8–10 leaves; flowering of panicles; appearance of female inflorescences (threads); milky ripeness of grain; waxy and full ripeness of grain. The beginning of a phase was recorded when 10% of plants were in the corresponding phase, mass onset – when 75% of plants reached it.

The determination of above-ground weed infestation in corn crops was carried out by counting the number and determining the species composition of weeds. The counting was usually carried out before the application of preventive herbicides by counting the number and identifying the species of weeds in the 0,25 $m^2$ plots. For this purpose, four replicates were established on the experimental plot, placed diagonally across the field [13].

Weed accounting were repeated 20 days after herbicide application to assess their biological effectiveness. Before harvest, a final weed monitoring was performed with simultaneous weed removal to determine the fresh weight. The data obtained allowed us to assess the overall impact of the herbicides on weed growth and development, as well as their indirect impact on corn yield.

Weeds are counted within the plot by biological groups (annual grasses, annual dicotyledons, perennial dicotyledons) with subsequent weighing in a wet and air-dry state. The measuring tape is placed in the center of the row.

The formation of plant density at the level of 50 thousand plants/ha was carried out before the application of insurance herbicides or inter-row cultivation. At the same time, the actual plant density was calculated in all variants and repetitions of the experiment and, if necessary, it was adjusted. Before harvesting, a repeated (final) count of the number of corn plants in the accounting plots was performed [13].

Field research. The improvement of the weed control system in grain corn crops was investigated in a single-factor experiment. Winter wheat was used as the preceding crop.

In the experiment, during the years of research, a mid-season high-yielding hybrid of corn hybrid DKC 3730 is a mid-early hybrid corn of the FAO 280 maturity group from the manufacturer DEKALB Bayer (formerly Monsanto).

Sowing was carried out with a Massey Ferguson MF 555 direct seed drill, aggregated with a Challenger 8122 tractor to a depth of 4–5 cm. The seeding density was 80–83 thousand pcs./ha. Fertilizers were applied at the rate of $N_{100}P_{70}K_{70}$ for early spring cultivation by evenly spreading over the surface. When sowing, $N_{20}P_{20}K_{20}$ was applied.

The experiment was single-factorial, the area of the plot was 25 $m^2$, the repetition was threefold, the placement of variants was randomized. The study was conducted according to the «Methodology of testing and application of pesticides» by S. O. Tribel, 2001 [14].

The weed protection system provided for the use of herbicides with different mechanisms of action according to the list of pesticides and agrochemicals permitted for use in Ukraine [15] (Table 1.).

*Table 1*

**Scheme of an experiment to evaluate the effectiveness of herbicides for spraying corn crops**

| № p/p | Variant | |
|---|---|---|
| | Pre-emergence herbicides | Post-emergence herbicides |
| 1 | Control | |
| 2 | Double Tri k.e. (metolachlor, 960 g/l), 1,3 l/ha | Stellar, (topramesone, 50 g/l + dicamba, 160 g/l), 1,25 l/ha + Surfactant Metolate, 1,25 l/ha |
| 3 | Frontier Optima (dimethenamid-P, 720 г/л), 1,2 l/ha | Kelvin Plus, v.g. (dicamba, 424 g/kg + diflufenzopyr, 170 g/kg + nicosulfuron, 106 g/kg), 0,35 kg/ha + surfactant Hasten, 1,0 l/ha |
| 4 | - | Stellar, 1,25 l/ha + Surfactant Metolate, 1,25 l/ha |
| 5 | – | Kelvin Plus, 0,35 kg/ha + hasten surfactant, 1.0 l/ha |
| 6 | – | Stellar, 0,8 l/ha + Frontier Optima, 0,8 l/ha + Surfactant Metolate, 0,8 l/ha |
| 7 | – | Kelvin Plus, 0,3 kg/ha + Frontier Optima, 0,8 l/ha + Surfactant Hasten, 1,0 l/ha |

**Note: Pre-emergence herbicides were applied the day after sowing, pre-sowing, post-emergence herbicides were applied in the 3-5 leaf phase of the crop.*

*Source: based on own research*

The technical effectiveness of the drugs is assessed by their ability to destroy weeds or suppress their growth processes at certain stages of ontogenesis and is determined by the formula 1:

$$Eg = 100 \times (h1-h2) : h1\ (\%),\ where\ (1)$$

h1 – the number of weeds in the control (without treatment), pcs./$m^2$;

h2 – the number of weeds in the experimental variant after applying the herbicide (20–25 days after application), (pcs./$m^2$) [15].

As a result of the obtained data on the average mass and density of corn plants, as well as the mass of weeds, the total biomass of the agrocenosis is calculated per 1 ha or 1 $m^2$ of sowing. These indicators are determined during the period of recording the weediness of crops and are used to assess the thresholds of weed damage [14].

The main structural elements of crop productivity (grain size, ear length, 1000-seed weight) were determined in accordance with generally accepted methodological recommendations.

Harvest accounting grain yield was recorded at the full ripeness stage by continuous harvesting of the accounting plots, with adjustment to 100% purity and standard moisture content (14%), separately for each treatment in all replications and also to determine the percentage of grain yield and its structural elements.

Calculations of economic efficiency assessment are carried out according to generally accepted methods and are processed using the Microsoft Excel computer program using the analysis of variance method.

**Research results.** In corn crops, where it is practically impossible to carry out phytocenotic weed control due to the limited ability to manipulate plant communities, a problem of particular importance arises. An important aspect is that weed growth in such systems can lead to reduced yields and requires improved control methods, such as the use of specialized herbicides, mechanical measures, or integrated approaches to weed management [12].

This issue really needs to be studied in detail, especially in experimental research settings, where the effectiveness of different weed control methods and the reduction of the negative consequences of weed infestation can be investigated in more detail. Such studies can help in the development of innovative technologies and strategies that will combine economic benefits with maximum conservation.

According to the results of the research, it was established that in the conditions of the Educational and Scientific Institute of Agrotechnology and Environmental Management VNAU during 2024–2025, a mixed type of weed infestation is formed in corn crops for grain, under the specified conditions, where both cereal and dicotyledonous weeds are represented. Grassy weeds were represented by the following species: *Echinochloa crus-galli* (L.) P. Beauv., *Setaria glauca* L., and *Elytrigia repens* (L.) Desv. Among dicotyledonous weeds, the following species were identified: *Galinsoga parviflora* Cav., *Plantago lanceolata* L., *Plantago major* L., *Viola arvensis* Murray, *Thlaspi arvense* L., *Matricaria perforata* Mérat., *Capsella bursa-pastoris* (L.) Medik., *Stellaria media* (L.) Vill., *Amaranthus retroflexus* L., *Chenopodium album* L., *Cirsium arvense* (L.) Scop., *Sonchus arvensis* L., *Artemisia vulgaris* L., and *Convolvulus arvensis* L.

According to the research results, late spring weed species predominated in corn crops, accounting for 70,4% of the total weed population observed during the crop growing season. The dominant species included *Echinochloa crus-galli* (L.) Roem. (18,1%) and *Setaria glauca* L. (30,4%). Among dicotyledonous weeds, *Galinsoga parviflora* Cav. (16,4%) and *Amaranthus retroflexus* L. (6,4%) were recorded. (Fig. 1).

Early spring weeds accounted for 7,8% of the total weed infestation, including *Chenopodium album* L. (7,5%) and *Polygonum convolvulus* L. (0,3%). Among overwintering weed species, the following were recorded: *Capsella bursa-pastoris* (L.) Medik. (3,7%), *Matricaria perforata* Mérat. (3,2%), *Thlaspi arvense* L. (2,6%), and *Viola arvensis* Murray (2,0%). Ephemeral weeds were represented by *Stellaria media* (L.) Vill., accounting for 5,4%.

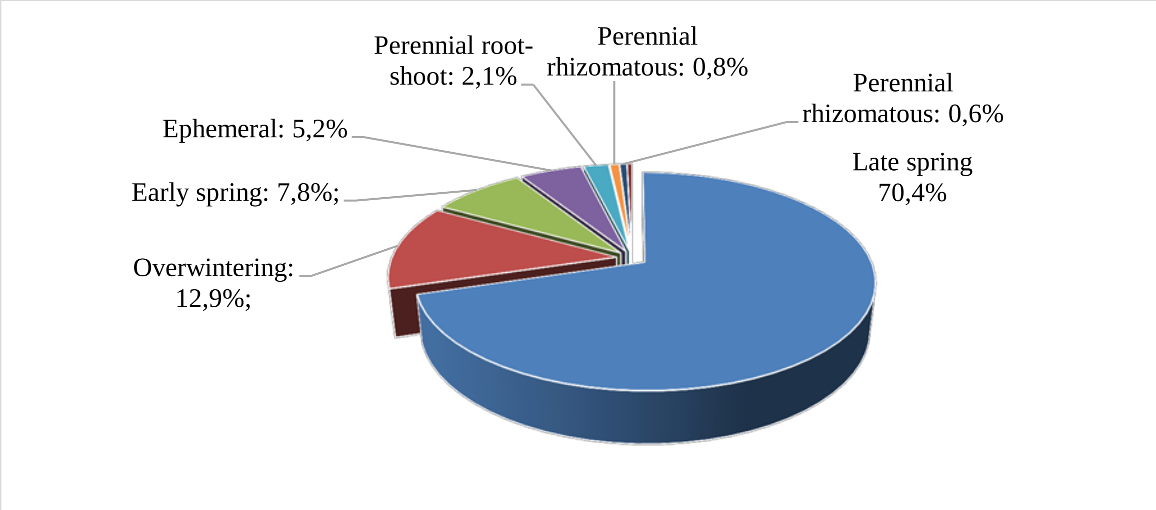


Fig. 1. The ratio of weeds in corn crops for grain the conditions of Educational and Scientific Institute of Agrotechnology and Environmental Management VNAU: 1– Late spring: 70,4%; 2 – Overwintering: 12,9%; 3 – Early spring: 7,8%; 4 – Ephemeral: 5,2%; 5 – Perennial root-shoot: 2,1%; 6 – Perennial rhizomatous: 0,8%; 7 – Perennial rhizomatous: 0,6%; 8 – Perennial taproot: 0,4%.

*source: formed on the basis of own research*

In the crops, perennial rhizomatous weeds were also recorded, including *Cirsium arvense* (L.) Scop. (0,8%), *Sonchus arvensis* L. (0,2%), and *Convolvulus arvensis* L. (1,4%), as well as the perennial rhizomatous grass weed *Elytrigia repens* (L.) Nevski (0,7%). A small share of the weed species composition was represented by perennial taproot weeds, namely *Artemisia vulgaris* L. (0,2%) and *Plantago lanceolata* L. (0,1%), while perennial rosette weeds were represented by *Plantago major* L. (0,1%).

Thus, it was established that the corn agrocenosis exhibits a mixed type of weed infestation, with the largest share represented by late-spring species such as chickweed, bluegrass, small-flowered galinsoga, white quinoa, and common schiritsa. The main number of weeds appears during the period 30.05–20.06.

Weed infestation in corn crops is a major challenge that significantly reduces both yield and product quality. Therefore, implementing an effective weed management system using herbicides is essential. Herbicides not only minimize competition from weeds for moisture, nutrients, and light, but also help optimize the costs associated with manual or mechanical weed control. Their application enables the adoption of energy- and resource-efficient technologies for corn cultivation, which is critical for modern agricultural production.

A systematic approach using reliable chemical formulations ensures effective weed control while minimizing adverse effects on both the crop and the environment. The use of herbicides is an essential component of modern cultivation technology for this crop. Chemical treatments make it possible to significantly reduce disparities in growth and yield, supporting energy- and resource-saving practices.

The research results indicate that the use of soil herbicides is most effective during the early stages of corn development. Specifically, applying these herbicides at the beginning of the growing season, in the 3–5 leaf stage, provides a high level of weed control. The low weed density observed in the crops (4,2–5,8 plants/m²) on the 30th day after treatment can be attributed to the favorable hydrothermal conditions in April–May, which promoted uniform weed germination and enhanced herbicide efficacy. These findings confirm that selecting the optimal timing for herbicide application, with consideration of prevailing weather conditions, is a critical factor for achieving high weed control efficiency in corn crops.

In the second decade of April, before sowing corn, a significant amount of precipitation fell, which provided the possibility of the drugs entering the moist soil during pre-sowing cultivation of the field. As is known, the optimal conditions for the effective action of soil herbicides are moderately warm weather with an air temperature of 15–20 °C and soil humidity of more than 20%. Wet soil is a necessary factor in the manifestation of phytotoxicity of herbicides of the chloroacetamide group (Double Tri, Akris), since their active substances are active exclusively in the soil solution.

It should be noted that among the studied soil herbicides, the highest efficiency in controlling weeds, in particular annual grasses, was provided by the use of the drug Frontier Optima at a rate of 1,2 l/ha, which includes the active ingredient dimethenamid-P. Its solubility is 3–5 times higher than that of S-metolachlor (the drug Double Tri), which causes higher mobility of the active ingredient in the soil and its greater availability to weed seedlings.

In corn crops, the weediness of the corn agrocenosis was characterized by a variegated species composition of weeds with a high overall level of weediness (108,2–156,4 pcs./m²). In the corn agrocenosis, late spring species *Echinochloa crus-galli* (L.) Roem. – 18,1%, *Setaria glauca* L. – 30,4% prevailed, among dicotyledons were found: *Galinsoga parviflora* Ca v. – 16,4%, *Amaranthus retroflexus* L. – 6,4%.

Early spring weeds accounted for 7,8% of the total weed infestation, including *Chenopodium album* L. (7,5%) and *Polygonum convolvulus* L. (0,3%). Among overwintering weed species, the following were recorded: *Capsella bursa-pastoris* (L.) Medik. (3,7%), *Matricaria perforata* Mérat. (3,2%), *Thlaspi arvense* L. (2,6%), and *Viola arvensis* Murray (2,0%). Ephemeral weeds were represented by *Stellaria media* (L.) Vill., accounting for 5,4%.

In the crops, perennial rhizomatous weeds were also recorded, including *Cirsium arvense* (L.) Scop. (0,8%), *Sonchus arvensis* L. (0,2%), and *Convolvulus arvensis* L. (1,4%), as well as the perennial rhizomatous grass weed *Elytrigia repens* (L.) Nevski (0,7%). A small share of the weed species composition was represented by perennial taproot weeds, namely *Artemisia vulgaris* L. (0,2%) and *Plantago lanceolata* L. (0,1%), while perennial rosette weeds were represented by *Plantago major* L. (0,1%).

Records conducted on the 21st day after spraying with post-emergence preparations showed that the largest number of weeds was destroyed when using a protection system that combined soil and preventive herbicides, in the following sequence: 1. Double Tri – 1,3 l/ha (before sowing) + Stellar – 1,25 l/ha + surfactant Metolat – 1,25 l/ha (after emergence); 2. Frontier Optima – 1,2 l/ha (before sowing) + Kelvin Plus – 0,35 kg/ha + surfactant Hasten – 1 l/ha (after emergence). The technical efficiency of these preparations against all weeds reached 97,5–99,7% (Table 2).

*Table 2*

**The effectiveness of herbicide use in weed control of corn crops**

| Variant | Weed accounting periods | | | | Technical efficiency of herbicides (first wave of weeds), % |
|---|---|---|---|---|---|
| | before applying post-emergence herbicides, (pcs./m$^2$) | 21 days after application of post-emergence herbicides, (pcs/m$^2$) | phase of full grain ripeness | | |
| | | | pcs/m$^2$ | g/m$^2$ | |
| Control | 108,2 | 180,2 | 188,4 | 978,3 | – |
| Soil and post-emergence herbicides | | | | | |
| Double Try – 1,3 l/ha + Stellar – 1,25 l/ha + Surfactant Metolate – 1,25 l/ha | 4,2 | 0,1 | 8,2 | 34,8 | 97,5 |
| Frontier Optima – 1,2 l/ha + Kelvin Plus – 0,35 kg/ha + Surfactant Hasten – 1 l/ha | 5,8 | 0,08 | 5,0 | 50,7 | 99,7 |
| Post-emergence herbicides | | | | | |
| Stellar – 1,25 l/ha + Surfactant Metolate – 1,25 l/ha | 156,4 | 15,7 | 20,1 | 88,6 | 90,4 |
| Kelvin Plus – 0,35 kg/ha + Hasten surfactant – 1 l/ha | 155,2 | 19,5 | 24,2 | 95,2 | 88,2 |
| Post-emergence herbicide mixtures | | | | | |
| Stellar – 0,8 l/ha + Frontier Optima – 0,8 l/ha + surfactant Metolate – 0,8 l/ha | 148,3 | 8,6 | 13,1 | 60,6 | 94,2 |
| Kelvin Plus – 0,3 kg/ha + Frontier Optima – 0,8 l/ha + Surfactant Hasten – 1 l/ha | 139,3 | 13,2 | 16,2 | 71,2 | 90,1 |

*source: formed on the basis of own research*

The lowest efficiency was provided by the preparations Stellar – 1,25 l/ha + surfactant Metolat – 1,25 l/ha and Kelvin Plus – 0,35 kg/ha + surfactant Hasten – 1,0 l/ha, the technical efficiency was 90,4% and 88,2%, respectively.

Among the research combinations, it should be noted the use of the following preparations: Frontier Optima – 1,2 l/ha (for pre-sowing cultivation) + Kelvin Plus – 0,35 kg/ha + surfactant Hasten – 1 l/ha (in the phase of 3–5 leaves of corn).

The accounting carried out in the phases of full maturity (before harvesting corn) showed that the weed infestation of crops in this variant was – 8,2 pcs./m$^2$ with a mass of 34,8 g/cm$^2$. The advantage of this variant lies in the synergy of chemical products that differ in their mechanism of action, duration of exposure and phytotoxicity. A change in the species composition of weeds was also noted, with a predominance of cereal annuals – 50,7%.

It should be noted that during the study period, cultivated plants demonstrated a significant competitive advantage over secondary (late-emerging) weeds. These weeds appeared later, by which time the cultivated crops had already developed a dense vegetative cover capable of effectively suppressing the growth of wild species. Consequently, the proportion of secondary weeds in the total biomass of the weed community remained minimal. This finding highlights the importance of ensuring optimal crop development during the early growth stages to promote natural weed suppression.

Therefore, the highest weed infestation of the corn agrocenosis was observed in the control (without treatment). At the time of full ripeness, their number of corn grains was 188,4 pcs./m$^2$, weight – 978,3 g/m$^2$, which is 7–28 times more than in other variants of the experiment with herbicides, respectively.

Herbicide treatment positively influenced the biometric parameters of maize, including cob length, the number of grains per cob, cob weight, and the weight of 1000 grains. The absolute values of these traits across the experimental variants ranged from 518 to 559 grains per cob and from 160 to 192 g for cob weight. The highest indicators were observed when using herbicides of soil and post-emergence action Frontier Optima – 1,2 l/ha (before sowing) + Kelvin Plus – 0,35 kg/ha + surfactant Hasten – 1 l/ha (after emergence) (Table 3).

*Table 3*

**Impact of herbicide use on corn yield structure, average 2024–2025**

| Variant | Length of the cob, cm | Number of grains per cob, pcs. | Mass of grain per cob, g | Weight of 1000 grains, g |
|---|---|---|---|---|
| Control | 16,2 | 369 | 82 | 198 |
| Soil and post-emergence herbicides | | | | |
| Double Try – 1,3 l/ha + Stellar – 1,25 l/ha + surfactant Metolate – 1,25 l/ha | 22,0 | 548 | 184 | 339 |
| Frontier Optima – 1,2 l/ha + Kelvin Plus – 0,35 kg/ha + surfactant Hasten – 1 l/ha | 22,2 | 559 | 192 | 349 |
| Post-emergence herbicides | | | | |
| Stellar – 1,25 l/ha + surfactant Metolate – 1,25 l/ha | 20,9 | 520 | 162 | 318 |
| Kelvin Plus – 0,35 kg/ha + Hasten surfactant – 1 l/ha | 20,4 | 518 | 160 | 314 |
| Post-emergence herbicide mixtures | | | | |
| Stellar – 0,8 l/ha + Frontier Optima – 0,8 1,5 l/ha + surfactant Metolate – 0,8 l/ha | 22,2 | 535 | 172 | 327 |
| Kelvin Plus – 0,3 kg/ha + Frontier Optima – 0,8 l/ha + surfactant Hasten – 1 l/ha | 21,5 | 528 | 164 | 319 |

*source: formed on the basis of own research*

The yield analysis showed that it was the highest in the variant with the use on a herbicide background from a combination of soil and insurance preparations and was 8,02–7,85 t/ha, and the retained yield was 3,62–3,79 t/ha against the control of 4,23 t/ha. The highest indicator was obtained when using herbicides Frontier Optima – 1,2 l/ha (for pre-sowing cultivation) + Kelvin Plus – 0,35 kg/ha + surfactant Hasten – 1,0 l/ha (phase of 3–5 leaves of the crop) and Double Tri – 1,3 l/ha (before sowing) + Stellar – 1,25 l/ha + surfactant Metolat – 1,25 l/ha (after emergence). When conducting research, it was noted that the influence of weather conditions under the combined system of chemical protection of corn best controlled the total number and mass of weeds.

A slightly lower corn yield was observed when applying a mixture of post-emergence herbicides Stellar (0,8 l/ha) and Frontier Optima – (0,8 l/ha) with the addition of the surfactant Metolat (0,8 l/ha). The synergistic interaction of these herbicides, which differ in both their mechanisms and durations of action, along with their phytotoxicity levels, provided effective weed control and resulted in a grain yield of 7,69 t/ha. This represents a saved yield of 3,46 t/ha compared to the untreated control.

It was noted that the lowest yield was obtained with the separate use of post-emergence herbicides Stellar and Kelvin Plus, which was inferior to their combined use in tank mixtures. The insufficient effectiveness of these drugs in weed control led to the formation of grain yield at the level of 7,49–7,69 t/ha.

*Table 4*

**Corn yield depending on herbicide treatment, average for 2024–2025**

| Variant | Yield, t/ha | Yield increase t/ha |
|---|---|---|
| Control | 4,23 | – |
| Soil and post-emergence herbicides | | |
| Double Try – 1,3 l/ha + Stellar – 1.25 l/ha + surfactant Metolate – 1,25 l/ha | 7,85 | 3,62 |
| Frontier Optima – 1,2 l/ha + Kelvin Plus – 0,35 kg/ha + surfactant Hasten – 1 l/ha | 8,02 | 3,79 |
| Post-emergence herbicides | | |
| Stellar – 1,25 l/ha + surfactant Metolate – 1,25 l/ha | 7,39 | 3,16 |
| Kelvin Plus – 0,35 kg/ha + Hasten surfactant – 1 l/ha | 7,29 | 3,06 |
| Post-emergence herbicide mixtures | | |
| Stellar – 0,8 l/ha + Frontier Optima -0,8 l/ha + surfactant Metolate – 0,8 l/ha | 7,69 | 3,46 |
| Kelvin Plus – 0,3 kg/ha + Frontier Optima -0,8 l/ha + surfactant Hasten – 1 l/ha | 7,49 | 3,26 |
| $LSD_{0,5}$ | 0,20 | – |

*source: formed on the basis of own research*

The results of the study indicated that corn yields increased over the years of observation. The highest yield, 8,02 t/ha, was recorded for the DKC 3730 hybrid (FAO 280) when treated with a combination of soil-applied and insurance herbicides, specifically Frontier Optima at 1,2 l/ha, in combination with Kelvin Plus (0,35 kg/ha) and the surfactant Hasten (1,0 l/ha). This treatment resulted in a yield increase of 3,79 t/ha compared to the untreated control.

**Conclusions.** Based on the results of research conducted at the of the National Scientific Research Center of the National Research Institute of Agricultural Sciences, the main elements and methods of controlling the development of weeds in corn crops have been developed. Optimal tank mixtures and combinations of modern soil and preventive herbicides have been established, which ensure effective control of weed infestation in crops. It is noted that in the corn agrocenosis a mixed type of weediness is formed, in the structure of which late spring weeds dominate, the share of which is 70,4%. The share of wintering species is significantly lower – 12,8%, early spring – 7,8% and ephemeral – 5,2%. The share of perennial weeds is insignificant and is represented by root-shoot (2,1%), rhizomatous (0.8%), rhizomatous (0,6%) and taproot species (0,4%). The largest mass of weed seedlings appears in the period from May 30 to June 20. The highest technical efficiency of weed control of 97,5–99,7% was achieved by combining soil and protective herbicides in the system: Frontier Optima – 0,8 l/ha (application before sowing) + Stellar – 1,25 l/ha in combination with the surfactant Metolat – 1,25 l/ha (application during crop growth). To limit the development of weeds, the most effective were protection systems that combine soil and vegetative action, in particular: Stellar – 0,8 l/ha + Frontier Optima – 0,8 l/ha + surfactant Metolat – 0,8 l/ha, as well as Kelvin Plus – 0,3 kg/ha + Frontier Optima – 0,8 l/ha in combination with the surfactant Hasten – 1,0 l/ha.

The highest corn grain yield – 8,02–7,85 t/ha – was obtained with a combination of soil and insurance herbicides: Frontier Optima (before sowing) + Kelvin Plus with surfactant Hasten (in seedlings) and Double Tri (before sowing) + Stellar with PAR Metolat (in seedlings). With these variants, the retained yield was 3,62–3,79 t/ha, while in the control – 4,23 t/ha. Among the post-emergence herbicide mixtures, the variant Frontier Optima + Stellar + surfactant Metolat was singled out, which provided a yield of 7,69 t/ha. With the autonomous use of Stellar and Kelvin Plus preparations, the grain yield was 7,49 t/ha and 7,69 t/ha, respectively.

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## *АНОТАЦІЯ*

## *ОЦІНКА ЗАБУР'ЯНЕНОСТІ ПОСІВІВ КУКУРУДЗИ ЗАЛЕЖНО ВІД ГЕРБІЦИДНОГО ЗАХИСТУ В УМОВАХ ВІННИЦЬКОЇ ОБЛАСТІ*

*У статті висвітлено результати досліджень, спрямованих на удосконалення основних елементів контролю розвитку бур'янів у посівах кукурудзи. Встановлено оптимальні бакові суміші та поєднання сучасних ґрунтових і страхових гербіцидів.*

*Відмічено, що в агроценозі кукурудзи формується змішаний тип забур'яненості, у структурі якого домінують пізні ярі бур'яни, частка яких становить 70,4 %. Значно меншою є участь зимуючих видів – 12,8 %, ранніх ярих – 7,8 % та ефемерів – 5,2 %. Частка багаторічних бур'янів є незначною і представлена коренепаростковими (2,1 %), кореневищними (0,8 %), коренемичкуватими (0,6 %) та стрижнекореневими видами (0,4 %). Найбільша маса сходів бур'янів з'являється у період з 30 травня по 20 червня.*

*Найвища технічна ефективність контролю бур'янів 97,5–99,7% була досягнута за умови поєднання ґрунтового та страхового гербіцидів у системі: Фронтьєр Оптіма – 0,8 л/га (внесення до сівби) + Стеллар – 1,25 л/га у поєднанні з ПАР Метолат – 1,25 л/га (внесення по сходах культури). Для обмеження розвитку бур'янів найбільш ефективними виявилися системи захисту, що поєднують ґрунтову та вегетативну дію, зокрема: Стеллар – 0,8 л/га + Фронтьєр Оптіма – 0,8 л/га + ПАР Метолат – 0,8 л/га, а також Кельвін Плюс – 0,3 кг/га + Фронтьєр Оптіма – 0,8 л/га у поєднанні з ПАР Хастен – 1,0 л/га.*

*Найвищу врожайність зерна кукурудзи* **–** *8,02–7,85 т/га – отримано за поєднання ґрунтових і страхових гербіцидів: Фронтьєр Оптіма (до сівби)* **+** *Кельвін Плюс із ПАР Хастен (по сходах) та Дабл Трай (до сівби) + Стеллар із ПАР Метолат (по сходах)***.** *За цих варіантів збережений урожай становив 3,62–3,79 т/га***,** *тоді як у контролі – 4,23 т/га***.** *Серед сумішей післясходових гербіцидів виокремлено варіант Фронтьєр Оптіма* **+** *Стеллар + ПАР Метолат***,** *який забезпечив урожайність 7,69 т/га***.** *За автономного застосування препаратів Стеллар і Кельвін Плюс урожайність зерна становила відповідно 7,49 т/га та 7,69 т/га***.**

***Ключові слова:*** *кукурудза, забур'яненість посівів,зелена маса, ґрунтові і страхові гербіциди, технічна ефективність, маса 1000 зерен, урожайність.*

***Табл. 4. Рис 1. Літ. 15.***

### Інформація про авторів

**Рудська Ніна Олександрівна** – кандидат сільськогосподарських наук, доцент кафедри ботаніки, генетики та захисту рослин Вінницького національного аграрного університету (21008, м. Вінниця, вул. Сонячна, 3, e-mail: nina.rudska@gmail.com, https://orcid.org/0000-0001-5771-407X).

**Колісник Олег Миколайович** − кандидат сільськогосподарських наук, доцент кафедри ботаніки, генетики та захисту рослин Вінницького національного аграрного університету (21008, м. Вінниця, вул. Сонячна, 3, e-mail: ooov@i.ua, https://orcid.org/0000-0002-1769-952X).

**Rudska Nina Oleksandrivna** – Candidate of Agricultural Sciences, Associate Professor of the Department of botany, genetics and plant protection, Vinnytsia National Agrarian University (21008, Vinnytsia, Soniachna Str. 3, e-mail: nina.rudska@gmail.com, https://orcid.org/0000-0001-5771-407X).

**Kolisnyk Oleg Mykolayovych** − Candidate of Agricultural Sciences, Associate Professor of the Department of Botany, Genetics and Plant Protection, Vinnytsia National Agrarian University (21008, Vinnytsia, Soniachna St. 3, e-mail: ooov@i.ua, https://orcid.org/0000-0002-1769-952X).

Надходження статті 21.10.25.
Прийнято 08.12.25.
Опубліковано 25.12.25.