THE IMPACT OF MCPA (2-METHYL-4-CHLOROPHENOXYACETIC ACID) IN THE CONTROL OF *CIRSIUM ARVENSE* AND *TARAXACUM OFFICINALE* SPECIES IN GRASSLAND ECOSYSTEMS

Ramona ȘTEF[1], Veronica SĂRĂȚEANU[1], Ioana GROZEA[1], Otilia COTUNA[1], Ciprian STROIA[1], Dan MANEA[1], Alin CĂRĂBEȚ[1]

[(1)]University of Life Sciences "King Michael I" from Timisoara, Romania, Calea Aradului, 119, Timișoara, Romania
author email: chirita_ramona@yahoo.com

Corresponding author email: alincarabet@usvt.ro

Abstract

This study aimed to determine the impact of MCPA (2-methyl-4-chlorophenoxyacetic acid) in reducing Cirsium arvense and Taraxacum officinale species in grassland ecosystems. The presence of Cirsium arvense and Taraxacum officinale species represents an obstacle in the preservation and restoration of biodiversity in temporary meadows. At the same time, these species reduce the yield of meadows, a fact that requires the application of control methods. The practical ecosystem in which the study was carried out belongs to the town of Carani, Timiș county. To reduce the population of Cirsium arvense and Taraxacum officinale were applied three herbicides: MCPA 50% DMA, MCPA 75% DMA and Starane. Hormonal herbicides MCPA 50% DMA (0.9 l/ha, 1.2 l/ha, 1.5 l/ha, 2.0l/ha) and MCPA 75% DMA (0.6 l/ha, 0.8 l/ha, 1.0 l/ha, 1.3 l/ha) were applied in four doses. The impact of the substance MCPA, in the control of Cirsium arvense and Taraxacum officinale species, was determined at 15 – 28 and 42 days after application. The herbicides used in the experiment reduced Cirsium arvense and Taraxacum officinale populations in grassland ecosystems by 60-100%. The application of 2-methyl-4-chlorophenoxyacetic acid (MCPA), in different doses, led to a survival of common dandelio, in the experimental variants of 3.33 - 20%. The population being controlled in a proportion of 80-96.67%, 42 days after applying the treatments. The impact of the herbicide, hormonal, MCPA was lower in population control of Cirsium arvense. The effectiveness of the herbicides depended on both the active substance content and the applied dose.

Key words: Cirsium arvense, Traxacum officinale, MCPA, control, grassland

INTRODUCTION

Grasslands are among the most important semi-natural ecosystems, playing a vital role in agriculture, biodiversity conservation, and maintaining ecosystem services such as carbon storage and regulation of hydrological cycles (Hein and Wilson, 2004). Grasslands provide a significant proportion of animal feed globally (O'Mara, 2012).

In Romania, grasslands occupy 4.9 million hectares, ranking 5th in Europe after France, Great Britain, Spain, and Germany (excluding the European part of the Russian Federation). Grasslands represent 33% of the agricultural area of Romania (Maruşca et al., 2010), playing an important role in the availability of fodder resources. However, improper maintenance and exploitation have caused changes in the floristic composition (grasses, legumes, and a small percentage of species from other botanical families that enhance palatability). As a result, 26% of the permanent (natural) grassland area has been invaded by low-value herbaceous vegetation, such as *Nardus stricta*, *Botriochloa ischaemum*, *Pteridium aquilinum*, *Deschampsia caespitosa*, *Rumex* sp., *Veratrum album*, *Urtica dioica*, *Ranunculus repens*, *Taraxacum* spp, *Cirsium arvense, Sorghum halepense, Ambrosia artemisiifolia* etc. (Marușca et. al., 2010, Sărățeanu et al., 2010; Ștef R., 2017; Chifan et al., 2019; Ștef et al., 2022; Sărățeanu et al., 2023).

Invasive weeds, *Cirsium arvense* (creeping thistle) and *Taraxacum officinale* (common dandelio), represent a major challenge for these ecosystems. These invasive species affect interspecific competition, limit land productivity and reduce forage quality, as a result of their ability to reproduce vegetatively and resistance to traditional control methods (Koricheva and Gurevitch, 2014). *Cirsium arvense* is recognized as one of the most invasive plant species in agricultural and natural ecosystems globally (Navasaitis et al., 2003). In Romania, this species is present not only in natural ecosystems but also in many agroecosystems, where it is considered one of the most harmful weeds. It is regarded as a problematic plant in nearly all regions of the country, being found in approximately 65% of arable crops (Manea et al., 2015).

The occurrence of *Cirsium arvense* in pastures diminishes biodiversity by outcompeting indigenous species and degrades the nutritional value of the land, thereby impacting its productivity (Bostock and Benton, 1979). The species' competitive edge stems from a combination of ecological, physiological, and reproductive traits. Consequently, the primary factors that contribute to its invasive nature and enduring presence include: both sexual and asexual reproduction, high adaptability, voraciousness, swift growth, allelopathic interactions, and an absence of natural predators.

Given the ecological and economic impact, control strategies for this species should include mechanical, chemical and biological methods (Hatcher and Melander, 2003).

The limited presence of the species *Taraxacum officinale* in agricultural ecosystems does not cause an imbalance and is considered a valuable component because it increases palatability through its pleasant taste and high protein and sodium content (Turek and Klimeš, 1984). In pastures, the species is considered nutritionally beneficial when its cover remains between 1% and 2% (Klimeš et al., 2003).

However, the plant also has some disadvantages: the leaves are prone to crumbling, it is susceptible to mold during storage, and the rosette allows it to occupy space at ground level and prevent light from reaching other plants, which reduces the usefulness of meadows (Regal and Krajčovič, 1963). According to Míka et al. (1998), *Taraxacum officinale* contains large amounts of phenols, thus releasing allelopathic substances into the environment and inhibiting the growth and germination of other species. In addition to these characteristics, *Taraxacum officinale* is competitive due to: the taproot system capable of storing carbohydrates (which determines rapid regeneration); sexual and asexual reproduction; rapid germination; stress tolerance; adaptability and ecological plasticity. Given its ambivalent characteristics, the proportion of *Taraxacum officinale* in grasslands should be limited by using control methods appropriate for grasslands.

Weed management in grasslands is complicated by the fact that tillage is not used, only during the renewal phase (Aronsson et al., 2015).

The main alternative to tillage is the use of herbicides, but European Union legislation obliges farmers to use integrated weed management (IPM) techniques. One of the principles of IPM is that preventive measures are prioritized over direct control methods and non-chemical methods are preferred over pesticides (Riemens et al., 2022). According to studies conducted by Koning et al. (2019), both broad-spectrum herbicides and tillage are effective methods of controlling weeds in agricultural ecosystems, but they have the disadvantage of being time-consuming.

Selective herbicides, which do not exert negative effects on grass and legume species, can be used to control weeds in agricultural ecosystems (Donovan et al., 2022). Bibliographic data highlights the use of 2-methyl-4-chlorophenoxyacetic acid (MCPA) in grassland ecosystems, considered an effective herbicide for weed control. However, its repeated and long-term use also raises challenges. MCPA is a selective phenoxy acid herbicide, primarily used to control broadleaf weeds. Studies show that excessive application can affect non-target plant species and soil microorganisms, disrupting the ecological balance (Hein and Wilson, 2004; Koricheva and Gurevitch, 2014). translate

In this study, the impact of MCPA (2-methyl-4-chlorophenoxyacetic acid) on reducing *Cirsium arvense* and *Taraxacum officinale* species in grassland ecosystems was investigated.

MATERIALS AND METHODS

Site description

The grassland ecosystem, in which the research was conducted, belongs to the Carani locality (GPS coordinates 45.904461 and 21.12868), Sânandrei, Timiș county, located in the western part of Romania.

Figure 1. Study area

The trial was conducted in a permanent pasture (over 15 years old). The area where the study was carried out is characterized by a temperate-continental climate, in terms of both temperature (10.9°C) and precipitation (631 mm).

Treatments and Experimental Design

The experiment was designed using the randomized block method with four replications. The plot size was 24 m² (3 x 8 m) Figure 2.

Figure 2. Trial setup

To reduce the population of *Cirsium arvense* and *Taraxacum officinale*, three herbicides were applied: MCPA 50% DMA, MCPA 75% DMA, and Starane. The hormonal herbicides MCPA 50% DMA and MCPA 75% DMA were applied post-emergence (on 09.04.2022) in four doses. The experiment included 10 variants (one untreated and nine treated with MCPA and Starane) (Table 1). The herbicide Starane was used as the reference product. The treatments were applied using a backpack sprayer (3 m wide, air pressure 2.2 bar, application volume 250 l/ha).

Table 1 Study details

Trt. no	**Herbicide**	**Active substance g/l-g/ha**	**Dose l/ha**
T1	Control - untreated	-	-
T2	MCPA 50% DMA	500 g/l	0.9 l/ha
T3	MCPA 50% DMA	500 g/l	1.2 l/ha
T4	MCPA 50% DMA	500 g/l	1.5 l/ha
T5	MCPA 50% DMA	500 g/l	2 l/ha
T6	MCPA 75% DMA	750 g/l	0,6 l/ha
T7	MCPA 75% DMA	750 g/l	0,8 l/ha
T8	MCPA 75% DMA	750 g/l	1,0 l/ha
T9	MCPA 75% DMA	750 g/l	1,33 l/ha
T10	Starane	250 g/l fluroxypyr	1 l/ha

After the treatments were applied, the control level of the species *Cirsium arvense* and *Taraxacum officinale* was determined. The efficacy of the herbicides was assessed using Abbott's formula at 15 (24.04.2022), 28 (07.05.2022), and 42 days after application (21.05.2022).

Efficacy after Abbott %= $\left(\frac{C_a - C_t}{C_a}\right) x\ 100$

unde C_a weed coverage in untreated plot, C_t weed coverage in treated plots

RESULTS AND DISCUSSIONS

On the day of treatments application, in the control plot, 16.35 plants/m^2 of *Cirsium arvense* and 29.55 plants/m^2 of the *Taraxacum officinale* species were identified.

The results obtained for the herbicide treatments applied in the analysed grassland from Carani were focused on two different species, respectively *Cirsium sp*. and *Taraxacum sp*. Also, the impact of the treatments on the two target species was assessed at three time-intervals from the application of the treatments, respectively 15, 28 and 42 days.

In Figures 3 and Figure 4 can be noticed a similar pattern of the response in both analysed species for each of the treatments and at all the considered time intervals from the application of the herbicides.

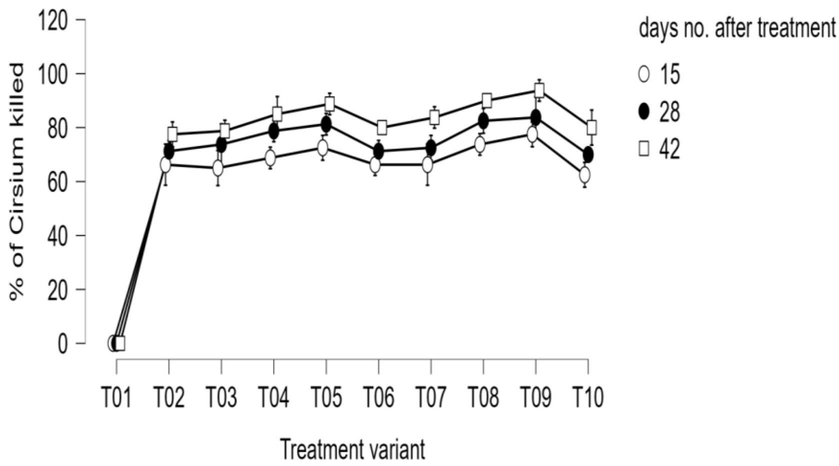

Figure 3. Descriptive plot of the response of *Cirsium arvense* to herbicide treatments in three time-intervals after the treatment application (standard error bars are displayed)

From the data presented in Figure 3, it is observed that 2 – methyl – 4 - chlorophenoxyacetic acid (MCPA), at 14 DAA, controlled the *Cirsium arvense* population, in the grassland ecosystem, in a proportion of 65% (in the variant in which MCPA 50% 1.2 l/ha was applied) and 77.50% (MCPA 75% 1.33 l/ha). At the second (28 days) and third (42 days) evaluations, the percentages regarding the reduction of the creeping thistle population, in the experimental plots, continued to increase, the maximum value being recorded when applying the herbicide MCPA 75% 1.33 l/ha (93.75%).

The active ingredient fluroxypyr, taken as a reference substance, reduced *Cirsium arvense* plants by 62.5% - 72.5% (Figure 4), values below those recorded in plots treated with the hormonal herbicide MCPA.

Figure 4. Herbicide efficacy on targeted weeds in grassland ecosystem

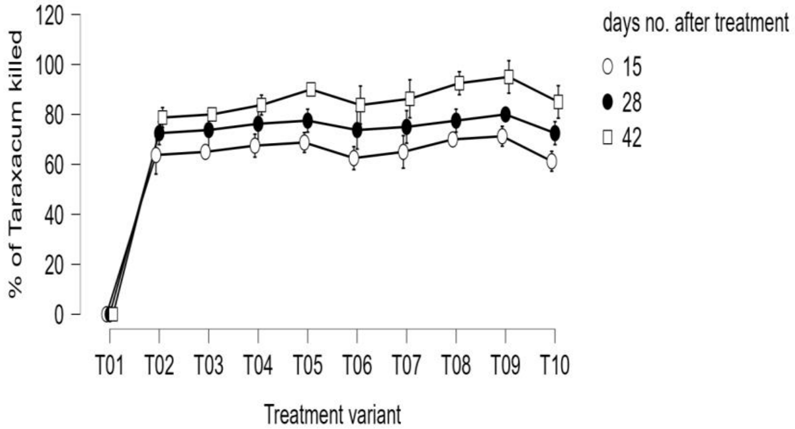

Figure 5. Descriptive plot of the response of *Taraxacum officinale* to herbicide treatments in three time-intervals after the treatment application (standard error bars are displayed)

Figure 5 shows the efficacies of the treatments in reducing the species *Taraxacum officinale*, from the permanent grassland, in Carani area. The application of the herbicide MCPA on *Taraxcum officinale* plants determined the modification of the metabolic and growth processes, contributing to the reduction of competition and propagation, by reducing the population by 62.5% (at 14 DAA in the variant treated with MCPA 75% 0.6 l/ha) - 95% (at 42 DAA in the variant in which MCPA 75% 1.33 l/ha was applied).In Table 2 is presented ANOVA analysis referring to the rate of plants killed depending by species (*Cirsium arvense* and *Taraxacum officinale*), herbicide treatment and number of days after treatment. The analysis shows the rejection of null hypothesis in case of treatment variant, days number after treatment, species ✻ days number after treatment and treatment variant ✻ days number after treatment.

Species compared in this research weren't showing the existence of the significance regarding their response to the treatment, confirming the null hypothesis as also was noticed in the cases of species ✻ treatment variant, and species ✻ treatment variant ✻ days number after treatment.

Table 2. ANOVA – rate (%) of plants killed depending by species, treatment and number of days after treatment

Cases	Sum of Squares	df	Mean Square	F	p
Species	10.417	1	10.417	1.128	0.290
Treatment variant	128804.205	9	14311.578	1549.524	< 0.001
Species ✻ Treatment variant	150.000	9	16.667	1.805	0.070
days no. after treatment	10171.875	2	5085.937	550.658	< 0.001
Species ✻ days no. after treatment	171.458	2	85.729	9.282	< 0.001
Treatment variant ✻ days no. after treatment	1426.042	18	79.225	8.578	< 0.001
Species ✻ Treatment variant ✻ days no. after treatment	130.625	18	7.257	0.786	0.715
Residuals	1662.500	180	9.236		

Note. Type III Sum of Squares

The ANOVA data analyses shows that the herbicides used in the experiment (MCPA 50%, MCPA 75%, and Starane) controlled *Cirsium arvense* and *Taraxacum officinale* populations similarly when other factors were not considered (Table 2). These data highlight the distinct efficacy of the herbicides. The results indicate that the herbicide is the factor with the greatest statistical impact on the control rate of the two species (*p* < 0.001), which is consistent with the findings of Donald (1994) and Kay et al. (2018). The results regarding the control of *Cirsium arvense* in the variants treated with phenoxyacid (MCPA) are similar to those reported by Donald (1994) and Kay et al. (2018).

Studies published by Donald, 1994 and Kay et al., 2018 argue that repeated application is necessary for optimal control, as the root system of the species determines rapid regeneration. Frequent application of herbicides in grasslands is not supported by researchers Smith (2015) and Heap (2020), as it determines the reduction of species diversity.

By analyzing the interaction between species and herbicide, a slight difference in response is observed, but the effect is not significant (p = 0.07).

The ANOVA interpretation of the results shows that the efficacy of the herbicides in controlling the two target species increases as time passes, indicating that the treatments need a longer period for translocation into the root system. Table 2 shows that the number of days after application of the treatment has a significant impact on the control of the species. By analyzing the data in Table 2, it is observed that there is a significant effect between species and time. This indicates that the species respond differently to the treatment over time.

The response of species to herbicide depends on the interaction between treatment variants and evaluation time, suggesting that treatment efficacy varies not only between variants but also over time.

In Table 3 is presented the post-hoc comparison among the herbicide treatment variants applied in the analysed grassland for the control of the target species. From the results it can be noticed that all the treatment variants were highly significantly different in comparison with the control (p < 0.001***).

Table 3. Post-hoc comparisons of the herbicide treatment variants (Tukey test)

			95% CI for Mean Difference					
		Mean Difference	**Lower**	**Upper**	**SE**	**t**	**p_{tukey}**	
T01	T02	-71.657	-74.467	-68.846	0.877	-81.678	< 0.001	***
	T03	-72.698	-75.509	-69.888	0.877	-82.865	< 0.001	***
	T04	-76.657	-79.467	-73.846	0.877	-87.377	< 0.001	***
	T05	-79.782	-82.592	-76.971	0.877	-90.939	< 0.001	***
	T06	-72.907	-75.717	-70.096	0.877	-83.102	< 0.001	***
	T07	-74.782	-77.592	-71.971	0.877	-85.240	< 0.001	***
	T08	-81.032	-83.842	-78.221	0.877	-92.364	< 0.001	***
	T09	-83.532	-86.342	-80.721	0.877	-95.213	< 0.001	***
	T10	-71.865	-74.676	-69.054	0.877	-81.915	< 0.001	***
T02	T03	-1.042	-3.852	1.769	0.877	-1.187	0.973	
	T04	-5.000	-7.811	-2.189	0.877	-5.699	< 0.001	***
	T05	-8.125	-10.936	-5.314	0.877	-9.261	< 0.001	***
	T06	-1.250	-4.061	1.561	0.877	-1.425	0.918	
	T07	-3.125	-5.936	-0.314	0.877	-3.562	0.017	*
	T08	-9.375	-12.186	-6.564	0.877	-10.686	< 0.001	***
	T09	-11.875	-14.686	-9.064	0.877	-13.536	< 0.001	***
	T10	-0.208	-3.019	2.602	0.877	-0.237	1.000	
T03	T04	-3.958	-6.769	-1.148	0.877	-4.512	< 0.001	***
	T05	-7.083	-9.894	-4.273	0.877	-8.074	< 0.001	***
	T06	-0.208	-3.019	2.602	0.877	-0.237	1.000	
	T07	-2.083	-4.894	0.727	0.877	-2.375	0.347	

		Mean Difference	95% CI for Mean Difference Lower	Upper	SE	t	p_{tukey}	
	T08	-8.333	-11.144	-5.523	0.877	-9.499	< 0.001	***
	T09	-10.833	-13.644	-8.023	0.877	-12.348	< 0.001	***
	T10	0.833	-1.977	3.644	0.877	0.950	0.994	
T04	T05	-3.125	-5.936	-0.314	0.877	-3.562	0.017	*
	T06	3.750	0.939	6.561	0.877	4.274	0.001	**
	T07	1.875	-0.936	4.686	0.877	2.137	0.504	
	T08	-4.375	-7.186	-1.564	0.877	-4.987	< 0.001	***
	T09	-6.875	-9.686	-4.064	0.877	-7.836	< 0.001	***
	T10	4.792	1.981	7.602	0.877	5.462	< 0.001	***
T05	T06	6.875	4.064	9.686	0.877	7.836	< 0.001	***
	T07	5.000	2.189	7.811	0.877	5.699	< 0.001	***
	T08	-1.250	-4.061	1.561	0.877	-1.425	0.918	
	T09	-3.750	-6.561	-0.939	0.877	-4.274	0.001	**
	T10	7.917	5.106	10.727	0.877	9.024	< 0.001	***
T06	T07	-1.875	-4.686	0.936	0.877	-2.137	0.504	
	T08	-8.125	-10.936	-5.314	0.877	-9.261	< 0.001	***
	T09	-10.625	-13.436	-7.814	0.877	-12.111	< 0.001	***
	T10	1.042	-1.769	3.852	0.877	1.187	0.973	
T07	T08	-6.250	-9.061	-3.439	0.877	-7.124	< 0.001	***
	T09	-8.750	-11.561	-5.939	0.877	-9.974	< 0.001	***
	T10	2.917	0.106	5.727	0.877	3.325	0.035	*
T08	T09	-2.500	-5.311	0.311	0.877	-2.850	0.128	
	T10	9.167	6.356	11.977	0.877	10.449	< 0.001	***
T09	T10	11.667	8.856	14.477	0.877	13.298	< 0.001	***

Note. Results are averaged over the levels of: Species, days no. after treatment

Note. P-value and confidence intervals adjusted for comparing a family of 10 estimates (confidence intervals corrected using the Tukey method).

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Analysing the post-hoc comparison of the time-interval after the treatment application (Table 4) there was noticed the existence of the highly significant differences among all the time-intervals considered for the observations regarding the response of the target species to the herbicide treatments. The control percentages of the target species recorded at 15 days after treatment (DAT) were significantly lower compared to those at 28 DAT, as indicated by the low *p* value. This suggests that the herbicide's effects become more pronounced during this interval. Comparing the efficacy observed at 15 DAT with that at 42 DAT, the treatments demonstrated significantly higher efficacy, nearly doubling the control rate. This finding indicates a consistent accumulation of herbicidal effects over time, likely due to the progressive degradation of the target species. Even beyond 28 days, the treatment's effects continued to increase significantly up to 42 days. This suggests that the active substance accumulates in plant tissues and remains effective over time, resulting in a sustained reduction in the target species.

ANOVA and post-hoc tests reveal that the time elapsed after treatment application significantly affects herbicide efficacy, with a gradual increase in plant destruction rates. The herbicide's effectiveness depended heavily on the time interval. This result aligns with the literature, which suggests that MCPA requires 2–3 weeks for translocation to the root system. In the experimental variants, the maximum efficacy against *Cirsium arvense* was recorded at 42 days, indicating a delayed effect. This finding is consistent with Mortensen's (2019) observations on systemic herbicides but contrasts with studies by Heap (2020) which suggest that maximum efficacy occurs within 21–28 days under adequate moisture conditions.

Table 4. Post-hoc comparisons of the time-interval after treatment (Tukey test)

			95% CI for Mean Difference				
		Mean Difference	**Lower**	**Upper**	**SE**	**t**	**p_{tukey}**
15	28	-7.500	-8.636	-6.364	0.481	-15.608	< 0.001 ***
	42	-15.938	-17.073	-14.802	0.481	-33.167	< 0.001 ***
28	42	-8.437	-9.573	-7.302	0.481	-17.559	< 0.001 ***

*** p < 0.001

Note. P-value and confidence intervals adjusted for comparing a family of 3 estimates (confidence intervals corrected using the Tukey method).

Note. Results are averaged over the levels of: Species, Treatment variant

Analysing the post-hoc comparisons of the species ✻ time-interval after treatment (Table 5) there it can be noticed that almost all of the situations compared were highly significant (p < 0.001***) except the differences between *Cirsium* and *Taraxacum* at 28 and 42 days after treatment that weren't statistically significant; and at 15 days after treatment when the differences were significant (p < 0.01**).

Table 5 Post-hoc comparisons of the species ✻ time-interval after treatment (Tukey test)

			95% CI for Mean Difference				
		Mean Difference	**Lower**	**Upper**	**SE**	**t**	**p_{tukey}**
Cirsium 15	Taraxacum 15	2.375	0.417	4.333	0.680	3.495	0.008 **
	Cirsium 28	-6.625	-8.583	-4.667	0.680	-9.749	< 0.001 ***
	Taraxacum 28	-6.000	-7.958	-4.042	0.680	-8.829	< 0.001 ***
	Cirsium 42	-13.875	-15.833	-11.917	0.680	-20.418	< 0.001 ***
	Taraxacum 42	-15.625	-17.583	-13.667	0.680	-22.993	< 0.001 ***
Taraxacum 15	Cirsium 28	-9.000	-10.958	-7.042	0.680	-13.244	< 0.001 ***
	Taraxacum 28	-8.375	-10.333	-6.417	0.680	-12.324	< 0.001 ***
	Cirsium 42	-16.250	-18.208	-14.292	0.680	-23.912	< 0.001 ***
	Taraxacum 42	-18.000	-19.958	-16.042	0.680	-26.488	< 0.001 ***
Cirsium 28	Taraxacum 28	0.625	-1.333	2.583	0.680	0.920	0.941
	Cirsium 42	-7.250	-9.208	-5.292	0.680	-10.669	< 0.001 ***
	Taraxacum 42	-9.000	-10.958	-7.042	0.680	-13.244	< 0.001 ***
Taraxacum 28	Cirsium 42	-7.875	-9.833	-5.917	0.680	-11.588	< 0.001 ***
	Taraxacum 42	-9.625	-11.583	-7.667	0.680	-14.164	< 0.001 ***
Cirsium 42	Taraxacum 42	-1.750	-3.708	0.208	0.680	-2.575	0.109

* p < 0.05, ** p < 0.01, *** p < 0.001

Note. P-value and confidence intervals adjusted for comparing a family of 6 estimates (confidence intervals corrected using the Tukey method).

Note. Results are averaged over the levels of: Treatment variant

MCPA showed good efficacy in controlling the two perennial species, but literature data suggest its use in combination with other herbicides or control techniques. Heap (2020) suggests combining MCPA with 2,4-D to increase its effectiveness in controlling perennial species.

CONCLUSIONS

The response of the target species *Cirsium ravense* and *Taraxacum officinale* at the herbicide treatments applied on the grassland from Carani wasn't significantly different, this fact highlighting the similarity in the response between the two species. As it was expected all the variants were highly significantly different in comparison with the non-treated control, but also there were identified other statistically significant variants among the variants of treatments applied.

There is recommended to use the minimum dose of herbicide that proved significant efficiency in the control of the species as *Cirsium arvense* or *Taraxacum officinale* from grasslands.

The treatment and the number of days after application are the most influential factors on herbicide effectiveness

REFERENCES

Aronsson H., Ringselle B., Andersson L., Bergkvist G. (2015). Combining mechanical control of couch grass (*Elymus repens* L.) with reduced tillage in early autumn and cover crops to decrease nitrogen and phosphorus leaching, Nutr Cycl Agroecosyst, 102:383–396

Bostock, S. J., & Benton, R. A. (1979). The ecology of thistles (Cirsium species) in grassland. *Journal of Ecology*, 67(2), 601–609.

Chifan R., Ștef Ramona, Grozea Ioana. (2019). The cyclohexanediones effect on the *Sorghum halepense* control in the sunflower agroecosystem, Research Journal of Agricultural Science, 51 (4), 262-272

Donald, W. W. (1994). The biology of Canada thistle (*Cirsium arvense*). *Weed Science*, 42(4), 177-187.

Hatcher, P. E., & Melander, B. (2003). Integrating mechanical and chemical control strategies for sustainable weed management. *Weed Science*, 51(2), 234-245.

Heap, I.M. (2020). International Survey of Herbicide Resistant Weeds. http://weedscience.org

Hein, G. L., Wilson, R. G. (2004). Impact of herbicides on carbohydrate reserves in *Cirsium arvense*. Weed Science.

Kay J, Edwards P, Clement A, Bryant R. (2018). The effect of pregraze mowing at different pregraze masses on cow and pasture performance. Sustainable meat and milk production from grasslands. Proceedings of the 27th General Meeting of the European Grassland Federation.

Klimeš F., Kolář L., Kobes M., Voženílková B. (2003). The impacts of various cultivation methods and permanent grassland use on the changes in *Taraxacum officinale* Web. cover rate, Plant Soil Environ., 49, (2): 49–54

Koning Laurie Anne, Friederike de Mol, Bärbel Gerowitt (2019). Effects of management by glyphosate or tillage on the weed vegetation in a field experiment, Soil and Tillage Research, Volume 186, 79-86

Koricheva, J., Gurevitch, J. (2014). Meta-analysis of weed management strategies. Journal of Ecology. Disponibil la Princeton University Press

Manea D. N., Peţ I., Ienciu Anişoara Aurelia, Ştef Ramona. (2015). Control of horse thistle (*Cirsium arvense* L. Scop.) in winter wheat crop, Research Journal of Agricultural Science, 47 (1), 82-89

Maruşca T., Marius I. Bărbos, Vasile A. Blaj, Vasile Cardasol, Neculai Dragomir, Vasile Mocanu, Ioan Rotar, Mariana Rusu, Ion Seceleanu I. (2010). Tratat de reconstrucţie ecologică a habitatelor de pajişti şi a terenurilor degradate montane, Editura Universităţii Transilvania din Braşov.

Míka, V., Michalko, J., & Vacek, Z. (1998). Phenolic compounds and their allelopathic effects on pasture ecosystems. *Grassland Science in Europe*, 3, 123–128.

Mortensen, DA, Egan, JF, Maxwell, BD, Rya N, MR, Smith, RG. (2012). Navigating a critical juncture for sustainable weed management. BioScience 62:75–84

Navasaitis, M., Ozolinčius, R., Smaliukas, D., Balevičienė, J. (2003). *Lietuvos dendroflora* [Dendroflora of Lithuania]. Vilnius: Lututė.

O Donovan T., Imelda A., Humphreyset J. (2022). Effectiveness of dock (*Rumex obtusifolius* L.) control in newleys and established grassland following the application ofherbicides, Grass and Forage Science published by John Wiley & Sons Ltd.

O'Mara F.P. (2012). The role of grasslands in food security and climate change. Ann. Bot. 110, 1263–1270

Regal, V., Krajčovič, V. (1963). Pícninářství. Praha:Státní zemědělské nakladatelství, ISBN 07-042-63-04/28.

Riemens M., Mette Sønderskov, Anna-Camilla Moonen, Jonathan Storkey. (2022). Per Kudsk. An Integrated Weed Management framework: A pan-European perspective, European Journal of Agronomy, Volume 133, 126443

Ringselle B., Bakken A. K., Mats H., Marit J., Tørresen K. S. (2023). Effects of integrated grassland renewal strategies on annual and perennial weeds in the sowing year and subsequent production years, European Journal of Agronomy 146 126799

Sărățeanu V., Suciu C. T., Cotuna O., Durău C. C., Paraschivu M. (2020). Adventive species *Asclepias syriaca* L. in disturbed grassland from Western Romania. Romanian Journal of Grassland and Forage Crops, 21. 61–72.

Sărăţeanu Veronica, Alexandru Moisuc, Otilia Cotuna (2010). *Ambrosia artemisiifolia* L. an invasive weed from ruderal areas to disturbed grasslands, Lucrări Ştiinţifice – vol. 53, Nr. 2, seria Agronomie

Smith RG. (2015). A succession-energy framework for reducing non-target impacts of annual crop production. Agric Syst 133:14–21

Stef Ramona, Dan Manea, Ioana Grozea, Raul Chifan, Bogdan Gheorghescu, Gicu-Gabriel Arsene, Carabet A. (2022). *Asclepias syriaca* - A new segetal species in Romania, Scientific Papers. Series A. Agronomy, Vol. LXV, No. 1

Ștef Ramona (2017). Chemical control of the invasive species *Ambrosia artemisiifolia* L. in sun flower agroecosystem, 17th International Multidisciplinary Scientific Geoconference Sgem 2017 Conference proceedings

Turek, S., Klimeš, L. (1984). The role of *Taraxacum officinale* in pastures: Nutritional value and palatability. Agricultural Science Journal, 22, 45–52.