INFLUENCE OF HERBICIDES IN WINTER WHEAT CROP AT AGRICULTURAL RESEARCH AND DEVELOPMENT STATION TURDA

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Abstract. *The paper presents the results obtained in the winter wheat crop during 2023-2024, on the Andrada variety, created at Agricultural Research and Development Station Turda, with a high yield potential and good qualitative traits. Herbicide treatments with either a single product or two were applied depending on the infestation level, spectrum, and dominance of weeds, using Broadway Star (70.8 g/kg pyroxulam, 14.2 g/kg florasulam, 70.8 g/kg cloquintocet-mexyl), Provalia (fluroxypyr 135 g/l + thifensulfuron methyl 30 g/l + metsulfuron methyl 5 g/l), Dicopur D (600 g/l 2,4-D acid from dimethylamine salt), and Sekator Progress OD (amidosulfuron 100 g/l + iodosulfuron-methyl-Na 25 g/l + mefenpyr diethyl 250 g/l), applied post-emergence in the early stem elongation phase (BBCH 30-32). The treatments with the best results in controlling monocot and dicot annual and perennial weeds, with the highest efficacy of over 95%, were at variant V_5, where a single herbicide, Provalia, was used, and at variant V_4, with two herbicides, Provalia + Broadway Star, to which foliar fertilizer AGRO-K and adjuvant Vital were added, resulting in the highest yield increases, over 1400 kg • ha^{-1}, with results presenting very significant positive statistical differences compared to the control. The use of herbicide treatments, correlated with the level of infestation, spectrum, and dominance of weeds, timing of application, technical efficacy potential, and local climatic conditions, represents an important method for eliminating competition between weeds and the crop.*

Keywords: *winter wheat, herbicides, assimilation, evapotranspiration*

INTRODUCTION

Modern agriculture relies on a complex integrated weed control strategy, combining the use of herbicides with agro-technical and preventive methods tailored to each crop. In Transylvania, direct losses caused by weeds in cereal crops typically range between 10-20% but reach up to 60% under extreme conditions (Muntean et al., 2014).

To reduce these losses, is applied an integrated system, which includes: preventing infestations through compliance with quarantine regulations, seed conditioning, and cleaning agricultural roads; agro-technical methods such as crop rotation, soil preparation, and rational fertilization; using a wide range of herbicides to eliminate annual and perennial weed species; as well as biological and physical methods, such as burning or mowing weeds (Şimon et al., 2023).

Effective weed control aims to keep weed infestation below the damage threshold by reducing water and nutrient consumption, selecting herbicides according to the degree of infestation and environmental conditions, and ensuring superior yields (Şarpe, 1987; Guş et al., 2004).

In the Transylvanian Plain, the best results for cereal crops are achieved through timely soil preparation and sowing, coupled with efficient land and herbicide management to maximize yields and maintain crop quality (Chetan F. et al., 2017).

Spring represents a critical phase for winter wheat, as weed competition during early spring significantly affects nutrient reserves, as well as the physiology and morphology of wheat plants (Berca and Ciorlăuş, 1994; Auld, 1996; Ionescu, 2000; Petcu et al., 2007).

To prevent weed-induced damage, the most appropriate herbicides should be selected and applied when winter wheat is in the late tillering and early stem elongation stages, while weeds are in the rosette stage (Şarpe et al., 1983).

The objective of the 2023-2024 research was to identify new herbicides for selective weed control in winter wheat, considering infestation levels and local conditions, aiming to broaden the control spectrum and reduce the negative environmental impact.

The studies conducted during 2023-2024 focused on the Andrada winter wheat variety, developed at Agricultural Research and Development Station Turda. This variety is recognized for its strong drought and heat resistance, excellent assimilation capacity (Bărdaş et al., 2019), and superior yield and quality (Kadar et al., 2019; Racz et al. 2016; Ceclan et al., 2015; Moldovan et al., 2012;).

MATERIAL AND METHODS

The soil on which the experiment was placed is of the type vertic clay-illuvial phaeosiom (RSST, 2012), with a pH ranging from 6.80 to 7.00. It has a humus content in the 0–30 cm depth range between 2.14% and 3.12%, and a clay content between 51.8% and 55.5%, classifying it as clayey in texture.

In the autumn, soil cultivation was performed to a depth of 30 cm using a Kuhn reversible plow, followed by seedbed preparation with a Gaspardo rotary harrow, achieving excellent soil preparation. Sowing was carried out with a Directa Corsa seeder, with a row spacing of 18 cm, ensuring a seed density of 550 grains/m², with the seeding rate per hectare calculated based on biological and physical indices.

Autumn fertilization was performed simultaneously with sowing, using 40 kg/ha nitrogen and phosphorus (N20:P20– 200 kg/ha), and in the spring, when vegetation resumed, ammonium nitrate (NH_4NO_3) was applied at a rate of 60 kg/ha N.

The first treatment for disease and pest control in winter wheat was applied during the early stem elongation stage (BBCH 30-32) using the fungicide Twist Plus (100 g/l trifloxystrobin + 200 g/l tebuconazole) – 1.0 l/ha and the insecticide Apis 200 (200 g/l acetamiprid) – 100 ml/ha, mixed with the foliar fertilizer AgroK (32% phosphorus (P_2O_5), 53% amino acids, potassium (K_2O), 3% organic extract, 2% inert substances) – 3 kg/ha, and the adjuvant Vital 90 (90% isodecyl alcohol ethoxylate) – 0.3 l/ha.

The second treatment for disease and pest control was applied at the beginning of flowering (BBCH 37-39) using the fungicide Revycare (100 g/l mefentrifluconazole + 100 g/l pyraclostrobin) – 0.5-1.0 l/ha and the insecticide Mavrick 2F (240 g/l fluvalinate) – 0.2 l/ha, mixed with the foliar fertilizer AgroK (32% P_2O_5, 53% K_2O, L-amino acids, 3% organic extract, 2% inert substances) – 3 kg/300 l water/ha and the adjuvant Vital (90% isodecyl alcohol ethoxylate) – 100 ml/100 l water.

Herbicide treatments were applied in the spring during the early tillering stage (BBCH 30-32), when the first internode appeared, and the weeds were at the rosette stage with 2-4 leaves or even more advanced (Table 1).

Table 1. List of herbicides and application rates in winter wheat crop

No.	Herbicide	Dose (g–l / ha)	Weed control
1.	Broadway Star (70,8 g/kg piroxulam, 14,2 g/kg florasulam, 70,8 g/kg cloquintocet-mexil)	260 g/ha + 250 l water	Annual and perennial monocots, Annual and perennial dicotyledons
2.	Provalia (135 g/l fluroxypyr +30 g/l thifensulfuron methyl + 5 g/l metsulfuron methyl)	0,5 l/ha – 1,0 l/ha + 250 water	Annual and perennial monocots, Annual and perennial dicotyledons
3.	Dicopur D (600 g/l 2,4-D acid from dimethylamine salt)	1,0 l/ha + 250 l water	Annual and perennial dicotyledons
4.	Sekator Progress OD (100 g/l amidosulfuron + 25 g/l iodosulfuron-methyl-Na + 250 g/l mefenpyr diethyl)	0,1 – 0,15 l/ha + 250 l water	Annual and perennial dicotyledons

The experiment was set up in a Latin rectangle design and includes 8 treatments, 15 m^2 for each variant (7 herbicide treatments and one untreated control), with 3 replications: V_1 - untreated control; V_2 - Broadway Star + adjuvant Vital; V_3 - Broadway Star + Dicopur + adjuvant Vital; V_4 - Broadway Star + Provalia + adjuvant Vital; V_5 - Provalia + adjuvant Vital; V_6 - Dicopur + adjuvant Vital; V_7 - Sekator Progress OD + Broadway Star + adjuvant Vital; and V_8 - Sekator Progress OD + adjuvant Vital.

Weed species counting was performed using a quadrat (0.25 m x 0.25 m) before and after herbicide application at 7, 14, and 28 days, as well as before the winter wheat harvest, when gravimetric determination of weeds was also carried out.

Physiological parameters were measured under semi-controlled conditions for normal CO_2 (390 µmol m^{-2} s^{-1}), variable PAR (0 to 2000 µmol m^{-2} s^{-1}), when plants were in the early stem elongation stage (BBCH 28-30). A total of 15 readings per plant were taken, with 5 plants per treatment and 3 replications. The measurement duration was determined by the adaptation period of the tissues in the testing chamber. Assimilation (A=µmol CO_2 m^{-2} s^{-1}) and evapotranspiration (E=mmol H_2O m^{-2} s^{-1}) were selected for analysis.

The research method used was non-destructive (leaves were not detached from the plants) and relied on the use of the CIRAS-3 leaf gas analyzer, which simultaneously measures multiple physiological and environmental indicators (PP Systems USA, 2014).

The data obtained were statistically processed using ANOVA with the Polifact software, for LSD at 5%, 1%, and 0.1% levels (ANOVA, 2015). Quality indices were determined using the INFRAMATIC 9500 NIR analyzer.

RESULTS AND DISCUSSIONS

The thermal regime in the autumn of 2023 (October-November) was generally about 1-2°C higher than the multiannual average, providing favorable conditions for wheat germination, promoting the initial plant development, and maintaining adequate values for root stabilization and preparing the plant for entry into vegetative dormancy.

During the winter period (December-February), the monthly average temperatures were generally about 1-2°C higher than the multiannual average, allowing the wheat to undergo vegetative dormancy without significant frost risks, ensuring favorable conditions for plant survival.

Spring (March-May) was characterized by a significant increase in temperature, especially in April, when the average temperature exceeded the multiannual values by 1-2°C, favoring rapid plant development and accelerating the vegetative growth process.

In the summer of 2023 (June-July), the monthly average temperatures exceeded the multiannual average by values ranging from 3.7 to 4.2°C, favoring rapid plant growth and accelerating crop maturation.

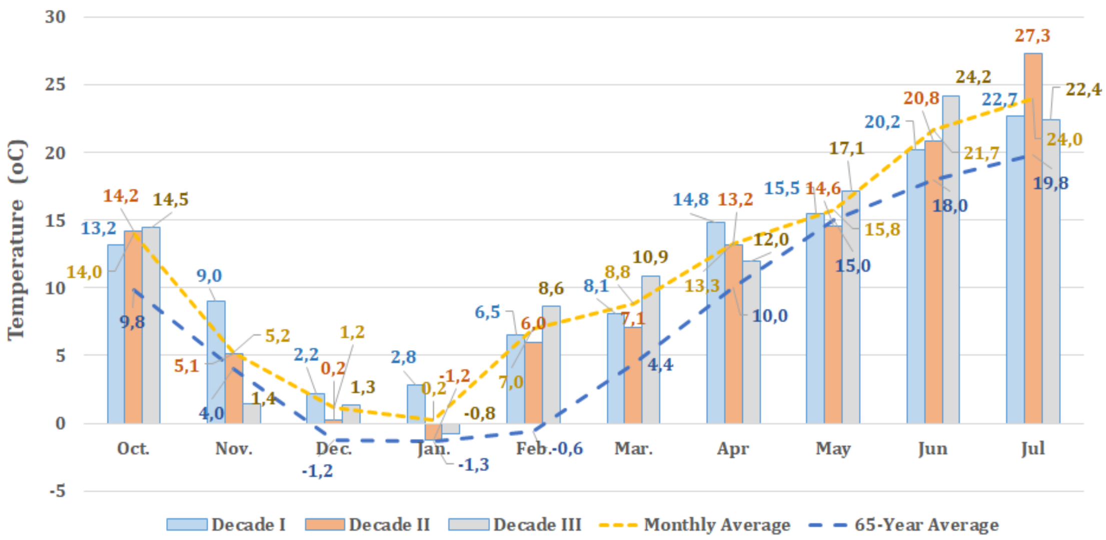

Figure 1. Temperature between October 2023 - July 2024 (A.R.D.S. Turda)

The precipitation regime in the autumn of 2023 (October-November) was higher than the multiannual average, with 19.8 mm of rainfall in October and 43.6 mm in November. These values supported the initial development of winter wheat, providing sufficient moisture for germination and root stabilization before vegetative dormancy.

During the winter period (December-February), precipitation was balanced, with 17.8 mm in December and 4.8 mm in January, below the multiannual average. Spring (March-May) was marked by abundant precipitation, especially in April (38.8 mm), exceeding the multiannual average and favoring rapid plant growth and accelerated vegetative development.

In the summer of 2023 (June-July), precipitation was significantly lower than the multiannual average (36.2 mm in June and 49.0 mm in July), resulting in a period of moderate drought. However, the impact was mitigated by the rainfall in the previous months. The drought set in starting in June, shortening the vegetative phases.

The characterization of the thermal and precipitation regime for the winter wheat crop in the 2023-2024 period was based on the primary data recorded by the Turda Meteorological Station (Figures 1 and 2).

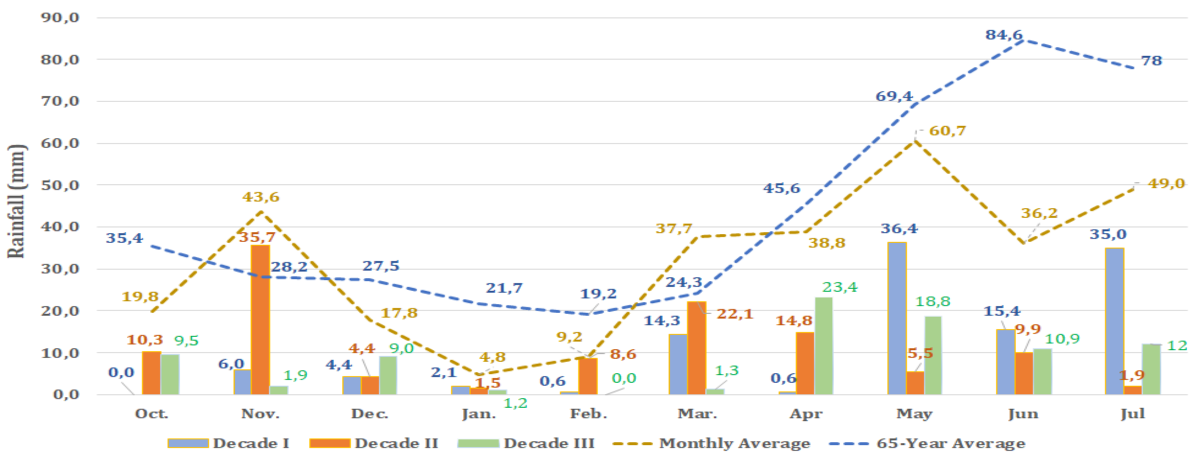

Figure 2. Rainfall bewteen October 2023-July 2024 (A.R.D.S. Turda)
Turda Meteorological Station (longitude: 23°47'; latitude: 46°35'; altitude: 427 m)

From the measurements taken one day after the application of herbicides, it is evident that the applied products did not affect the assimilation of wheat plants in the V_3 (Broadway Star + Dicopur D + AGRO-K + adjuvant Vital) and V_7 (Sekator Progress OD + Broadway Star + AGRO-K + adjuvant Vital) variants, with values over 13.60 µmol m² s⁻¹, similar to the untreated control, indicating good initial tolerance. In contrast, the V_2 (Broadway Star + AGRO-K + adjuvant Vital) and V_4 (Broadway Star + Provalia + AGRO-K + adjuvant Vital) variants recorded significant reductions in assimilation, below 12.33 µmol m² s⁻¹, suggesting physiological stress on photosynthesis, which was statistically confirmed ($p < 0.05$), with very significant negative differences compared to the untreated control (Table 2).

Seven days after the herbicide application, increased assimilation showed more intense photosynthetic activity, indicating a greater capacity of the plants to fix carbon dioxide and produce organic substances. The V_2 (Broadway Star + AGRO-K + adjuvant Vital) and V_8 (Sekator Progress OD + AGRO-K + adjuvant Vital) variants recorded the highest assimilation values, exceeding 17.00 µmol m² s⁻¹, with very significant differences compared to the control ($p < 0.001$).

In the V_7 and V_5 (Sekator Progress OD + Broadway Star + AGRO-K + adjuvant Vital; Provalia + AGRO-K + adjuvant Vital) variants, assimilation exceeded 16.30 µmol m² s⁻¹, indicating a good recovery and effective adaptation ($p < 0.05$), while the other variants showed no significant differences compared to the control, indicating stable tolerance (Table 2).

Table 2. The influence of herbicides on assimilation in winter wheat

No	Herbicide	Assimilation (A-µmolm $^{-2}$ s $^{-1}$)		Significance	
		1 day	7 days		
V_1	Control variant (cv)	13,93	15,57	cv	cv
V_2	Broadway Star + AGRO-K+adj Vital	12,33	17,70	00	***
V_3	Broadway S + Dicopur D +AGRO-K+ adj Vital	13,67	15,47	-	-
V_4	Broadway S + Provalia+ AGRO-K+adj Vital	12,17	15,53	000	-
V_5	Provalia + AGRO-K+ adj Vital	12,43	16,37	00	*
V_6	Dicopur D + AGRO-K+ adj Vital	12,93	15,73	0	-
V_7	Sekator P. OD +Broadway+AGRO-K+adj Vital	13,97	16,90	-	**
V_8	Sekator Progress OD + AGRO-K+ adj Vital	12,87	17,03	0	***

LSD (p 5%) – 0,83; LSD (p 1%) – 1,16; LSD (p 0.1%)- 1.61.
LSD (p 5%) – 0,75; LSD (p 1%) – 1,04; LSD (p 0.1%)- 1.45

Notes: cv – control variant; - insignificant; * -significant positive; ** - significantly positive difference; *** - very significantly positive; 0 - significant negative; 00- significantly negative difference; 000 - very significantly positive; LSD - Least Significant Difference

The highest values of evapotranspiration, recorded one day after the application of herbicides, exceeding 1.05 mmol H_2O m⁻² s⁻¹, were observed in the V_4 (Broadway Star + Provalia + AGRO-K + adjuvant Vital), V_3 (Broadway Star + Dicopur D + AGRO-K + adjuvant Vital), and V_8 (Sekator Progress OD + AGRO-K + adjuvant Vital) treatments, confirmed statistically with distinct and highly significant positive differences compared to the untreated control ($p < 0.001$). The products applied in these experimental treatments influenced stomatal opening and led to an increase in water consumption (Table 3).

The V_2 (Broadway Star + AGRO-K + adjuvant Vital), V_5 (Provalia + AGRO-K + adjuvant Vital), and V_7 (Sekator Progress OD + Broadway Star + AGRO-K + adjuvant Vital) treatments recorded evapotranspiration values exceeding 0.90 mmol H_2O m^{-2} s^{-1}without showing statistically significant differences compared to the control.The lowest evapotranspiration value, 0.79 mmol H_2O m^{-2} s^{-1}, was recorded in the V_6 (Dicopur D + AGRO-K + adjuvant Vital) treatment, statistically confirmed ($p < 0.01$), with distinctly significant negative differences compared to the untreated control.

These differences indicate significant variability between treatments in response to herbicides, and statistical analysis highlights a significant negative impact on evapotranspiration for certain weed control treatments.

The measurement of physiological parameters performed seven days after herbicide application shows that the lowest evapotranspiration values, below 0.60 mmol H_2O m^{-2} s^{-1}, were recorded in the V_7 (Sekator Progress OD + foliar fertilizer AGRO-K + adjuvant Vital) and V_8 (Broadway Star + foliar fertilizer AGRO-K + adjuvant Vital) treatments, confirmed statistically as being highly significantly negative compared to the untreated control ($p < 0.001$).

The highest evapotranspiration values, exceeding 1.15 mmol H_2O m^{-2} s^{-1}, were observed in the V_5 (Provalia + AGRO-K + adjuvant Vital), V_2 (Broadway Star + AGRO-K + adjuvant Vital), V_4 (Broadway Star + Provalia + AGRO-K + adjuvant Vital), and V_6 (Dicopur D + AGRO-K + adjuvant Vital), treatments.

These values were statistically confirmed as significantly higher than the untreated control ($p < 0.001$), indicating a positive influence on stomatal opening and more intensive use of water resources. This reaction may indicate a stimulation of plant metabolic activity, promoting essential physiological processes for their growth and development (Table 3).

Table 3. The influence of herbicides on evapotranspirationn winter wheat

No	Herbicide	Evapotranspiration (Ev-mmol H_2O $m^{-2}s^{-1}$)		Significance	
		1 day	7 days		
V_1	Control variant (cv)	0,91	1,07	**cv**	**cv**
V_2	Broadway Star + AGRO-K+adj Vital	0,97	1,23	-	**
V_3	Broadway S + Dicopur D +AGRO-K+ adj Vital	1,12	1,14	***	-
V_4	Broadway S + Provalia+ AGRO-K+adj Vital	1,06	1,22	**	**
V_5	Provalia + AGRO-K+ adj Vital	0,93	1,19	-	*
V_6	Dicopur D + AGRO-K+ adj Vital	0,79	1,27	00	***
V_7	Sekator Progress OD + Broadway+AGRO-K	0,92	0,54	-	000
V_8	Sekator Progress OD + AGRO-K+ adj Vital	1,13	0,57	***	000

LSD (p 5%) – 0,09; LSD (p 1%) – 0,12; LSD (p 0.1%)- 0.17.
LSD (p 5%) – 0,10; LSD (p 1%) – 0,14; LSD (p 0.1%)- 0.19.
Notes: cv – control variant; - insignificant; * -significant positive; ** - significantly positive difference; *** - very significantly positive; 0 - significant negative; 00- significantly negative difference; 000 - very significantly positive; LSD - Least Significant Difference.

At the time of herbicide application, the weed spectrum averaged approximately 25–30%, with the predominant species being: Polygonum convolvulus - 42.6%, Setaria glauca - 16.3%, Chenopodium album - 11.9%, Amaranthus retroflexus - 8.7%, Veronica hederifolia - 4.6%, Polygonum aviculare - 3.9%, Viola arvensis - 3.2%, Stachys annua - 2.6%, Convolvulus arvensis - 2.2%, Anagallis arvensis - 1.9%, Xanthium strumarium - 1.4%, Anthemis arvensis - 0.7%, Echinochloa crus-galli - 0.5%.

The applied treatments demonstrated maximum efficacy in variants using a single herbicide and those involving multiple herbicides. The best results in weed control, observed at 7, 14, and 28 days after application, were recorded for variants V_5 and V_2, where the herbicides Provalia (135 g/l fluroxypyr + 30 g/l thifensulfuron methyl + 5 g/l metsulfuron methyl) and Broadway Star (70.8 g/kg pyroxulam, 14.2 g/kg florasulam, 70.8 g/kg cloquintocet-mexil) were used together with the foliar fertilizer AGRO-K and the adjuvant Vital. The efficacy of these herbicides exceeded 95% and 90%, respectively, with a significant impact on several weed species. Thus, Polygonum convolvulus, Convolvulus arvensis, and Veronica hederifolia exhibited symptoms of yellowing and stem twisting, while Viola arvensis (field violet) and Setaria glauca (yellow foxtail) showed signs of wilting. Amaranthus retroflexus (redroot pigweed), Chenopodium album (common lambsquarters), and Stachys annua (annual woundwort) displayed necrosis on leaves and stems.

Regarding herbicide combinations, the best results were obtained with variants V_4 (Broadway Star – 60 g/l pyroxasulfone + Provalia + adjuvant Vital) and V_7 (Sekator Progress OD – 50 g/l pinoxaden + Broadway Star – 40 g/l pyroxasulfone + adjuvant Vital), with efficacy exceeding 97% and 91%, respectively.

These combinations demonstrated effective weed control with a significant impact on both annual and perennial species, including monocotyledons and dicotyledons (Table 4).

After 28 days, the effectiveness of herbicide treatments began to decline, and the wheat crop experienced reinfestation. By the time of harvest, the average weed presence was below 10–15%. The most dominant species were: Polygonum convolvulus (48.0%), Setaria viridis (15.4%), Polygonum aviculare (8.7%), Convolvulus arvensis (5.3%), Silene latifolia (4.0%), Viola arvensis (3.4%), Xanthium strumarium (1.5%), Anagallis arvensis (1.3%), Hibiscus trionum and Stachys arvensis (0.9%), Chenopodium album (0.6%), Cirsium arvense, Veronica heterophylla, and Echinochloa crus-galli (0.5%).

Considering only the variants where a single herbicide product was applied, the data indicates that the highest yields were recorded in V_5 and V_2 variants, corresponding to Provalia (135 g/l fluroxypyr + 30 g/l thifensulfuron methyl + 5 g/l metsulfuron methyl + AGRO-K + adjuvant Vital) and Broadway Star (70.8 g/kg pyroxulam, 14.2 g/kg florasulam, 70.8 g/kg cloquintocet-mexil + AGRO-K + adjuvant Vital). These treatments achieved yields exceeding 6000 kg • ha^{-1}, with an average efficacy of 90%, statistically confirmed as highly significant compared to the untreated control ($p < 0.001$).

For the variants where two combined herbicides were applied, the best yield, over 6150 kg/ha, was recorded in variant V4 (Broadway Star – 70.8 g/kg pyroxsulam, 14.2 g/kg florasulam, 70.8 g/kg cloquintocet-mexyl + Provalia – 135 g/l fluroxypyr, 30 g/l thifensulfuron methyl, 5 g/l metsulfuron methyl + AGRO-K + adjuvant Vital), with the difference compared to the control being statistically confirmed as highly significant positive ($p < 0.001$), indicating superior efficiency in weed management and substantially improving agricultural yield (Table 4).

Table 4. The effect of herbicides applied to winter wheat on weed infestation levels and yield.

No	Herbicide	% of control on days				kg • ha^{-1}	Signif.
		7	14	28	Mean		
V_1	Control variant (cv)	0%	0%	0%	0%	5028	cv
V_2	Broadway Star + AGRO-K + adj Vital	87%	93%	90%	90%	6018	***
V_3	Broadway S + Dicopur D +AGRO-K+ adj Vital	85%	90%	88%	87%	5880	***
V_4	Broadway S + Provalia+ AGRO-K+ adj Vital	95%	99%	97%	97%	6188	***
V_5	Provalia + AGRO-K+ adj Vital	92%	97%	95%	95%	6317	***
V_6	Dicopur D + AGRO-K+adj Vital	30%	40%	35%	35%	5114	-
V_7	SekatorP.OD+ Broadway+AGRO-K+adj Vital	87%	95%	92%	91%	5935	***
V_8	Sekator Progress OD + AGRO-K+ adj Vital	85%	90%	87%	87%	5477	**

LSD (p 5%) – 236,40; LSD (p 1%) – 327,67; LSD (p 0.1%)- 455.21

For the winter wheat variety Andrada, quality indices are influenced not only by herbicides but also by biotic and abiotic factors, such as temperature, humidity, and soil type, which can either stimulate or limit the accumulation of protein and gluten, as noted by Racz et al. in 2022 (Moldovan et al., 2012). The best variants showed improvements in protein content, exceeding 11.60%, with V_7 (Sekator Progress OD + Broadway + AGRO-K + adj Vital), V_8 (Sekator Progress OD + AGRO-K + adj Vital), V_3 (Broadway S + Dicopur D + AGRO-K + adj Vital), and V_4 (Broadway S + Provalia + AGRO-K + adj Vital) registering significant differences compared to the untreated control.

For gluten content, most variants recorded positive values, with the highest observed in variants V_7 (Sekator Progress OD + Broadway + AGRO-K + adj Vital) and V_8 (Sekator Progress OD + AGRO-K + adj Vital), both exceeding 23%, and showing significant and very significant differences compared to the control.
The lowest quality indices were recorded for variant V_6 (Dicopur D + AGRO-K + adj Vital), which had a low protein content (10.47%) and gluten content (18.4%), showing very significant negative differences compared to the untreated control (Table 5).

Table 5. The influence of herbicides on protein and gluten content in winter wheat

No	Herbicide	Protein %	Significance	Gluten %	Significance
V_1	Control variant (cv)	11.30	Mt	21,4	cv
V_2	Broadway Star + AGRO-K + adj Vital	11.40	-	21,9	***
V_3	Broadway S + Dicopur D +AGRO-K+ adj Vital	11.77	***	22,8	***
V_4	Broadway S + Provalia+ AGRO-K+ adj Vital	11.60	*	22,2	***
V_5	Provalia + AGRO-K+ adj Vital	11.43	-	21,5	***
V_6	Dicopur D + AGRO-K+adj Vital	10.47	000	18,4	-
V_7	Sekator Progress OD + Broadway +AGRO-K	12.07	***	23,5	***
V_8	Sekator Progress OD + AGRO-K+ adj Vital	12.13	***	23,0	**

LSD (p 5%) – 0,21; LSD (p 1%) – 0,30; LSD (p 0.1%) - 0.41.
LSD (p 5%) – 0,57; LSD (p 1%) – 0,79; LSD (p 0.1%) - 1,10
Notes: cv – control variant; - insignificant; * -significant positive; ** - significantly positive difference; *** - very significantly positive; 0 -significant negative; 00 - significantly negative difference; 000 - very significantly positive; LSD - Least Significant Difference.

CONCLUSIONS

The appropriate selection of herbicides significantly influences assimilation and evapotranspiration, reduces physiological and water stress, contributes to efficient water use, and supports optimal crop development, thereby improving final production and plant health.

The highest yields were obtained in the V_5 – Provalia + AGRO-K + adj Vital, V_2 – Broadway Star + AGRO-K + adj Vital, and V_4 – Broadway Star + Provalia + AGRO-K + adj Vital treatments, with yield increases of over 950 kg/ha, showing highly significant positive differences compared to the control ($p < 0.001$).

Regarding the quality indices of winter wheat, the best results were obtained in the V_7 (Sekator Progress OD + Broadway + AGRO-K + adj Vital) and V_8 (Sekator Progress OD + AGRO-K + adj Vital) treatments, which showed the highest protein content, over 12.00%, and the highest gluten values, over 23.0%, with highly significant differences compared to the control ($p < 0.001$).

The application of herbicides to the Andrada winter wheat variety significantly reduced the number of weeds, with high efficacy for annual monocotyledonous and dicotyledonous species, allowing for healthy crop development and thus contributing to increased yield and quality.

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