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EFFECTIVE STRATEGIES TO MINIMIZE THE IMPACT OF WEED FLORA ON RAPESEED CROPS

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***Abstract**. Rapeseed (Brassica napus L.) plays a key role in the global economy as a major source of vegetable oil used for food, feed, and biofuel production. Beyond its industrial importance, rapeseed remains a highly profitable crop. However, achieving optimal yields requires careful crop management, as rapeseed is highly sensitive to weed competition. The present study aimed to evaluate the efficacy of weed control in rapeseed cultivation using the pre-emergent herbicide Successor Pro (petoxamide 600 g/L) and the post-emergent herbicides Effigo S (240 g/L clopyralid + 80 g/L picloram + 40 g/L aminopyralid), Korvetto (5 g/L halauxifen-methyl + 120 g/L clopyralid), and Panarex 40 EC (40 g/L quizalofop-p-tefuril + 75% ethametsulfuron-methyl), applied individually or in combination across nine experimental variants. The influence of weed control on yield performance was also assessed. The experiments were conducted during the 2023/2024 and 2024/2025 agricultural seasons at the M.S.I. Agricultural Holding, located in Diosig, Bihor County. The initial weed infestation level in the rapeseed plots was substantial—163 weed plants/m², representing 11 different species. In all four single-treatment variants, weed control efficiency was relatively modest: V1 – Successor Pro (62.8%), V2 – Effigo S (45.3%), V3 – Korvetto (50.8%), and V4 – Panarex 40 EC (32.7%). The most effective combinations were: V7 – Successor Pro + Panarex 40 EC (93.5%), V8 – Effigo S + Panarex 40 EC (90.4%), and V9 – Korvetto + Panarex 40 EC (98.2%). All active substances contained in the tested herbicides were selective for the rapeseed crop (hybrid LID Invicto). Herbicide efficacy significantly influenced yield outcomes, with the highest seed yields recorded in variants V8 (3527 kg/ha), V7 (3618 kg/ha), and V9 (3845 kg/ha).*

***Keywords**: Rapeseed (Brassica napus L.), weeds control, herbicides*

INTRODUCTION

Rapeseed (*Brassica napus* L.) currently occupies a particularly important position in the global economy as a source of vegetable oils used in human and animal nutrition, as well as in industry (biodiesel) (Agrointel., 2019). The progress achieved in the breeding of this plant, through the creation of varieties and hybrids with high oil content, free of erucic acid and with a low glucosinolate content, has led to the expansion of the areas cultivated with rapeseed, not only worldwide but also in our country. In addition, rapeseed remains an attractive crop from a financial perspective; the benefits in terms of profit per ton and the high market demand are evident and well known. However, to achieve the best results, rapeseed requires very good care, as the plant has a low tolerance to weeds. In autumn, weeds compete with the crop at one of the most critical stages, when plants are poorly developed and unprepared for winter (some specialized studies state that rapeseed forms up to 50% of its yield during autumn), making it necessary for farmers to pay close attention to crop management during this season. Therefore, weed control is recommended in the early stages of vegetation, when rapeseed plants are still small and not yet heavily infested, depending on the weed growth stage. Early weed elimination allows rapeseed to develop vigorously throughout the growing season, as the plant has a strong natural ability to suppress later-emerging weeds. Moreover, herbicides tend to be less effective when applied late in autumn, on weeds already affected by frost or drought. Prevention remains the first method of weed control; however, to ensure high yield potential while maintaining the highest crop protection standards, the use of innovative solutions is necessary (BASF România, 2022, O'Donovan et al., 2006, Pourazar & Habibiasl, 2023, Sănătatea Plantelor, 2017).

In rapeseed cultivation, both annual and perennial monocotyledonous and dicotyledonous weeds can occur. Among these, only 15–20 species are highly harmful and appear frequently (almost every year) in most rapeseed-growing regions, such as *Setaria* sp., *Echinochloa crus-galli*, *Sorghum halepense*, *Elymus repens*, *Galinsoga parviflora*, *Amaranthus* sp., *Sinapis arvensis*, *Digitaria sanguinalis*, *Hibiscus trionum*, *Solanum nigrum*, *Centaurea cyanus*, *Polygonum* sp., *Convolvulus arvensis*, *Xanthium* sp., *Cirsium arvense*, *Sonchus arvensis*, *Veronica hederifolia*, *Viola arvensis*, *Capsella bursa-pastoris*, *Stellaria media*, *Anthemis arvensis*, *Atriplex patula*, etc. (Agropataki, 2020, Ciocârlan et al., 2004, Manea, D.N., 2022, Manea, D.N., 2025).

Cruciferous weeds are among the most dangerous in rapeseed cultivation due to the difficulty of their control. *Sinapis arvensis* L., *Raphanus raphanistrum* L., and *Capsella bursa-pastoris* L. are the dominant cruciferous species (Mihele & Manea, 2025, Salimi et al., 2019, Shimi et al., 2016). In addition to the weed flora that causes yield losses through competition for growth factors and by reducing crop density, newly emerged rapeseed seedlings are also suffocated by volunteer plants (commonly called "samulastră"), with winter wheat and barley remaining in the field after harvest being the most frequent (Bayer CropScience România, 2024, Berca, M., 2004, Delchev & Barakova, 2018).

In this context, the present study aimed to determine the effectiveness of weed control in rapeseed cultivation using a diverse range of pre-emergent and post-emergent herbicides. The influence of weed control on yield levels was also evaluated. The research was carried out during the 2023/2024 and 2024/2025 agricultural years, in the experimental field located at Mihele Sorin Ionel Agricultural Holding, Diosig locality, Bihor County.

MATERIAL AND METHODS

The primary objective of this study was to evaluate the effectiveness of several herbicides and herbicide combinations for weed control in rapeseed (*Brassica napus* L.) crops. To achieve this goal, the following research stages were conducted: establishment of the experimental field, weed mapping, herbicide application, assessment of herbicide selectivity on rapeseed plants, determination of weed control efficacy, and evaluation of yield performance. The hybrid LID Invicto, developed by Lidea, was used in the experiment. LID Invicto is a semi-early rapeseed hybrid characterized by superior yield potential, remarkable adaptability to climatic variability, and high tolerance to biotic stress (Figure 1).

Main agronomic characteristics: The hybrid exhibits outstanding productivity across diverse pedoclimatic regions, owing to its high nitrogen use efficiency ("Nitrogen Master" trait). It shows genetic resistance to the Turnip Yellows Virus (TuYV), excellent emergence vigor allowing suitability for delayed sowing, and enhanced tolerance to autumn infestations of flea beetles. LID Invicto also possesses genetic resistance to *Phoma lingam* (RLM7 gene), high frost tolerance without premature stem elongation, strong resistance to pod shattering, and an exceptional oil content of 49.3%. The recommended sowing density is 400,000–450,000 viable seeds per hectare (Agroexpert, 2025).

Weed control in rapeseed (*Brassica napus* L.) and volunteer wheat was achieved using the herbicides Effigo S, Korvetto, Panarex 40 EC, and Successor Pro, applied either individually or in combination. Effigo S is a foliar-applied herbicide targeting annual and perennial broadleaf weeds in rapeseed. It is formulated as a clear, homogeneous, brown soluble liquid (SL) containing 240 g/L clopyralid, 80 g/L picloram, and 40 g/L aminopyralid. The product is neither oxidizing nor explosive. Application is possible pre-emergent or early post-emergent (1–3 leaf stage), in autumn at the 3–9 leaf stage, or in spring prior to floral bud visibility. Recommended doses are 0.2 L/ha in autumn and 0.25 L/ha in spring, with a single application per season. Spraying solution should be prepared using 100–400 L water/ha (Pesticid.ro, n.d.).

Korvetto is a post-emergent herbicide applied in spring to winter rapeseed for the control of a broad spectrum of broadleaf weeds. It contains halauxifen-methyl (Arylex™ active) and clopyralid, both synthetic auxins. Application is performed from the beginning of stem elongation (rosette stage, BBCH-30) until floral buds are present but still covered by leaves (BBCH-50). Korvetto is suitable for all winter rapeseed varieties (conventional and Clearfield®). A single spring application of 1 L/ha in 100–400 L water/ha is recommended (Corteva Agriscience, n.d.).

Panarex 40 EC targets narrow-leaved grass weeds in broadleaf crops. It contains 40 g/L quizalofop-p-tefuryl and 75% ethametsulfuron-methyl as an emulsifiable concentrate. Panarex 40 EC is systemic, absorbed by grass leaves and translocated throughout the plant. Application is post-emergent, when grass weeds have 2–4 leaves or are at least 10 cm high for *Sorghum halepense*. In rapeseed, application rates range from 0.75 to 1.5 L/ha, with 50–300 L water/ha depending on equipment and weed size (UPL România, 2025).

Successor Pro is a selective pre-emergent and early post-emergent herbicide for the control of grass and broadleaf weeds in corn, rapeseed, and sunflower. It contains 600 g/L petoxamid. Application is pre-emergent after sowing or early post-emergent, with best results on well-prepared, finely tilled soils. Recommended dose is 1.5–2.0 L/ha in 200–400 L water/ha. Post-emergent application should target weeds at the germination stage; emerged annual and/or broadleaf weeds require additional post-emergent control.

The field experiment was conducted at Mihele Sorin Ionel Agricultural Holding, Diosig, Bihor County, over the 2023/2024 and 2024/2025 seasons. Ten experimental variants were arranged in a randomized complete block design with three replications, each harvestable plot covering 45 m². Variants differed according to the herbicide(s) applied (Figure 1) (Mihele & Manea, 2025).

Weed mapping prior to post-emergent applications followed the quantitative numerical method: weeds were counted by species in at least five sample areas, with results expressed per 1 m²; samples were selected along the diagonal of each plot. Post-application assessments were conducted at 7, 14, and 28 days to evaluate both herbicide efficacy and selectivity, including the appearance of any phytotoxic symptoms.

A water volume of 200 L/ha was used for solution preparation. The preceding crop was winter wheat in both years. Herbicide selectivity and efficacy were evaluated using the EWRS scale (EWRS, 2025). Rapeseed yields were recorded for each experimental variant, and data were analyzed using analysis of variance.

Experimental variants are presented in Table 1.

Table 1

Herbicide variants evaluated

Variant	Herbicide (commercial product)	Active substance	Dose		Application timing
			Commercial product	Active substance/ha	
V1	Successor Pro	Petoxamid 600 g/l	2.0 l/ha	1200 g/ha	pre-em
V2	Effigo S	240 g/l clopyralid +80 g/l picloram + 40 g/l aminopyralid	0.25 l/ha	60 g/l clopyralid +20 g/l picloram+10 g/l aminopyralid	post-em (spring)
V3	Korvetto	5 g/l halauxifen-methyl + 120 g/l clopyralid	1.0 l/ha	5 g/l halauxifen-methyl + 120 g/l clopyralid	post-em (spring)
V4	Panarex 40 EC	40 g/l quizalofop-P-tefuryl + 75% ethametsulfuron-methyl	1.0 l/ha	40 g/l quizalofop-P-tefuryl + 75 % ethametsulfuron-methyl	post-em (spring)
V5	Successor Pro + Effigo S	Petoxamid 600 g/l + 240 g/l clopyralid +80 g/l picloram + 40 g/l aminopyralid	2.0 l/ha+ 0.25 l/ha	1200 g/ha + 60 g/l clopyralid + 20 g/l picloram + 10 g/l aminopyralid	pre-em + postem (spring)
V6	Successor Pro + Korvetto	Petoxamid 600 g/l+5 g/l halauxifen-methyl + 120 g/l clopyralid	2.0 l/ha+ 1.0 l/ha	1200 g/ha + 5 g/l halauxifen-methyl + 120 g/l clopyralid	pre-em + postem (spring)
V7	Successor Pro + Panarex 40 EC	Petoxamid 600 g/l+ +40 g/l quizalofop-P-tefuryl + 75% ethametsulfuron-methyl	2.0 l/ha+ 1.0 l/ha	1200 g/ha + 40 g/l quizalofop-P-tefuryl+ 75 % ethametsulfuron-methyl	pre-em + postem (spring)
V8	Effigo S + Panarex 40 EC	240 g/l clopyralid + 80 g/l picloram + 40 g/l aminopyralid + 40 g/l quizalofop-P-tefuryl + 75% ethametsulfuron-methyl	0.25 l/ha + 1.0 l/ha	60 g/l clopyralid + 20 g/l picloram + 10 g/l aminopyralid + 40 g/l quizalofop-P-tefuryl + 75 % ethametsulfuron methyl	post-em + post-em (spring)
V9	Korvetto+ Panarex 40 EC	5 g/l halauxifen-methyl + 120 g/l clopyralid + 40 g/l quizalofop-P-tefuryl + 75% ethametsulfuron-methyl	1.0 l/ha+ 1.0 l/ha	5 g/l halauxifen-methyl + 120 g/l clopyralid + 40 g/l quizalofop-P-tefuryl + 75% ethametsulfuron methyl	post-em + post-em (spring)
V10	Control (untreated)	-	-	-	-

Figure 1. General view of the experimental rapeseed field

RESULTS AND DISCUSSIONS

The assessment of the initial weed flora in the rapeseed (*Brassica napus* L.) plots revealed a substantial infestation level, with 163 weed plants per m² representing 11 different

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species. Data summarized in Table 2 were obtained from weed mapping conducted a few days prior to post-emergent herbicide application.

Table 2

Weed flora composition in the rapeseed crop (2023–2025 experimental cycle)

No.	Common name	Scientific name	Individuals/m²	Relative abundance (%)	Class/Botanical family
1.	Wild oat	*Avena fatua*	12.6	7.7	*M.a./Poaceae*
2.	Shepherd's purse	*Capsella bursa-pastoris*	13.9	8.5	*D.a./Brassicaceae*
3.	Creeping thistle	*Cirsium arvense*	6.7	4.1	*D.p./Asteraceae*
4.	Flixweed	*Descurainia sophia*	5.4	3.3	*D.a./Brassicaceae*
5.	Couch grass	*Elymus repens*	8.3	5.1	*M.p./Poaceae*
6.	Dead-nettle	*Lamium purpureum*	15.8	9.7	*D.a. /Lamiaceae*
7.	Wild mustard	*Sinapis arvensis*	14.3	8.8	*D.a./Brassicaceae*
8.	Common chickweed	*Stellaria media*	29.2	17.9	*D.a./Caryophyllaceae*
9.	Field pennycress	*Thlaspi arvense*	10.1	6,2	*D.a./Brassicaceae*
10.	Volunteer wheat	*Triticum aestivum*	24.9	15.3	*M.a./Poaceae*
11.	Speedwell	*Veronica* sp.	21.8	13.4	*D.a./Plantaginaceae*
TOTAL:			163	100.0	-

Annual broadleaf weeds were predominant, accounting for seven species: dead-nettle (*Lamium purpureum*, 13.9 plants/m²), common chickweed (*Stellaria media*, 5.4 plants/m²), henbit (*Lamium amplexicaule*, 15.8 plants/m²), redshank (*Polygonum persicaria*, 29.2 plants/m²), wild mustard (*Sinapis arvensis*, 14.3 plants/m²), shepherd's purse (*Capsella bursa-pastoris*, 10.1 plants/m²), and corn spurry (*Spergula arvensis*, 21.8 plants/m²). Notably, three species (*Lamium purpureum*, *Stellaria media*, and *Veronica* sp.) accounted for 41% of the total weed population and were present in all plots (100% frequency). Despite their relatively small size and short life cycle, these species pose a significant threat to rapeseed crops due to their high abundance during the early seedling stage. A perennial dicotyledonous species, creeping thistle (*Cirsium arvense*), was also identified, occurring in compact patches with a density of 6.7 plants/m². Additionally, the annual monocotyledonous weed wild oat (*Avena fatua*) was observed at 12.6 plants/m². Volunteer wheat (*Triticum aestivum*) was highly abundant (24.9 plants/m²), reflecting its common occurrence in autumn-sown rapeseed following wheat, a scenario increasingly encountered in agricultural practice. Only one perennial narrow-leaved weed, couch grass (*Elymus repens*), was present at a significant density of 883 plants/m² (Figure 2).

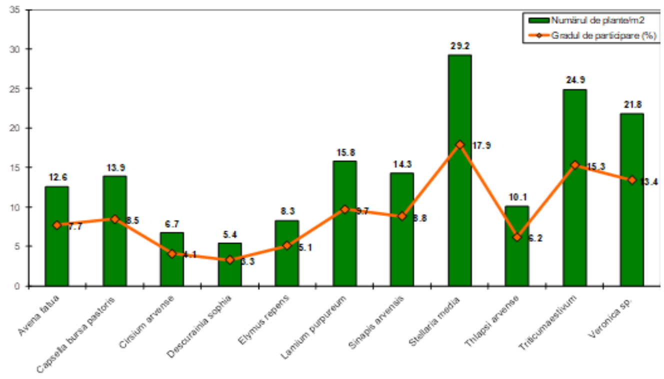

Figure 2. Weed flora composition in the rapeseed crop (graphical representation)

The recorded species belonged to six botanical families: *Asteraceae* – 1 species; *Brassicaceae* – 4 species; *Caryophyllaceae* – 1 species; *Lamiaceae* – 1 species; *Plantaginaceae* – 1 species; *Poaceae* – 3 species. The distribution of these weed species across the four major botanical classes is illustrated in Figure 3.

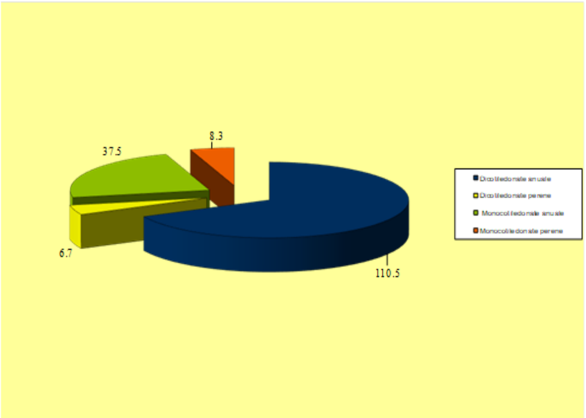

Figure 3. Distribution of the weed species identified among the 4 botanical classes

Weed control efficacy following herbicide treatments. Two weeks after herbicide application, the impact of the treatments on weed suppression was assessed across the nine experimental variants of winter rapeseed (Table 3).

The four herbicides were applied either individually or in combination. As a general trend, in the four single-herbicide treatments, the effect on weed populations was relatively modest: V1 – Successor Pro (62.8% control), V2 – Effigo S (45.3%), V3 – Korvetto (50.8%), and V4 – Panarex 40 EC (32.7%). This outcome is likely due to the fact that, although three of the four products (V2, V3, V4) contain two or three active substances, they were unable to adequately target the full spectrum of 11 weed species identified in the field. Statistically, this is supported by significantly negative differences in V2, V3, and V4 compared to the experimental mean of 71.1% weed control. The grass-specific herbicide Panarex 40 EC, applied alone, showed the lowest control (32.7%), most likely reflecting the predominance of broadleaf weeds in all experimental plots (Table 3). A synergistic effect was observed when Successor Pro (petoxamid 600 g/L, 2.0 L/ha) was applied pre-emergent, followed by a post-emergent application of one of the three tested herbicides: V5 – Successor Pro + Effigo S (81.3%), V6 – Successor Pro + Korvetto (85.6%), and V7 – Successor Pro + Panarex 40 EC (93.5%). Further evidence comes from plots where two post-emergent herbicides were combined: V8 – Effigo S + Panarex 40 EC (90.4%), and V9 – Korvetto + Panarex 40 EC (98.2%), the latter achieving the highest observed weed control. Combining a grass-specific herbicide with a broadleaf herbicide provides significantly superior control compared to single-herbicide treatments, indicating an optimal strategy for effective weed management in rapeseed crops (Figure 4).

Statistical analysis confirmed that combined herbicide applications resulted in distinctly significant positive differences (V5) or highly significant positive differences (V6, V7, V8, V9) relative to the experimental mean (Table 3).

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Importantly, no visual adverse effects on rapeseed plants were observed in any of the single or combined herbicide treatments, demonstrating that all active ingredients in the tested products are highly selective for the LID Invicto hybrid.

Table 3

Impact of herbicide use on weed control in the rapeseed crop, compared to the experimental mean

Variant	Applied product(s)	Relative efficacy of herbicides (%)	Difference from the mean (%)	Significance of the difference
V1	Successor Pro	62.8	-8.3	0
V2	Effigo S	45.3	-25.8	000
V3	Korvetto	50.8	-20.3	000
V4	Panarex 40 EC	32.7	-38.4	000
V5	Successor Pro + Effigo S	81.3	10.2	**
V6	Successor Pro + Korvetto	85.6	14.5	***
V7	Successor Pro + Panarex 40 EC	93.5	22.4	***
V8	Effigo S + Panarex 40 EC	90.4	19.3	***
V9	Korvetto+ Panarex 40 EC	98.2	27.1	***
V10	Experimental mean (control)	71.1	0,0	-

$LSD_{5\%}$ - 5.79 % $LSD_{1\%}$ - 8.49 % $LSD_{0.1\%}$ - 10.35 %

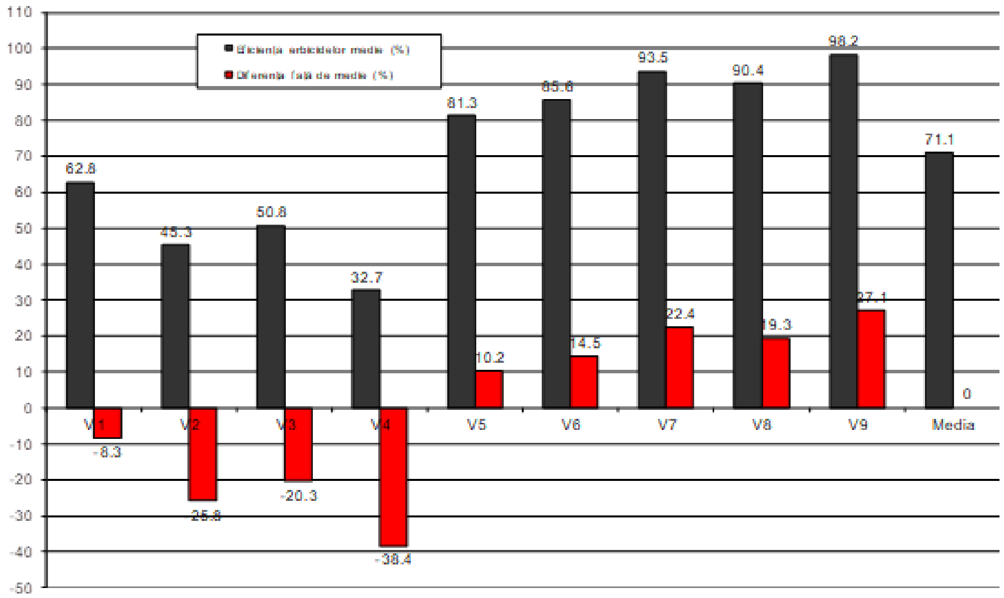

Figure 4. Graphical representation of the effects of herbicide use in the experiment, compared to the experimental mean (2022–2025)

Effect of herbicide efficacy on rapeseed yields. As anticipated, the effectiveness of herbicides in controlling weeds directly influenced the yields recorded in the experimental plots. Average yields for the 2022/2025 cycle are presented in Table 4, relative to the untreated control.

Among the four herbicides applied individually, yields ranged from 2377 kg/ha (Effigo S) to 2781 kg/ha (Successor Pro). The grass-specific herbicide **Panarex 40 EC**, applied alone, produced a relatively low yield of 1752 kg/ha, which can be explained by the limited presence of grass weeds in the overall infestation (approximately 23%). All five variants with combined herbicides achieved yields above 3000 kg/ha, from 3103 kg/ha (V5 – Successor Pro + Effigo S) to 3845 kg/ha (V9 – Korvetto + Panarex 40 EC).

Table 4

Rapeseed yields evaluated relative to the untreated control (mean values 2022–2025)

Variant	Applied product(s)	Mean absolute yields (kg/ha)	Absolute difference (kg/ha)	Significance of the difference
V_1	Successor Pro	2781	1405	***
V_2	Effigo S	2377	1001	***
V_3	Korvetto	2518	1142	***
V_4	Panarex 40 EC	1752	376	*
V_5	Successor Pro + Effigo S	3103	1727	***
V_6	Successor Pro + Korvetto	3294	1918	***
V_7	Successor Pro + Panarex 40 EC	3618	2242	***
V_8	Effigo S + Panarex 40 EC	3527	2166	***
V_9	Korvetto+ Panarex 40 EC	3845	2151	***
V_{10}	**Control (untreated)**	**1376**	**0,0**	**-**

$LSD_{5\%}$ - 341 kg/ha $LSD_{1\%}$ - 603 kg/ha $LSD_{0.1\%}$ - 825 kg/ha

Compared to the control (mean yield 2979 kg/ha), single-herbicide treatments consistently resulted in lower yields (Table 5, Figure 5).

The Successor Pro + Effigo S combination produced a modest yield increase of 124 kg/ha. Successor Pro + Korvettowas more effective, achieving a significant increase of 315 kg/ha. The combination Successor Pro + Panarex 40 ECresulted in a distinctly significant yield increase of 639 kg/ha. Similarly, in V8 (Effigo S + Panarex 40 EC), the yield gain of 548 kg/ha was also statistically considered distinctly significant.

The most statistically significant yield increase, compared to the experimental mean, was observed in V9 – Korvetto + Panarex 40 EC, with a gain of 866 kg/ha.

Table 5

Rapeseed yields evaluated relative to the experimental mean (average values 2022–2025)

Variant	Applied product(s)	Mean absolute yields (kg/ha)	Absolute difference (kg/ha)	Significance of the difference
V_1	Successor Pro	2781	-198	-
V_2	Effigo S	2377	- 602	00
V_3	Korvetto	2518	-461	0
V_4	Panarex 40 EC	1752	-1254	000
Control	**Experimental mean**	**2979**	-	**Mt.**
V_5	Successor Pro + Effigo S	3103	124	-
V_6	Successor Pro + Korvetto	3294	315	*
V_7	Successor Pro + Panarex 40 EC	3618	639	**
V_8	Effigo S + Panarex 40 EC	3527	548	**
V_9	Korvetto+ Panarex 40 EC	3845	866	***

$LSD_{5\%}$ - 285 kg/ha $LSD_{1\%}$ - 513 kg/ha $LSD_{0.1\%}$ - 749 kg/ha

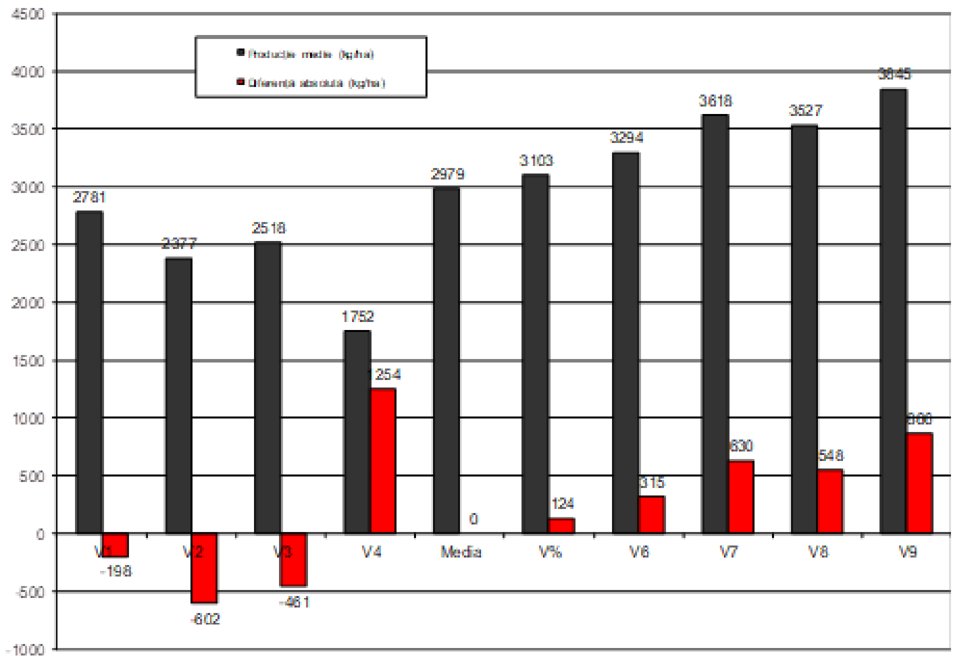

Figure 5. Graphical representation of yield increases, compared to the experimental mean (2022–2025)

CONCLUSIONS

During the experimental cycle (2023/2025), the winter rapeseed plots were infested by 11 weed species, including both broadleaf and narrow-leaved species. Dicotyledons were the most frequently observed, particularly from the genera *Lamium*, *Veronica*, and *Stellaria*. Among the *Poaceae*, volunteer wheat (*Triticum aestivum*) and wild oat (*Avena fatua*) were dominant.

Overall weed infestation was relatively high, with 163 plants/m², spanning six diverse botanical families.

The grass-selective herbicide Panarex 40 EC (40 g/L quisalofop-p-tefuril + 75% etametsulfuron methyl), applied at 1.0 L/ha, was highly effective against grasses but had limited impact on the dominant dicotyledonous weeds.

Single-herbicide treatments showed modest control of weeds: V1 – Successor Pro (62.8%), V2 – Effigo S (45.3%), V3 – Korvetto (50.8%).

In rapeseed, a complex weed spectrum typically requires combining multiple active substances (2–3 for dicotyledons and at least one for grasses) to achieve significantly better control than single-herbicide treatments;

The most effective combinations were: V7 – Successor Pro + Panarex 40 EC (93.5%), V8 – Effigo S + Panarex 40 EC (90.4%), and V9 – Korvetto + Panarex 40 EC (98.2%);

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No visible phytotoxicity was observed in any variant treated with one or two herbicides, confirming that all active substances tested are highly selective for LID Invicto rapeseed;

As anticipated, herbicide efficacy strongly influenced yields. The highest yields were obtained in V8 (3527 kg/ha), V7 (3618 kg/ha), and V9 (3845 kg/ha).

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