

STUDY OF THE EFFECT OF SOME FOLIAR HERBICIDES ON ALFALFA (*Medicago sativa* L.) IN CHANGING CLIMATE CONDITIONS

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Abstract

In a study, conducted during the period 2023-24, it was found that weed control in alfalfa is difficult to achieve with a single herbicide application. The efficacy varies depending on the species composition of the weeds. The highest efficacy against Eastern groundsel, Prickly lettuce and Shepherd's purse was reported when Corum - 125 ml/da is applied, against Field pennycress and Flixweed with Pulsar Plus - 160 ml/da, against Milk thistle with Cleranda SC - 200 ml/da. The highest phytotoxicity was registered at variant treated with Onix - 100 ml/da - score 4, and it is not completely overcome and remains visible until the first swath. At all other other variants, the phytotoxicity is weaker and is overcome by the plants. The highest chlorophyll index was recorded with untreated control, and the lowest with Onyx treatment - 100 ml/da at the first reporting, with the values of the indicator increasing at subsequent reading dates. Foliar herbicides treatments does not unidirectionally affect the plants height, as well as the yield of green and dry mass.

Key words: alfalfa, weeds, weed control, yield.

INTRODUCTION

According to Radović et al. (2009) alfalfa is a forage crop of great importance. It is having a protein-rich forage with high digestibility. The sown areas with alfalfa in Bulgaria for 2023 were 85 536 ha, and the total dry mass production - 279 873 tons (<https://www.mzh.government.bg>)

Managing the weeds in the stands is a critical part of alfalfa growing (Beck et al., 2017). In alfalfa fields a great number of weeds are developing together with the crop: Annual - *Amaranthus retroflexus*, *Chenopodium album*, *Stellaria media*, *Lamium applexiculare*, *Sinapis arvensis*, *Anthemis arvensis*, *Capsella bursa-pastoris*, *Polygonum convolvulus*, *Erygeron canadense*, *Echinochloa crus-galli*, etc.; Perennial - *Convolvulus arvensis*, *Cirsium arvense*, *Sonchus arvensis*, *Cynodon dactylon*, *Sorghum halepense*, *Rumex crispus*, etc. A big problem is the parasitic weed *Cuscuta* spp. (Bogatsevskia et al., 2008; Tonev et al., 2019). The weed management in alfalfa have to be performed by integrated approach combining preventive, cultural and chemical means (Bogatsevskia et al., 2008; Tonev et al., 2019).

A great number of studies are being conducted worldwide related to chemical weed control in alfalfa. Herbicides with high crop selectivity

have been registered for weed control in alfalfa (Srinivasan et al., 2006; Zhang et al., 2010). According to Dillehay et al. (2010) and Meiss et al. (2010), the realization of the full biological potential of alfalfa and the longevity of the crop are closely related to the competitive impact of weeds depending on the degree and duration of weeding.

Both soil and foliar herbicides have been found to be highly effective against most annual monocotyledonous and dicotyledonous weed species that infest alfalfa stands (Dimitrova, 2001; Arregui et al., 2001; Cummings et al., 2004; Dimitrova, 2007; Meighani et al., 2010). Devine et al. (1993) found that plant species and varieties exhibit different sensitivity to a particular herbicide. Similar studies in Bulgaria are limited. Marinov-Serafimov and Kertikova (2011) found specific varietal responses of alfalfa genotypes to the herbicidal product Pledge 50 VP.

The critical period for weed control has been well studied in many crops, and the results are used to develop recommendations for better weed management. However, the research on the critical period for weed control in alfalfa is limited. With the advent of new, more effective foliar herbicides, establishing the critical period may further improve yields. The objective of a study conducted by Dillehay et al. (2011) was to

determine the critical period for weed control in spring-sown alfalfa. In 2004, the critical period varied depending on location, but began at the 0.5 tri-foliate growth stage of alfalfa and ended at the 7 tri-foliate growth stage.

The herbicides metribuzin and simazine applied in the fall were evaluated in field trials conducted from 1978 to 1980 in western Nebraska for selective weed control in non-irrigated, established alfalfa. All herbicides effectively controlled the weed *Bromus tectorum*. Broadleaf weeds were controlled to varying levels by the herbicides tested. All herbicide treatments increased yield and protein content compared with the untreated control (Wilson, 1981).

The efficacy of spring-applied herbicides was evaluated in western Nebraska from 1982 to 1984 for selective weed control in alfalfa. Weed densities were lowest in plots treated pre-plant with benefin in combination with post emergence applications of 2,4-D. Combinations of sethoxydim with bromoxynil and fluzafop-butyl with bromoxynil provided lower control of the grass weeds than sethoxydim or fluzafop-butyl applied alone (Wilson, 1986).

Marinov-Serafimov et al. (2016) conducted an experiment in 2014-2015 at the Institute of Forage Crops – Pleven, Bulgaria, studying the selectivity of three herbicides Listego 40, Cleranda, and Stratos ultra at alfalfa, variety Dara. The digestibility of dry and organic matter of the forage in all variants of the experiment varied in the range from 59.61 to 60.88%, and did not depend on the selectivity of the studied herbicides to alfalfa.

There is still low amount of information for the influence of different herbicides to alfalfa. Therefore, the aim of this study is to establish the efficacy of various herbicide products on against some weeds in alfalfa and the influence of treatments on the growth and reproductive performance of the crop.

MATERIALS AND METHODS

The experiment was carried out in the experimental field at the experimental field of the Agricultural University – Plovdiv, Bulgaria. The experiment was carried out in two consecutive years - 2023 (3rd vegetation of alfalfa) and 2024 (4th vegetation of alfalfa). The

experiment was set up using the long plots method. The plot size is 60 m².

The experiment included the following variants:

1. Untreated control;
 2. Cleranda SC (375 g/l metazachlor + 17.5 g/l imazamox) – 2.00 L ha⁻¹;
 3. Pulsar 40 (40 g/l imazamox) – 1.20 L ha⁻¹;
 4. Pulsar Plus (25 g/l imazamox) – 1.60 L ha⁻¹;
 5. Corum (480 g/l bentazone + 22.4 g/l imazamox) – 1.25 L ha⁻¹;
 6. Onix 60 EC (600 g/l pyridate) – 1.00 L ha⁻¹.
- The herbicides were applied in the phenophase 3rd – 5th fully developed tri-foliate of alfalfa (BBCH 13-15).

For the purpose of the experiment, an alfalfa variety was grown - “PR 54 Q 14” from Corteva Agriscience (<https://www.corteva.bg>). The sowing was performed in the autumn of 2022 after preceding crop winter wheat.

Weed infestation in alfalfa is represented by: *Senecio vernalis* Waldst. & Kit. – 14 pieces/m² in 2023 and 18 pieces/m² in 2024; *Lactuca serriola* L. – 10 pieces/m² in 2023 and 15 pieces/m² in 2024; *Capsella bursa-pastoris* L. – 7 pieces/m² in 2023 and 10 pieces/m² in 2024; *Thlaspi arvense* L. – 5 pieces/m² in 2023 and 7 pieces/m² in 2024; *Sonchus oleraceus* L. – 9 pieces/m² in 2023 and 5 pieces/m² in 2024; *Descurainia sophia* L. – 6 pieces/m² in 2023 and 8 pieces/m² in 2024.

The efficacy of the herbicides was assessed using the 10-score visual scale of EWRS (European Weed Research Society) on the 14th and 28th days after treatments. The selectivity of the herbicides was assessed using the 9-score EWRS scale on the 7th and 14th days after treatment (1. No symptoms; 2. Very weak symptoms - weak suppression; 3. Weak but easily recognizable symptoms; 4. More pronounced symptoms (e.g. chlorosis); 5. Thinning, severe chlorosis or suppression, with expected yield reduction; 6. Severely damaged to complete death /Moderately bad/; 7. Severely damaged to complete death /Poor/; 8. Severely damaged to complete death /Very bad/; 9. Severely damaged to complete death /Absolutely bad/).

The following indicators were recorded for alfalfa: - Leaf chlorophyll content index (CCI Index) - 7, 14 and 21 days after treatment (only at the first swath). The measurement was performed with a portable chlorophyll measuring device (CCM-200 plus Chlorophyll Content Meter) from ADC BioScientific Ltd.,

UK (<https://www.optisci.com/ccm-200.html>). The chlorophyll content index was recorded on twenty randomly chosen alfalfa plants from a variant, and the average values from the twenty measurements are presented.

- Plant height at the first and second swath (cm). Measurements were made on thirty plants of each variant;

- Fresh and dry mass at the first and second swath (t ha⁻¹). To perform statistical analysis, each plot was divided into three parts of 20 m² to obtain three replications. Each 20 m² was mowed separately and the alfalfa was weighed in a fresh state. To determine the dry mass, the alfalfa mass from each 20 m² of the plot was spread out and periodically turned over for drying and weighed again separately. The results were averaged per plot and converted into t ha⁻¹. The first swath was done in the budding stage of the alfalfa. The second swath was done 35 days after the first.

For statistical processing of the data, the Duncan method was used with the SPSS 19 program. Differences were considered significant at p<0.05.

RESULTS AND DISCUSSIONS

On table 1 the average amount of precipitation, as well as the average minimum and maximum air temperatures during the alfalfa growing seasons (for the period January-December in 2023 and for the period January-August in 2024). According to the meteorological data, we can determine how agro-climatic conditions affect the development of alfalfa.

Table 1. Average monthly precipitation (mm) and average monthly minimum and maximum air temperatures (C°) during the trial period (2023/2024)

Months	Precipitation		min t°	max t°	min t°	max t°
	2023	2024	2023		2024	
January	36.8	47.8	1.6	11.2	-1.9	9.9
February	21.3	6.8	-0.5	14.2	2.6	17.4
March	14.8	39.3	2.3	17.3	4.9	17.7
April	70.3	37.3	6.4	20.3	8.4	25.8
May	78.8	74.5	10.8	23.5	11.2	24.3
June	60.8	5.3	14.8	31.3	17.5	35.1
July	31.8	11.3	18.7	37.8	18.9	37.1
August	21.4	19.5	17.8	36.7	17.9	36.8
September	15.0	-	14.4	30.9	-	-
October	2.3	-	8.6	26.5	-	-
November	52.8	-	3.9	15.8	-	-
December	51.0	-	-0.2	12.1	-	-

It is seen from Table 1 that the amount of precipitation during the months from March to June in the two experimental years (2023 and 2024) contributed to relatively good moisture storage and the production of two swaths.

The temperatures (min and max) were suitable for the plants development. Despite the high winter temperatures, no negative impact of the warm winter months on the growth and development of alfalfa was found. There were higher temperatures in the second experimental year, especially in the period June-August.

During the experimental period, no more than two swaths of alfalfa were made due to the low amounts of precipitation during the period July-September.

Based on the analysis of meteorological data, we can indicate the two experimental years as relatively unfavorable for the growth, development and realization of the productive potential of alfalfa.

The efficacy of the studied herbicides is presented in 6 tables. Similar efficacy was found during the two experimental years, with efficacy being lower on the first reporting date and higher on the second.

On Table 2 is presented the efficacy against *S. vernalis*. On average for the period, on the 14th and 28th day after treatments, the highest efficacy was recorded after the application of Corum – 1.25 L ha⁻¹ – 75 and 92.5% respectively. On average for the two years, on the 14th and 28th, the lowest efficacy was recorded after the treatment with Onix 60 – 1.00 L ha⁻¹ – 42.5 and 52.5% respectively. For the other tested herbicide products, the efficacy ranged from 45 to 55% on the 14th day and from 65 to 75% on the 28th day.

Table 2. Efficacy of the herbicides against the weed *S. vernalis*, %

Treatments	2023		2024		Average	
	14 day	28 day	14 day	28 day	14 day	28 day
1. Untreated control	-	-	-	-	-	-
2. Cleranda SC – 2.00 L ha ⁻¹	50	70	60	80	55	75
3. Pulsar 40 – 1.20 L ha ⁻¹	40	60	50	70	45	65
4. Pulsar Plus – 1.60 L ha ⁻¹	45	65	60	75	52.5	70
5. Corum – 1.25 L ha ⁻¹	70	90	80	95	75	92.5
6. Onix 60 EC – 1.00 L ha ⁻¹	40	50	45	55	42.5	52.5

Table 3 presents the efficacy against *L. serriola*. On average for the period, on the 14th and 28th day after treatments, the highest efficacy was recorded after the application of Corum – 1.25 L ha⁻¹ – 75 and 92.5% respectively. On average for the two years of the experiment, the lowest efficacy was recorded after the treatment with Onix 60 EC – 1.00 L ha⁻¹ – 37.5 and 47.5% respectively. For the other tested herbicide products, the efficacy ranged from 52.5 to 67.5% on the 14th day and from 77.5 to 87.5% on the 28th day.

Table 3. Efficacy of the herbicides against the weed *L. serriola*, %

Treatments	2023		2024		Average	
	14 day	28 day	14 day	28 day	14 day	28 day
1. Untreated control	-	-	-	-	-	-
2. Cleranda SC – 2.00 L ha ⁻¹	60	80	75	95	67.5	87.5
3. Pulsar 40 – 1.20 L ha ⁻¹	50	70	55	80	52.5	75
4. Pulsar Plus – 1.60 L ha ⁻¹	55	75	65	80	60	77.5
5. Corum – 1.25 L ha ⁻¹	70	90	80	95	75	92.5
6. Onix 60 EC – 1.00 L ha ⁻¹	35	45	40	50	37.5	47.5

On Table 4 is the efficacy against the weed *C. bursa-pastoris*. The efficacy of the evaluated products against this weed was higher than that found for the abovementioned species.

Table 4. Efficacy of the herbicides against the weed *C. bursa-pastoris*, %

Treatments	2023		2024		Average	
	14 day	28 day	14 day	28 day	14 day	28 day
1. Untreated control	-	-	-	-	-	-
2. Cleranda SC – 2.00 L ha ⁻¹	70	90	75	95	72.5	92.5
3. Pulsar 40 – 1.20 L ha ⁻¹	65	85	75	90	70	87.5
4. Pulsar Plus – 1.60 L ha ⁻¹	75	90	80	85	77.5	87.5
5. Corum – 1.25 L ha ⁻¹	75	95	75	95	75	95
6. Onix 60 EC – 1.00 L ha ⁻¹	40	50	50	60	45	55

On average for the period, on the 14th and 28th day after treatment, the highest efficacy after the application of Corum – 1.25 L ha⁻¹ – 75 and 95% respectively was recorded. The efficacy of the treatment with Pulsar 40 and Pulsar Plus against the weed was high as well. On average for the two years of the trial, on the 14th and 28th day after treatment, the lowest efficacy was recorded after the treatment with Onix 60 EC – 1.00 L ha⁻¹ – 45 and 55% respectively.

The efficacy against the weed *Th. arvense* is shown on Table 5. Both for *C. bursa-pastoris* and for *Th. Arvense* as well, the efficacy of the studied herbicidal products was higher than that recorded for the weeds *S. vernalis* and *L. serriola*. On average for the period, on the 14th and 28th day after treatment, the highest efficacy was recorded after the application of Pulsar Plus – 1.60 L ha⁻¹ – 77.5 and 95% respectively. The efficacy of the treatment with Pulsar 40 and Corum against the weed was high – 72.5 and 92.5% respectively on the 14th and 28th day after treatment. On average for the two years of the experiment, the lowest efficacy after the treatment with Onyx 60 EC – 1.00 L ha⁻¹ – 37.5 and 47.5% respectively was recorded.

Table 5. Efficacy of the herbicides against the weed *Th. arvense*, %

Treatments	2023		2024		Average	
	14 day	28 day	14 day	28 day	14 day	28 day
1. Untreated control	-	-	-	-	-	-
2. Cleranda SC – 2.00 L ha ⁻¹	75	90	70	95	72.5	92.5
3. Pulsar 40 – 1.20 L ha ⁻¹	70	85	65	85	67.5	85
4. Pulsar Plus – 1.60 L ha ⁻¹	75	95	80	95	77.5	95
5. Corum – 1.25 L ha ⁻¹	70	90	75	95	72.5	92.5
6. Onix 60 EC – 1.00 L ha ⁻¹	35	45	40	50	37.5	47.5

On Table 6 is presented the efficacy against the weed *S. oleraceus*. On average for the period, the highest efficacy was recorded after the application of Cleranda SK – 2.00 L ha⁻¹ – 75 and 97.5% on the 14th and on the 28th day after treatments respectively. The efficacy of the treatment with Pulsar 40, Pulsar Plus and Corum against the weed on the 14th day after treatment was 70%. On the 28th day, the efficacy of Pulsar

40 and Pulsar Plus was 90%, and that of Corum was 97.5%.

Table 6. Efficacy of the herbicides against the weed *S. oleraceus*, %

Treatments	2023		2024		Average	
	14 day	28 day	14 day	28 day	14 day	28 day
1. Untreated control	-	-	-	-	-	-
2. Cleranda SC – 2.00 L ha ⁻¹	70	95	80	100	75	97,5
3. Pulsar 40 – 1.20 L ha ⁻¹	65	85	75	95	70	90
4. Pulsar Plus – 1.60 L ha ⁻¹	75	90	65	90	70	90
5. Corum – 1.25 L ha ⁻¹	70	90	70	95	70	92,5
6. Onix 60 EC – 1.00 L ha ⁻¹	50	60	50	60	50	60

The efficacy against the weed *D. sophia* is shown on Table 7. On average for the period, on the 14th and 28th day after the herbicidal applications, the highest efficacy after the treatment with Pulsar Plus – 1.60 L ha⁻¹ – 87.5 and 100% respectively was recorded. The efficacy of the treatment with Cleranda SC (77.5%), Pulsar 40 (82.5%) and Corum (72.5%) against the weed on the 14th day after treatment was high as well. On the 28th day, the efficacy of Cleranda SC and Pulsar 40 was 97.5%, and that of Corum – 95%. On average for the two years of the experiment, on the 14th and 28th day after treatment, the lowest efficacy was recorded after the treatment with Onyx – 1.00 L ha⁻¹ – 50 and 55% respectively.

Table 7. Efficacy of the herbicides against the weed *D. sophia*, %

Treatments	2023		2024		Average	
	14 day	28 day	14 day	28 day	14 day	28 day
1. Untreated control	-	-	-	-	-	-
2. Cleranda SC – 2.00 L ha ⁻¹	75	95	80	100	77,5	97,5
3. Pulsar 40 – 1.20 L ha ⁻¹	85	100	80	95	82,5	97,5
4. Pulsar Plus – 1.60 L ha ⁻¹	85	100	90	100	87,5	100
5. Corum – 1.25 L ha ⁻¹	70	95	75	95	72,5	95
6. Onix 60 EC – 1.00 L ha ⁻¹	50	55	50	55	50	55

Visual symptoms of phytotoxicity 7 and 14 days after treatment with the herbicides are presented in Table 8. Seven days after the herbicidal praying, the strongest symptoms of phytotoxicity were found at variants 3 (Pulsar 40 – 1.20 L ha⁻¹), 4 (Pulsar Plus – 1.60 L ha⁻¹), and 6 (Onix 60 EC – 1.00 L ha⁻¹) – score 3.

Table 8. Visual phytotoxicity 7 and 14 days after treatments, scores by EWRS

Treatments	2023		2024	
	7 day	14 day	7 day	14 day
1. Untreated control	-	-	-	-
2. Cleranda SC – 2.00 L ha ⁻¹	2	1	2	1
3. Pulsar 40 – 1.20 L ha ⁻¹	3	1	3	1
4. Pulsar Plus – 1.60 L ha ⁻¹	3	1	3	1
5. Corum – 1.25 L ha ⁻¹	2	1	2	1
6. Onix 60 EC – 1.00 L ha ⁻¹	3	1	3	1

The expressed phytotoxic symptoms of Pulsar 40 and Pulsar Plus were stronger yellowing of the leaves (stronger chlorosis). On the 14th day, the symptoms of phytotoxicity were overcome by the crop. The symptoms caused by the herbicide Onix 60 EC were chlorosis and necrotic spots on the alfalfa leaves. In this variant, the symptoms of phytotoxicity were not completely overcome, and by the second reporting date. On the old leaves of the plants, the symptoms of phytotoxicity remain visible until the time of the first mowing. On the 7th day after the herbicidal applications, phytotoxicity score of 2 in variants 2 (Cleranda SK – 2.00 L ha⁻¹) and 5 (Corum – 1.25 L ha⁻¹) was found. Slight yellowing of the leaves was observed (weak chlorosis). On the 14th day, the symptoms of phytotoxicity were overcome by the crop.

The obtained data for the chlorophyll content index (CCI) for alfalfa is presented in Table 9. Quantification of pigments in plant leaves using non-invasive optical methods is quick and easy, providing reliable data on the relative chlorophyll content compared to traditional and chemical methods (Richardson et al., 2002). Miri (2009) reported that the chlorophyll content index (CCI) is directly and positively correlated with yields. The chlorophyll content in leaves is also used to measure the nitrogen content in leaves, but also as an important indicator of nitrogen deficiency in plants (Cerovic et al., 2012).

In addition, the chlorophyll content index (CCI) can be used as a tool to support decision-making on nitrogen fertilization of crops, as well as to estimate the yield of cultivated plants. The index varies widely among different crops. Tracking the index over time aims to identify any potential disturbances in plants as a result of the treatments.

Table 9. Chlorophyll content index (CCI)

Treatments	2023			2024		
	7 days	14 days	21 days	7 days	14 days	21 days
1. Untreated control	26.2 a	31.6 c	38.6 b	29.0 a	32.9 c	36.7 d
2. Cleranda SC – 2.00 L ha ⁻¹	24.2 b	35.7 a	42.0 a	22.6 c	36.1 a	44.7 a
3. Pulsar 40 – 1.20 L ha ⁻¹	23.2 c	33.5 b	41.9 a	24.4 b	35.9 a	44.9 a
4. Pulsar Plus – 1.60 L ha ⁻¹	22.9 c	32.9 b	41.5 a	24.7 b	34.8 b	43.5 b
5. Corum – 1.25 L ha ⁻¹	24.0 b	34.1 b	41.6 a	23.9 b	36.2 a	42.6 c
6. Onix 60 EC – 1.00 L ha ⁻¹	17.9 d	26.8 d	34.9 c	20.7 d	31.2 d	35.8 e

Figures with different letters are with a proven difference by Duncan's multiple range test ($p < 0.05$)

The data obtained from the dynamic measurements showed that the CCI index increases over time. On the first measurement date and in both experimental years, the highest index was recorded in the untreated control 26.2 CCI (2023) and 29.0 CCI (2023). The lowest chlorophyll index was measured in variant 6 (Onyx 60 EC – 1.00 L ha⁻¹) in both experimental years – 17.9 CCI in 2021 and 20.7 CCI in 2022. On the 7th day after treatment, the chlorophyll index in the remaining variants varied from 22.9 to 24.2 CCI.

On the 14th day after treatments, the highest chlorophyll index was established in variant 2 (Cleranda SC – 2.00 L ha⁻¹) in 2023 – 35.7 CCI. In 2024 with proven higher results were variants 2 (Cleranda SC – 2.00 L ha⁻¹), 3 (Pulsar 40 – 1.20 L ha⁻¹) and 5 (Corum – 1.25 L ha⁻¹) – 36.1, 35.9 and 36.2 CCI respectively. The studied parameter in the untreated control was lower on the second measurement date in both years. On the 21st day after treatment in 2023 with proven higher results for the chlorophyll index compared to the untreated weedy control and option 6 (Onyx – 100 ml/da) are options 2. (Cleranda SC – 2.00 L ha⁻¹), 3 (Pulsar 40 – 1.20 L ha⁻¹), 4 (Pulsar Plus – 1.60 L ha⁻¹) and 5 (Corum – 1.25 L ha⁻¹) - 42.0, 41.9, 41.5 and 41.6 CCI respectively.

On the 21st day after the application of the herbicidal products in 2023 with proven higher results for the chlorophyll index compared to the other variants were variants 2 (Cleranda SC – 2.00 L ha⁻¹) and 3 (Pulsar 40 – 1.20 L ha⁻¹) - 44.7 and 44.9 CCI respectively.

The results obtained for the plant height before the 1st and 2nd swathing of alfalfa are presented in Table 10. Larger differences in plant height were recorded for the first swath. On average for the two experimental years, variant 6 (Onyx 60 EC – 1.00 L ha⁻¹) had the lowest plants – 48.59 cm for the first swath and 51.19 cm for the second swath. The plants from this variant were proven to be lower than the untreated control – 51.92 cm for the first and 51.97 cm for the second swath. In variant 5 (Corum – 1.25 L ha⁻¹) the highest plants were measured – 66.59 cm for the first swath. In the second swath, the plants from variant 3 (Pulsar 40 – 1.20 L ha⁻¹) were the highest – 54.46 cm.

Table 10. Height of the plants at 1st and 2nd swaths, cm

Treatments	2023		2024		Average	
	Swat h 1	Swat h 2	Swat h 1	Swat h 2	Swat h 1	Swat h 2
1. Untreated control	54.71 d	50.12 d	57.12 d	53.22 c	55.92	51.67
2. Cleranda SC – 2.00 L ha ⁻¹	62.54 b	52.19 b	65.19 b	54.07 b	63.87	53.33
3. Pulsar 40 – 1.20 L ha ⁻¹	61.48 c	53.41 a	64.51 c	55.50 a	63.00	54.46
4. Pulsar Plus – 1.60 L ha ⁻¹	60.84 c	51.20 c	63.40 c	52.74 c	62.12	51.97
5. Corum – 1.25 L ha ⁻¹	65.89 a	52.61 b	67.29 a	53.47 b	66.59	53.04
6. Onix 60 EC – 1.00 L ha ⁻¹	49.81 e	50.67 d	47.36 e	51.70 d	48.59	51.19

Figures with different letters are with a proven difference by Duncan's multiple range test ($p < 0.05$)

At the plots treated with herbicides, dry matter yields at the first swath were 30 to 81% and 11 to 78% of those of the untreated and hand-weeded controls, respectively. At the second swath, alfalfa dry matter yields were not affected by the weed control method (Kunelius, 1974). Idris et al. (2014) found that the reduction in yields due to weed competition is 57% and 37% at the first swath, in the first and second year, respectively. The herbicide treatments significantly increased alfalfa yield compared to the untreated control (Cosgrove and Barrett, 1987, Kostov and Pacanoski 2006; Pacanoski, 2011). Our research data corresponds with the findings of the abovementioned authors.

The obtained data from the current trial is shown on table 11. As in the plant height, in the of fresh matter yield from the first swath, larger differences were recorded as well. On average for the two experimental years, the untreated control had the lowest yield of fresh matter – 11.20 t ha⁻¹ in the first cut and 13.30 t ha⁻¹ in the second swath.

Table 11. Fresh mass yield from the 1st and 2nd swath, t ha⁻¹

Treatments	2023		Total from the two swaths
	Swath 1	Swath 2	
1. Untreated control	09.80 c	13.60 c	23.40
2. Cleranda SC – 2.00 L ha ⁻¹	13.20 c	14.00 a	27.20
3. Pulsar 40 – 1.20 L ha ⁻¹	13.50 bc	14.20 a	27.70
4. Pulsar Plus – 1.60 L ha ⁻¹	14.00 b	13.80 b	27.80
5. Corum – 1.25 L ha ⁻¹	15.10 a	14.50 a	29.60
6. Onix 60 EC – 1.00 L ha ⁻¹	11.80 d	14.10 a	25.90
Treatments	2024		Total from the two swaths
	Swath 1	Swath 2	
1. Untreated control	12.70 c	13.00 c	25.70
2. Cleranda SC – 2.00 L ha ⁻¹	13.80 d	13.70 ab	27.50
3. Pulsar 40 – 1.20 L ha ⁻¹	14.20 c	13.90 ab	28.10
4. Pulsar Plus – 1.60 L ha ⁻¹	14.70 b	14.10 a	28.80
5. Corum – 1.25 L ha ⁻¹	16.20 a	14.30 a	30.50
6. Onix 60 EC – 1.00 L ha ⁻¹	10.50 f	13.80 ab	24.30
Treatments	Average		Total from the two swaths - Average
	Swath 1	Swath 2	
1. Untreated control	11.20	13.30	24.50
2. Cleranda SC – 2.00 L ha ⁻¹	13.50	13.90	27.40
3. Pulsar 40 – 1.20 L ha ⁻¹	13.90	14.10	27.90
4. Pulsar Plus – 1.60 L ha ⁻¹	14.40	14.00	28.30
5. Corum – 1.25 L ha ⁻¹	15.70	14.40	30.10
6. Onix 60 EC – 1.00 L ha ⁻¹	11.30	14.00	25.20

Figures with different letters are with a proven difference by Duncan's multiple range test (p<0.05).

The average total yield of fresh matter in the untreated control was 24.50 t ha⁻¹. Variant 5 (Corum – 1.25 L ha⁻¹) stood out with the highest yields of fresh matter – 16.20 t ha⁻¹ in the first and 14.30 t ha⁻¹ in the second swath. The average total yield of fresh matter from the two swaths in this variant was 30.10 t ha⁻¹. In the other variants of the experiment, the average total yield of fresh matter from the two cuts

varied from 25.20 t ha⁻¹ in variant 6 (Onyx 60 EC – 1.00 L ha⁻¹) to 28.30 t ha⁻¹ in variant 4 (Pulsar Plus – 1.60 L ha⁻¹).

The results obtained for the dry matter yield at the 1st and 2nd swaths of alfalfa are presented in Table 12. Average for the two trial years with the lowest dry matter yield were the untreated control and variant 5 (Onyx 60 EC – 1.00 L ha⁻¹) – 4.00 t ha⁻¹ at the first swath. At the second swath, the lowest dry matter yields were found to be from the untreated control and variant 5. Variant 5 (Corum – 1.25 L ha⁻¹) stood out with the highest dry matter yields – 5.10 t ha⁻¹. The average total dry matter yield from the two swaths in this variant was 9.70 t ha⁻¹.

Table 12. Dry matter yield at the 1st and 2nd swaths of alfalfa

Treatments	2023		Total from the two swaths
	Swath 1	Swath 2	
1. Untreated control	3.80 c	4.10 ab	7.90
2. Cleranda SC – 2.00 L ha ⁻¹	4.50 b	4.20 ab	8.70
3. Pulsar 40 – 1.20 L ha ⁻¹	4.10 bc	4.50 a	8.60
4. Pulsar Plus – 1.60 L ha ⁻¹	4.30 b	4.20 ab	8.50
5. Corum – 1.25 L ha ⁻¹	4.90 a	4.30 a	9.20
6. Onix 60 EC – 1.00 L ha ⁻¹	3.90 c	4.20 ab	8.10
Treatments	2024		Total from the two swaths
	Swath 1	Swath 2	
1. Untreated control	4.20 c	4.30 c	8.50
2. Cleranda SC – 2.00 L ha ⁻¹	4.80 b	4.50 b	9.30
3. Pulsar 40 – 1.20 L ha ⁻¹	4.70 b	4.60 b	9.30
4. Pulsar Plus – 1.60 L ha ⁻¹	4.80 b	4.60 b	9.40
5. Corum – 1.25 L ha ⁻¹	5.20 a	4.90 a	10.10
6. Onix 60 EC – 1.00 L ha ⁻¹	4.10 c	4.00 d	8.10
Treatments	Average		Total from the two swaths - Average
	Swath 1	Swath 2	
1. Untreated control	4.00	4.20	8.20
2. Cleranda SC – 2.00 L ha ⁻¹	4.70	4.40	9.10
3. Pulsar 40 – 1.20 L ha ⁻¹	4.40	4.60	9.00
4. Pulsar Plus – 1.60 L ha ⁻¹	4.60	4.40	9.00
5. Corum – 1.25 L ha ⁻¹	5.10	4.60	9.70
6. Onix 60 EC – 1.00 L ha ⁻¹	4.00	4.10	8.10

Figures with different letters are with a proven difference by Duncan's multiple range test (p<0.05).

CONCLUSIONS

The highest efficacy against the weeds *S. vernalis*, *L. serriola* and *C. bursa-pastoris* after the application of Corum was recorded, and the highest efficacy against the weeds *Th. arvense* and *D. sophia* was reported from Pulsar Plus. The highest efficacy against the weed *S. oleraceus* was recorded by Cleranda SC. During

the first measurement date, during both experimental years, the highest chlorophyll index was recorded in the untreated control, and the lowest at Onyx 60 EC. On the following measurement dates in the herbicide-treated variants, with the exception of variant 6, the chlorophyll index increased. In the first swath, variant 6 (Onyx 60 SC) was distinguished by the lowest plants, and variant 5 (Corum) by the highest. In the second swath, the plants of variant 3 (Pulsar 40) were the highest. Variant 5 (Corum) showed the highest yields of fresh and dry alfalfa mass.

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