

ANALYSIS OF THE EFFECTIVENESS OF THE CORN PROTECTION SYSTEM AGAINST HARMFUL ORGANISMS IN THE CONTEXT OF INCREASING PRODUCTIVITY, UNDER CONDITIONS OF ENVIRONMENTALLY BALANCED MANAGEMENT OF NATURAL RESOURCES

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ABSTRACT

The research was conducted under the conditions of LLC «Orhanik-D» using a medium-early maize hybrid, Orzhysia (FAO 240). During the 2024-2025 growing seasons, herbicide efficacy was generally high, ranging from 49 to 100%. The conducted studies revealed a close relationship between agronomic tillage methods, soil and climatic conditions, maturity group and biological characteristics of the hybrid, as well as the timing of herbicide application. Optimization of herbicide application increased the effectiveness of weed control and improved the structural elements of the corn grain yield and provided a statistically significant increase in yield. The lowest level of weed control efficiency (approximately 50%) was recorded for the soil-applied herbicide Harness, which was about 20% lower than that achieved with the post-emergence herbicide Prima TZ Gold applied at a rate of 4.0 l ha⁻¹. Complete weed control (100%) was obtained with Elumis at a rate of 1.8 l ha⁻¹. The highest maize grain yield (12.35 t ha⁻¹) was achieved in the treatment with the application of Maister Power at a rate of 1.3 l ha⁻¹, resulting in a yield increase of 6.05 t ha⁻¹ (96.0%) compared to the control. Elumis (1.8 l ha⁻¹) proved to be a viable alternative to Maister Power, ensuring a grain yield of 12.1 t ha⁻¹ and a yield increase of 5.80 t ha⁻¹ relative to the control. In contrast, the application of Harness (2.0 l ha⁻¹) and Prima TZ Gold (4.0 l ha⁻¹) within the maize cultivation technology was less effective, as the yield increase over the control was considerably lower, ranging from 2.65 to 3.35 t ha⁻¹ (42.1-53.2%).

Keywords: agrophytocenosis, weed infestation, herbicide, soil moisture, yield, green biomass, grain quality, nitrates

INTRODUCTION

Maize is a C4 crop, and its high grain and feed biomass yields have contributed to the expansion of the crop in many developing countries. However, the inappropriate and excessive use of chemical herbicides can have negative environmental impacts, including the accumulation of herbicide residues in the soil, the development of weed resistance, and the contamination of groundwater. Studies have shown that maize fields are typically home to about 25–30 species of annual and perennial weeds (Evans et al., 2003). Yield losses are mainly due to the increase in weed biomass, density, and species diversity (Blackshaw et al., 2002). Weeds are one of the main factors that hinder the efficient cultivation of crops. Structural and economic constraints have led to soil degradation and the proliferation of weeds, many of which are difficult to control (Farkas, 2006). Weeds can significantly reduce yields, with evidence suggesting that maize yield losses in the absence of weed control can be as high as 40–60% (Thobatsi, 2009). In modern conditions, weed control is carried out using advanced technologies that require in-depth knowledge of plants, soil characteristics, crop management systems, and environmental factors that affect weed control (Bolandi Amoghein et al., 2013). A key criterion for evaluating agricultural land management systems at the national or individual field level today is attention to weed control measures. This is because the damage from improper weed control can be greater than the damage from pests and diseases (Gupta, 2006).

Maize is typically cultivated with wide row spacing; therefore, during the early stages of growth it is unable to exert sufficient phytocenotic pressure on weeds and, consequently, cannot effectively compete with weed vegetation for light, space, moisture, and nutrients. Meanwhile, a lack of resources at the initial growth stages represents a serious constraint to the formation of high yield potential. Thus, in order to ensure optimal crop development at early stages, soil-applied weed control measures should not be neglected, as they constitute the foundation upon which subsequent crop protection treatments are built (Wang et al., 2019; Kolisnyk et al., 2020b; Kaletnik & Lutkovska, 2021; Silver et al., 2021; Lohosha et al., 2023; Tsurkan et al., 2023). Effective weed control in maize crops is considered one of the most pressing challenges for achieving high grain yields in 2025. Perennial root-sprouting weeds are regarded as particularly harmful to grain maize production. Yield losses of up to 40% have been reported under heavy infestation with field sow-thistle (*Cirsium arvense*). Therefore, specialists emphasize the need to create favorable conditions for strong and uniform crop emergence and to ensure reliable weed control in maize fields (Adamchuk et al., 2024; Sobko et al., 2024; Kolisnyk et al., 2025b).

Perennial root-sprouting species, including field bindweed (*Convolvulus arvensis*), significantly reduce the expected yield level. Maize itself exhibits relatively weak suppressive ability against weed infestation, while a substantial proportion of weeds emerge prior to crop establishment. In the Forest-Steppe zone, species such as spurge and ragweed dominate; in Polissia, wild radish, lamb's quarters, and wild mustard are widespread; whereas in the Steppe zone, barnyard grass, couch grass, sow-thistle, and pigweed prevail. These weed species substantially limit the normal growth and development of maize plants (Kolisnyk et al., 2020a; Rudska et al., 2023; Voytovyk et al., 2024; Kolisnyk et al., 2025a; Lys et al., 2025). The primary objective of the present study on maize crop management was to create optimal conditions for rapid and uniform crop establishment. Ensuring effective weed control is a key prerequisite for achieving stable and positive production outcomes.

Soil moisture is a critical factor for plant growth and development. Its availability determines plant growth and development, nutrient solubility and uptake, and the course of chemical, physicochemical, and biochemical processes in the soil that affect soil fertility, as well as the technological properties of soil during tillage operations. Weed infestation of field crops is an inevitable phenomenon under conditions of intensive agriculture, particularly when crop rotation requirements are not properly observed, which has become increasingly common in recent years. The main causes of high weed infestation in agricultural crops, including maize, are both the biological characteristics of weed species and insufficient implementation of preventive and control measures. Increased weed pressure is also associated with the adoption of soil-conservation tillage systems based on reduced tillage and non-moldboard implements. Since weeds compete directly with crops for soil moisture, it can be assumed that soil moisture content in highly infested plots is lower than in weed-free areas. The aim of this study was to evaluate the effectiveness of the herbicides Harness (2.0 l ha⁻¹), Primextra TZ Gold (4.0 l ha⁻¹), Elumis (1.8 l ha⁻¹), and MaisTer® Power (1.3 l ha⁻¹) in improving the grain yield of the maize hybrid Orzhysia. In particular, to adapt to climate change, especially under martial law, establish effective use of herbicides on corn crops for grain with maximum realization of the genetic potential of productivity and quality, stable resistance to adverse environmental factors.

MATERIAL AND METHODS

Studies on the quality of silage maize and the elements of its cultivation technology have been conducted during 2024–2025 under the conditions of LLC «Orhanik-D», Sutysky village, Vinnytsia region, Ukraine (Fig. 1). The experiments were carried out using a maize hybrid of a single maturity group, the medium-early hybrid Orzhysia (Originator – Institute of Grain Economy of NAAS, Poltava Institute of Agroindustrial Production named after M. I. Vavilov of NAAS of Ukraine). Simple modified corn hybrid High-tech hybrid, resistant to the process of crop thickening. It is distinguished by high resistance to stem brittleness. It has a high degree of resistance to lodging, does not have the property of bushing. It demonstrates high yield and low pre-harvest grain moisture. Recommended growing areas are Polissya, Forest-steppe, Steppe of Ukraine. Purpose – grain; Maturity group – medium early; Grain type – siliceous-toothed, orange-red; Average number of rows – 16-18; Number of grains in a row – up to 36. Plant height – 250-260 cm. FAO – 240; Weight of 1000 grains – 280–290 g; Grain yield potential – 11–12 t ha⁻¹; Resistance to diseases and stress factors: Drought resistance – 8; Resistance to lodging – 8. Cold resistance – 8; Main diseases – 8; Main pests – 8.



Figure 1. Geographic coordinates of the research site: latitude 49°03'00", longitude 28°25'12", 210.0 m above sea level (map date ©2025 Google).

The soil of the experimental site was a gray forest medium loam according to its texture, with a humus content (Tyurin method) of 1.5%, hydrolytic acidity of 1.3 mg-eq per 100 g of soil, sum of absorbed bases of 28 mg-eq per 100 g of soil, nitrogen content of 9.6 mg per 100 g of soil (Kornfield method), available phosphorus of 8.5 mg and exchangeable potassium of 11.4 mg per 100 g of soil (Chirikov method). Over the two years of our research, precipitation in March ranged between 35.0–35.5 mm per month. However, in 2025, March was 1.6 °C warmer than in 2024 (Table 1).

Table 1. Characteristics of weather conditions.

Months	2024		2025	
	Amount of precipitation, mm	Mean temperature, °C	Amount of precipitation, mm	Mean temperature, °C
January	71.6	-1.6	13.1	2.1
February	38.2	4.8	5.9	-3.6
March	35.5	5.2	35.0	6.8
April	84.5	12.2	24.4	10.3
May	22.9	15.8	192.2	12.5
June	80.0	21.1	19.7	19.4
July	57.2	23.5	103.6	21.7
August	32.6	22.2	42.0	19.2
September	30.7	18.8	72.6	16.1
October	43.7	9.7	67.8	8.3
November	46.3	2.5	x	x
December	49.0	0.6	x	x

During the entire maize growing season (April-September), total precipitation amounted to 307.9 mm in 2024 and 384.3 mm in 2025. However, its distribution across years and months was highly uneven. May 2024 was quite dry, with only 22.9 mm of rainfall. For table beet plants, insufficient May rains were partly compensated by June precipitation, but afterwards the plants still did not receive enough moisture. In 2025, weather conditions were also challenging regarding rainfalls: there was relatively dry April and June, and heavy precipitation in May and July. Soil moisture conditions were somewhat better in autumn. In 2025, during the months of the vegetation period, the temperature regime was 1.9–2.7 °C lower compared to 2024.

Field experiments were conducted in accordance with the Methodological recommendations for conducting field experiments to determine weed infestation and the effectiveness of weed control means in agrophytocenoses (Lebid et al., 2008a), Methods for conducting field experiments with corn (Lebid et al., 2008b), Methods for state variety testing of agricultural crops (Vovkodav, 2001). The actual soil moisture was determined by the thermostatic-gravimetric method, which meets the requirements of DSTU B V.2.1-17:2009 (Altukhova et al., 2010). Microsoft Excel and Statistica 6.0 programs were used to process the obtained statistical data (Ermantraut et al., 2007). The cultivation technology was generally accepted for this soil and climatic zone. Winter wheat was used as the preceding crop. Sowing was carried out from the third decade of April to the first decade of May using a precision seeder (John Deere) with a row spacing of 70 cm, forming a target plant density of 75000 plants per hectare. The primary tillage system included disking followed by moldboard plowing to a depth of 22-25 cm. The fertilization system involved the application of a bio-organic fertilizer based on digestate at a rate of 60 t ha⁻¹, obtained through anaerobic digestion of pig manure at a biogas plant. The experiment was arranged in a randomized complete block design with four replications. The total plot area was 25 m², while the accounting plot area was 10.5 m², consisting of four adjacent rows 5 m in length. The field experiments were established in accordance with the Methodological Recommendations for Conducting Field Research and were planned and conducted taking into account the stages of corn development (Malienko et al., 2017, 2020).

RESULTS AND DISCUSSION

The conducted studies revealed a close relationship between agronomic cultivation practices, soil and climatic conditions, maturity group and biological characteristics of the hybrid, as well as the timing of herbicide application. Table 2 presents the results of the effect of herbicide application on field soil moisture content. The impact of herbicides is primarily associated with the efficiency of weed control, as weeds are known to intensively consume soil moisture and act as strong competitors with maize plants. Soil moisture content was determined using the thermogravimetric method by drying soil samples in a thermostat.

Table 2. Field soil moisture content as affected by herbicide application, %.

Experimental variant	Soil layer, cm	Time of measurement	
		BBCH 63	BBCH 89
Control (no protection)	0-10	17.4	15.4
	10-20	17.6	15.7
	20-30	18.7	16.0
	0-30	17.9	15.7
Harness (2.0 l ha ⁻¹)	0-10	17.8	15.6
	10-20	18.7	16.2
	20-30	19.6	17.4
	0-30	18.7	16.4
Primextra TZ Gold (4.0 l ha ⁻¹)	0-10	18.5	16.0
	10-20	19.3	15.6
	20-30	19.7	17.1
	0-30	19.2	16.2
MaisTer® Power (1.3 l ha ⁻¹)	0-10	18.7	16.5
	10-20	19.4	17.1
	20-30	19.8	18.0
	0-30	19.3	17.2

Elumis (1.8 l ha ⁻¹)	0-10	18.5	17.1
	10-20	19.7	17.4
	20-30	20.1	17.7
	0-30	19.4	17.4

It was established that in the control variant, where no weed control was applied, the soil moisture content was the lowest, amounting to 17.9% in the 0-30 cm soil layer. Soil moisture was measured in layers of 0-10 cm, 10-20 cm, and 20-30 cm. Across all variants, soil moisture increased with depth. Following the application of the pre-emergence herbicide Harness (2.0 l ha⁻¹) at the maize flowering stage, soil moisture was higher than in the control plot by 0.8%, reaching 18.7%. In variants with the lowest weed infestation, soil moisture increased further to 19.3-19.4%. At the maize grain maturation stage, the advantage in soil moisture following herbicide application was maintained. In the control plots without herbicide treatment, soil moisture was 15.7%, which was 0.7-1.7% lower compared to plots treated with chemical weed control agents. The damage caused by weeds is multifaceted and diverse. By engaging in interspecific competitive interactions with cultivated plants, weeds consume water and nutrients. The presence of weed components in agrocenoses also promotes the development of pests and diseases. The classification of weeds is based on key principles: type of nutrition, lifespan, and mode of reproduction. This classification is practical in nature and most fully meets the requirements of applied agriculture. The fundamental classification unit of weeds is the biological type or biological group, which comprises plants that share similar life characteristics, including nutrition type, lifespan, and reproductive strategy (Kolisnyk et al., 2020b; Singh et al., 2020; Mazur et al., 2023; Tsytsiura, 2024; Kolisnyk et al., 2025b).

In maize agrocenoses, harmful annual weeds include: smallflower galinsoga (*Galinsoga parviflora* (Cav.)), common mustard (*Barbarea vulgaris* (R.Br.)), common ragweed (*Ambrosia artemisiifolia*), species of panicum (*Panicum* spp. (L.)), common purslane (*Portulaca oleracea* (L.)), yellow foxtail (*Setaria glauca* (L.)), among others.

Currently, maize is one of the crops with the highest availability of herbicides. The list of chemical agents authorized for use on maize includes more than 70 products (Vovkodav, 2001; Palamarchuk & Telekalo, 2018; Resul et al., 2022; Rudska et al., 2023). Most of these are highly selective, i.e., they can affect specific target species without damaging other organisms and can act on specific structures without impacting others. Selectivity is most commonly applied in crop production when assessing pesticide properties. The primary modes of action of toxic substances include accumulation in harmful organisms, interaction with cellular structures unique to pests, and disruption of vital biochemical systems essential for pest survival while sparing beneficial organisms. The harmfulness of weeds on maize yield exhibits a nonlinear dependence on both weed density and the duration of their presence in the agro-phytocenosis. Based on these indicators, thresholds and normative levels can be established to characterize the impact of weeds on crop productivity within the full range of their occurrence (Palamarchuk et al., 2023; Palamarchuk, 2023; Partal et al., 2023; Zakharchenko et al., 2024; Kolisnyk et al., 2024). The first assessment of weed infestation was conducted at the BBCH 14 stage, prior to the application of pre-emergence herbicides (Table 3). Weed density in the control plot was 85 plants/m². Similarly, plots designated for Primextra TZ Gold (4.0 l ha⁻¹) and Master Power herbicides had weed densities of 80 and 70 plants/m², respectively. In the second and fourth variants, where the pre-emergence herbicide Harness was applied, the number of weeds was lower.

Table 3. Weed density prior to herbicide application, plants m².

Weed species	Experimental variant				
	Control (no protection)	Harness (2.0 l ha ⁻¹)	Primextra TZ Gold (4.0 l ha ⁻¹)	Maister® Power (1.3 l ha ⁻¹)	Elumis (1.8 l ha ⁻¹)
White goosefoot (<i>Chenopodium album</i>)	23	7	13	19	9
Lady's thumb (<i>Polygonum persicaria</i>)	3	5	2	4	7
Yellow foxtail (<i>Setaria glauca</i>)	11	2	7	4	1
Common purslane (<i>Portulaca oleracea</i>)	5	1	4	3	2
Field sow-thistle (<i>Sonchus arvensis</i>)	4	5	4	7	5
Field chickweed (<i>Stellaria media</i>)	4	4	7	5	5
Rough smartweed (<i>Polygonum lapathifolium</i>)	4	0	7	5	0
Field mustard (<i>Sinapis arvensis</i>)	2	3	3	3	3
Shepherd's purse (<i>Capsella bursa-pastoris</i>)	29	11	33	20	14
Total	85	38	80	70	46

At application rates of 1.5 and 2.0 l ha⁻¹, acetochlor effectively controlled *Portulaca oleracea* and *Setaria glauca*, and demonstrated excellent efficacy against *Polygonum lapathifolium*. However, it had no effect on *Polygonum*

persicaria, *Sonchus arvensis*, and *Stellaria media*. At the four-leaf stage, weed density in plots treated with Harness (2.0 l ha⁻¹) was 38 plants/m², whereas in plots treated with Elumis (1.8 l ha⁻¹) it was 46 plants/m².

The visual distribution of the proportion of individual weed species is presented in Figure 2. *Capsella bursa-pastoris* accounted for one-third of the total weed population, *Chenopodium album* for 27%, grasses for 19%, perennial-rooted weeds for 10%, and other weed species for up to 5%.

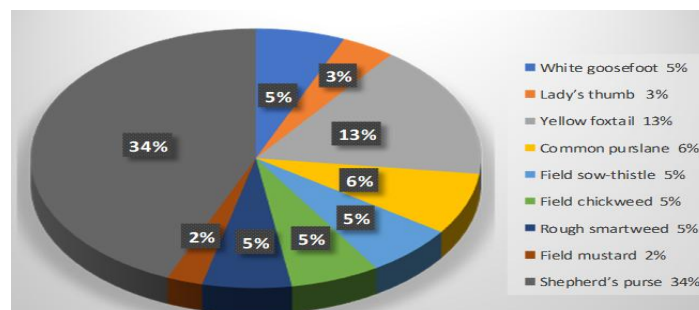


Figure 2. Weed species composition in maize crops for grain, %.

Quantitative and species-specific assessments of weeds were conducted prior to maize harvest. This evaluation allows the effectiveness of applied weed control methods to be assessed. As shown in Table 4, the Master Power herbicide (1.3 l ha⁻¹) was the most effective, with only 4 plants/m² remaining. This combined herbicide efficiently controlled annual weeds and exhibited sufficient soil activity to suppress new seedlings. However, under conditions of intensive precipitation, its efficacy against *Sonchus arvensis* and *Stellaria media* was limited, and a few individual *Chenopodium album* plants were still present.

In plots treated with Primextra TZ Gold (4.0 l ha⁻¹), only grassy weeds and, to a lesser extent, *Stellaria media* remained. The total weed density in these plots was 22 plants/m².

Table 4. Weed density in maize crops prior to herbicide application, plants/m².

Weed species	Experimental variant				
	Control (no protection)	Harness (2.0 l ha ⁻¹)	Primextra TZ Gold (4.0 l ha ⁻¹)	MaisTer® Power (1.3 l ha ⁻¹)	Elumis (1.8 l ha ⁻¹)
White goosefoot (<i>Chenopodium album</i>)	7	5	0	2	1
Lady's thumb (<i>Polygonum persicaria</i>)	6	4	2	2	1
Yellow foxtail (<i>Setaria glauca</i>)	19	6	0	0	0
Common purslane (<i>Portulaca oleracea</i>)	5	4	1	0	0
Field sow-thistle (<i>Sonchus arvensis</i>)	9	4	8	0	0
Field chickweed (<i>Stellaria media</i>)	13	3	11	0	0
Rough smartweed (<i>Polygonum lapathifolium</i>)	3	0	0	0	0
Field mustard (<i>Sinapis arvensis</i>)	3	2	0	0	0
Shepherd's purse (<i>Capsella bursa-pastoris</i>)	17	9	0	0	0
Total	73	37	22	4	2

The herbicide Elumis (30 g l⁻¹ nicosulfuron, 75 g l⁻¹ mesotrione) demonstrated exceptionally high efficacy. In these treatments, no weeds were observed at the time of maize harvest. Analysis of weed infestation structure prior to maize harvest indicated that *Chenopodium album* was dominant, accounting for 21%, followed by *Echinochloa crus-galli* and *Sinapis arvensis* at 18%, and *Cirsium arvense* at 10%. The share of other weed species was less than 10% (Fig. 3). The characterization of crop structural elements reflects the influence of specific agronomic practices. The analysis of these parameters is important, as structural components directly affect crop yield.

It has been shown that certain structural traits, such as the number of grain rows per cob, are more stable under environmental conditions, whereas others respond more strongly to the applied cultivation technology (Radchenko et al., 2022; Hryhoriv et al., 2024; Radchenko et al., 2024; Zinati et al., 2025).

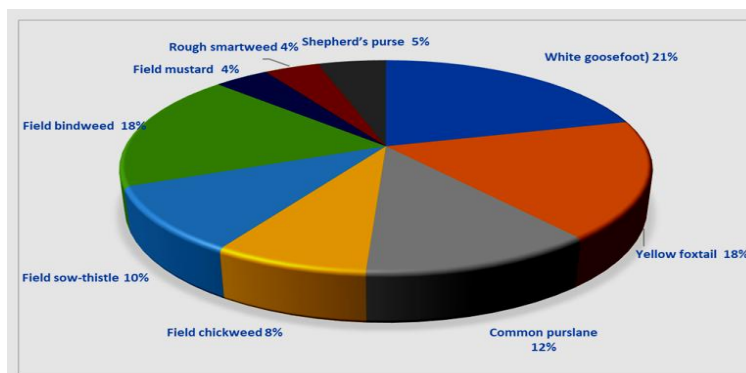


Figure 3. Weed species composition in maize grain crops prior to harvest, %.

On average, over the years of the study, an increase in fertilizer rates positively influenced the structural parameters of maize yield (Table 5). The highest effect on grain weight per cob was observed with fertilization after flowering. In this treatment, grain weight per cob ranged from 187.3 to 200.5 g, providing an increase of 12.4-25.6 g, or 8.5-16.6%, compared to the control.

An important and objective indicator for evaluating individual components of crop production technology is yield. Maize yield is influenced by soil and climatic conditions, which affect both the quantity and quality of the harvest. By improving the growth and development conditions of cultivated plants, high yields can be achieved. Yield refers to the amount of product (in this case, grain) harvested from the total cultivated area. Yield is classified as either economic (marketable) or biological. Economic yield is determined as the ratio of the total harvest to the sown area of the crop ($t\ ha^{-1}$ or $c\ ha^{-1}$).

Table 5. Maize yield structure depending on herbicide application, average 2024-2025.

No	Experiment option	Herbicide application rate	Number of grain rows per cob, pcs	Number of grains per row, pcs	Grain weight per cob, g
1	Control (no protection)	-	14.5	32.0	129.2
2	Harness	(2.0 l ha^{-1})	14.3	33.7	134.7
3	Primextra TZ Gold	(4.0 l ha^{-1})	14.6	33.8	135.4
4	MaisTer® Power	(1.3 l ha^{-1})	14.5	31.9	137.6
5	Elumis	(1.8 l ha^{-1})	14.5	33.8	137.1

Biological yield is the total biomass (grain plus straw) obtained per unit area. Biomass is collected without losses from 1 or 10 m^2 plots and then scaled to 1 ha. For biological maize yield, the total mass of plants from sampled plots is measured (roots are excluded), and after threshing, the grain weight is recorded; the results are recalculated per m^2 and for the entire field area. In our study, maize grain yield was significantly influenced by the hydrothermal conditions of the experimental years. Higher yields were recorded in 2025, and this trend was observed across all experimental treatments (Table 6).

Table 6. Effect of herbicides on maize grain yield, $t\ ha^{-1}$.

No	Experimental treatment	Herbicide application rate	Yield, $t\ ha^{-1}$			Yield increase relative to control, $t\ ha^{-1}$
			2024p.	2025 p.	Average for 2024-2025	
1	Control (no protection)	-	6.10	6.50	6.30	-
2	Harness	(2.0 l ha^{-1})	8.70	9.20	8.95	2.65
3	Primextra TZ Gold	(4.0 l ha^{-1})	9.40	9.90	9.65	3.35
4	MaisTer® Power	(1.3 l ha^{-1})	11.90	12.80	12.35	6.05
5	Elumis	(1.8 l ha^{-1})	11.70	12.50	12.10	5.80
LSD $t\ ha^{-1}$			0.5			

Maize grain yield formation was also influenced by the factor under study-herbicide application. The highest average yield over the experimental years ($12.35\ t\ ha^{-1}$) was obtained with the treatment using the herbicide Maister Power at $1.3\ l\ ha^{-1}$. The yield increase relative to the control was $6.05\ t\ ha^{-1}$, or 96.0%. A viable alternative to

Maister Power was the application of Elumis (30 g l⁻¹ nicosulfuron, 75 g l⁻¹ mesotrione), which provided an average grain yield of 12.10 t ha⁻¹ and a yield increase over the control of 5.80 t ha⁻¹ in 2024-2025.

Incorporating Harnes (2.0 l ha⁻¹) and Primekstra TZ Gold (4.0 l ha⁻¹) into the maize cultivation technology was less effective, as the yield increase relative to the control was significantly lower, ranging from 2.65 to 3.35 t ha⁻¹, or 42.1-53.2%. Considering the least significant difference (LSD) at 0.5 t ha⁻¹, these results can be considered statistically reliable and valid.

CONCLUSIONS

Under the conditions of this study, herbicide application improved the structural elements of maize grain yield and provided a statistically significant increase in yield. At the first assessment (BBCH 14), weed infestation in the control plot was 85 plants/m². Harnes at 2.0 l ha⁻¹ effectively controlled *Polygonum persicaria* and *Echinochloa crus-galli*, and provided excellent control of *Galium aparine*. However, it was less effective against *Galium mollugo*, *Cirsium arvense*, and *Veronica arvensis*. At the four-leaf stage, weed density in plots treated with Harnes (2.0 l ha⁻¹) was 38 plants/m², while Elumis (1.8 l ha⁻¹) plots had 46 plants/m². The highest grain yield (12.35 t ha⁻¹) was achieved with Maister Power at 1.3 l ha⁻¹, corresponding to a yield increase over the control of 6.05 t ha⁻¹, or 96.0%. The use of Elumis (1.8 l ha⁻¹) as an alternative provided a grain yield of 12.10 t ha⁻¹ and an increase over the control of 5.80 t ha⁻¹. Incorporating Harnes (2.0 l ha⁻¹) and Primekstra TZ Gold (4.0 l ha⁻¹) into the cultivation technology was less effective, with yield increases ranging from 2.65 to 3.35 t ha⁻¹, or 42.1-53.2%.

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