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Weeds Control in Potatoes under Agro-Climatic Conditions of Barsa Country, Romania

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ABSTRACT

Potato (*Solanum tuberosum*) is one of the most intensive field crops, which requires permanent care. The number of registered herbicides has been limited and in most cases their efficacy greatly depends on precipitation. It is important to conduct location specific experiments on weed management because the efficiency of a given chemical is limited only to controlling certain weed species and it can vary with different factors. The present study was carried out between 2022-2023 to National Institute for Research and Development for Potato and Sugar Beet Brasov and to a farmer in Codlea, Romania. The experiment was laid out in randomized complete block design with four replications. The study determined the degree of damage to crops and weeds, fresh and dry weight of weeds, their number and floristic composition. Two factors were analyzed: factor I - potato varieties: Brasovia variety to NIRDPSB Brasov and Ultra variety to Codlea; factor II - four different combination of herbicides to control weeds and the untreated plot (V1: Control; V2: metribuzin; V3: metribuzin + metribuzin fractional doses; V4: aclonifen + metribuzin; V5: aclonifen). In the period of examination were registered a predominant number of six weeds species (Green foxtail, Lambs quarters, Redroot pigweed, Field bindweed, Birdeye speedwell, Cleavers). The measurement of weeds was made by using a metric frame (4 x 0.25 m^2 quadrats), recording the number of weeds per square meter. All treatments significantly reduced the weed density and dry weight during both year of experiments as compared to the untreaterd variant. Among the herbicides, metribuzin applied fractional or in combination with aclonifen gave very good control of broadleaf weeds and the highest marketable potato yields. Chemical weeds control has proven high efficiency in reducing the number and biomass of weeds.

Keywords: applied dose, herbicides, potato, weeds, yield.

INTRODUCTION

Potatoes are vegetable crops that are cultivated in most regions of the world, and are known for their importance as excellent sources of vitamin A, C and E, minerals (such as calcium) and carotenoids (Anderson, 2015).

Herbicides will remain in future agriculture efficient tool for control of weeds as part of an integrated weed control (Delchev et al., 2022).

At a global scale, among all pests, weeds have the greatest impact on the yield reduction, with an average of 34%. In addition, as an intermediate host, they can be a source of diseases and pests, and secondary weed infestation can greatly limit the yield (Praczyk and Skrzypczak, 2011; Gugała et al., 2018). The damage caused by weeds can be diverse and often leads to a decrease in yields (Partal et al., 2023), an increase for production costs, a depreciation of product quality, being also an ideal host for pathogens and pests, etc. (Mortensen et al., 2000; Roman and Lazureanu, 2012).

30-40 days pass from planting to the potato emergence, a period during which, due to the conditions of temperature and humidity in the soil the weeds develop at an intense rate. In this interval, the potato practically cannot compete with weeds, which consume water and nutrients from the soil. Another characteristic of the potato field is the fact that planting in spaced rows creates favorable conditions for the development of weeds both in the interval between the ridges and in the ridge, between the potato plants.

Using pre-emergence herbicides with prolonged residual effects helps improve the efficacy of weed control during the critical period of competition (Inoue et al., 2012).

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For example, the same herbicide may have varying efficacy depending on the environmental conditions at and after the application time (Barbaś et al., 2020).

Response of potato to weed infestation varies from field-to-field depending on environmental conditions, weed species composition, weed density, the relative time of weed and crop emergence, duration of weed-crop competition, potato cultivar, and other agronomic factors (Baziramakenga and Leroux, 1994; Bellinder et al., 2004).

As other researchers have mentioned (Ganie et al., 2023), labeled herbicide options for weed control are limited for use in potato, and research on weed management in potato is relatively scarce compared to other major crops.

Knowledge about the efficacy of herbicides in weed control, the effect on soil quality and their persistence in soil are extremely important for the proper use of such products in the environment (Petcu et al., 2015). It is important to conduct location specific experiments on weed management because the efficiency of a given chemical is limited only to controlling certain weed species and it can vary with the weed density, time of weed emergence, cropping system and the environmental conditions under which the crop is grown.

The objectives of the present study aimed to find suitable herbicides for controlling weeds in potato fields and the possibility to incresase yield using this kind of products.

MATERIAL AND METHODS

Experiments were carried out to the National Institute of Research and Development for Potato and Sugar Beet Brasov and to Codlea, in a farm located at 17 km away, between years 2022-2023 (Table 1).

The field experiments each year were set up in random block, 4 replicate plots with 4 rows each with 20 plants. The size of elementary plot was 18 m^2, with the distance 75/30 cm.

Herbicide use:

- V1: Control (untreated);
- V2: Sencor Liquid (metribuzin 600 g/l) - 0.9 l/ha;
- V3: Sencor Liquid 0.65 l/ha applied in pre-emergence + Sencor Liquid 0.25 l/ha applied in post-emergence;
- V4: Sencor Liquid 0.65 l/ha + Challange 600 SC (aclonifen 600 g/l) - 2.0 l/ha;
- V5: Challange 600 SC - 4.0 l/ha.

Herbicides were applied with a knapsack sprayer with 10 l capacity (nozzle type TJ 11002).

All other plant protection products, to control potato late blight and Colorado beetle, were used according to the Good Agricultural Practice (GAP).

Evaluation of weed control was carried out by the method of quantitative and qualitative determination, on constant square area of 1 m^2, in the stage of the full flowering of potato plants. The efficiency of the applied methods of weed control (%) was based on a 0-to-100% scale, where 0 = no control and 100 = no living weeds. Weeds dry matter was determined after drying at 80°C for 48 hours maintaining constant moisture content.

Yield determination was done harvesting manually all tubers from two central rows. All tubers were weighed and divided on size fractions (<35 mm, 35-55 mm, >55 mm).

Statistical analysis was done using factorial analysis of variance (ANOVA), the statistical and rating differences between mean values was performed by LSD test.

Table 1. Characteristics of the experiment

Year	2022	2023	2022	2023
	Brasov		Codlea	
Variety	Darilena	Darilena	Ultra	Ultra
Soil	Chernoseum		Cambic chernoseum	
Clay	27		30	
Humus	4.68		4.0	
pH	6.7		6.5	
Precrop	wheat	wheat	colza	barley
Fertilization	NPK15.15.15 - 1000 kg	NPK15.15.15 - 1000 kg	NPK8.14.34 - 1000 kg	NPK8.14.34 - 1000 kg
Planting mode	manual	manual	manual	manual
Planting data	1.05	9.04	16.04	29.04
Planting distance (cm)	75/30	75/30	75/25	75/25
Harvest	26.09	20.09	19.09	30.09

The growing season 2022 was warm and dry. During the vegetation period (April - August) the air temperature (16.6^{o}C) was higher on average by 1.8^{o}C, compared to MAA (multiannual average) (14.8^{o}C). Between April 1 and August 31, total rainfall (244.8 mm) was below the MAA level (404.9 mm), registering 159.7 mm less. In terms of temperatures September was at the level of MAA and in terms of the volume of precipitation it was 13.1 mm above the average.

Also 2023 growing season was warm but no so dry. The temperatures between April and August (16.0^{o}C) was higher on average by 1.2^{o}C, compared to MAA. The rainfalls in June (111.1 mm) and August (77.5 mm) exceeded the MAA (96.7 mm, respectively, 76.4 mm) as volume, but it must be stated that there were quantitatively significant rains in a short period of time (Table 2). After a wet August a significant precipitation deficit was registered in September, only 11 mm compared to 65.6 mm.

Table 2. Air temperature and rainfalls during the experiment (2022-2023)

Year	Month						**Average**
	April	May	June	July	August	September	
	Air temperature (°C)						
2022	8.3	14.8	19.0	20.6	20.2	13.6	**16.08**
2023	7.3	13.8	17.6	20.5	20.9	16.9	**16.17**
MMA	8.5	13.6	16.5	18.1	17.5	13.6	**14.63**
	Amount of rainfall (mm)						**Total**
2022	64.8	48.3	31.6	50.1	50.4	65.6	**310.8**
2023	83.1	77.5	111.1	59.1	77.5	11.0	**419.3**
MMA	50.0	82.0	96.7	99.8	76.4	52.5	**407.4**

RESULTS AND DISCUSSION

In two-year period of examination a number of 6 species were registered like predominant and few other as sporadic (*Cirsium arvense, Sinapis arvensis, Capsella bursa-pastoris, Agropyron repens*). According to that the potato crop weed communities in the studied areas is relatively poor in species (Table 3).

As some authors suggest (Ghersa and Leon, 1999) it is possible that in a certain geographical area and culture system, weed communities to be stable structures that can become quite uniform and predictable from year to year.

Table 3. Name and features of observed weeds

Scientific name	Common name	WSSA code	Family	Life cycle
Chenopodium album	*Lamb's quarters*	CHEAL	Chenopodiaceae	Annual
Amaranthus retroflexus	*Redroot pigweed*	AMARE	Amaranthaceae	Annual
Convolvulus arvensis	*Field bindweed*	CONAR	Convolvulaceae	Perennial
Galium aparine	*Cleavers*	GALAP	Rubiaceae	Annual
Veronica persica	*Birdeye speedwell*	VERPE	Plantaginaceae	Annual
Setaria viridis	*Green foxtail*	SETVI	Poaceae	Annual

Among the herbicide treatments in 2022, in both location, significantly the lowest weed density (13 weeds no./m^2, respectively, 11 weeds no./m^2) was observed with the application of the mix metribuzin + aclonifen. The research data revealed that the weed number was also reduced with the application of metribuzin fractionate (14 weeds no./m^2) in Codlea. Highest number of weeds was recorded in Control variant (72 weeds no./m^2, respectively, 74 weeds no./m^2) also in both location (Table 4).

Table 4. Weeds density (no./m^2) (Brasov - Codlea, 2022)

Location	Variant	Application rate (l/ha)	Weeds species						
			CHEAL	CONAR	GALAP	VERPE	AMARE	SETVI	OTHER*
Brasov	Control	-	4	10	7	10	13	22	6
Codlea		-	4	8	9	8	11	20	4
Brasov	Metribuzin	0.9	2	6	6	0	3	10	2
Codlea			3	4	5	0	2	8	0
Brasov	Metribuzin + Metribuzin	0.65 + 0.25	1	3	4	1	3	4	3
Codlea			2	1	1	0	3	5	2
Brasov	Metribuzin + Aclonifen	0.65 + 2.0	1	0	2	3	1	4	2
Codlea			1	0	0	1	0	5	4
Brasov	Aclonifen	4.0	3	4	3	1	1	4	3
Codlea			5	3	2	2	2	6	4

**Cirsium arvense, Sinapis arvensis, Capsella bursa-pastoris, Agropyron repens.*

In 2023 the Aclonifen application in both locations contributed to the presence of the lowest number of weeds (13 weeds no./m^2, respectively, 15 weeds no./m^2). A low number of weeds also presented the variant with Metribuzin + Aclonifen (16 weeds no./m^2 in both experiments). As expected, the highest number of weeds was recorded in Control variant in both locations as in the previous year (85 weeds no./m^2, respectively, 86 weeds no./m^2) (Table 5).

Table 5. Weeds density (no./m^2) (Brasov - Codlea, 2023)

Location	Variant	Application rate (l/ha)	Weeds species						
			CHEAL	CONAR	GALAP	VERPE	AMARE	SETVI	OTHER*
Brasov	Control	-	8	10	11	12	14	21	9
Codlea		-	7	11	9	12	16	24	7
Brasov	Metribuzin	0.9	4	5	7	3	0	8	2
Codlea			4	4	5	1	2	9	3
Brasov	Metribuzin + Metribuzin	0.65 + 0.25	2	0	4	0	4	4	2
Codlea			3	2	2	2	3	4	3
Brasov	Metribuzin + Aclonifen	0.65 + 2.0	1	2	2	3	2	4	2
Codlea			0	4	2	1	0	5	4
Brasov	Aclonifen	4.0	3	0	3	1	1	2	3
Codlea			5	1	0	2	2	1	4

**Cirsium arvense, Sinapis arvensis, Capsella bursa-pastoris, Agropyron repens*.

The dominant group of weed species in Control plots is presented with: *Chenopodium album (CHEAL)* (8 individuals/m^2 in 2022 and 15 individuals/m^2 in 2023, respectively), *Convolvulus arvensis* (CONAR) (18 and 21 individuals/m^2), *Gallium aparine (GALAP)* (16 and 20 individuals/m^2), *Amaranthus retroflexus (AMARE)* (24 and 30 individuals/m^2), *Veronica persica (VERPE)* (18 and 24 individuals/m^2) and *Setaria viridis* (SETVI) (22 and 45 individuals/m^2). Some other species like *Cirsium arvense*, *Sinapis arvensis*, *Capsella bursa-pastoris*, *Agropyron repens* were less important and add up.

Setaria viridis (SETVI) was determined as the most distributed weed species (42 individuals/m^2 in 2022 and respectively, 45 in 2023). The combination of preemergence applied active ingredients Metribuzin + Aclofinen had the highest efficacy on this species.

Weight of weeds fresh matter was 124.9 g/m² to the untreated (Control) variant to Brasov and 71.0 g/m² in Codlea in 2022. In Brasov, to the variants treated with herbicides, the weight of the fresh matter varied between 16.4 g for the Metribuzin + Aclonifen variant and 4.9 g for the fractionated Metribuzin variant, and in Codlea between 5.5 g for the variant treated with Aclonifen and 15.5 g for the Metribuzin + Aclonifen variant. Also dry matter varied between 59.6 g to Control plot and 2.5 g in Metribuzin plot to Brasov and between 23.5 g in Control and 2.7 g in Metribuzin also to Codlea (Table 6).

SETVI was the most abundant weed species in both years (88 plants in 2022, respectively, 82 plants in 2023), followed by GALAP (39 plants in 2022 and 45 plants in 2023) and AMARE (39 plants in 2022 and 44 plants in 2023).

Table 6. Weight of weed fresh matter/m² and dry matter 2022

Weeds/ herbicide	Total weeds - Brasov		Total weeds - Codlea	
	Weight of fresh matter in g/m²	Dry matter in g	Weight of fresh matter in g/m²	Dry matter in g
Control	124.9	59.6	71.0	23.5
Metribuzin	10.2	3.8	12.5	4.2
Metribuzin + Metribuzin	4.9	2.5	5.8	2.7
Metribuzin + Aclonifen	16.4	7.0	15.5	7.5
Aclonifen	6.3	4.2	5.5	3.4

In 2023 in Brasov the weight of weeds fresh matter was 410.7 g/m² to the untreated (Control) variant and to the variants treated with herbicides varied between 78.9 g/m² to the Metribuzin variant to 31.5 g/m² to the variant Metribuzin + Aclonifen. The dry matter in the same location varied between 80.6 g/m² to Control variant to 18.8 g to Metribuzin + Aclonifen variant.

The weight of weeds fresh matter in Codlea varied between 380.8 g/m² to Control variant and 25.7 g/m² to Metribuzin + Aclonifen variant. Also dry matter varied between 67.8 g/m² to Control plot and 11.9 g in Metribuzin + Aclonifen (Table 7).

Table 7. Weight of weed fresh matter/m² and dry matter 2023

Weeds/ herbicide	Total weeds - Brasov		Total weeds - Codlea	
	Weight of fresh matter in g/m²	Dry matter in g	Weight of fresh matter in g/m²	Dry matter in g
Control	410.7	80.6	380.8	67.8
Metribuzin	78.9	54.2	36.2	12.8
Metribuzin + Metribuzin	74.6	32.3	26.3	13.2
Metribuzin + Aclonifen	31.5	18.8	25.7	11.9
Aclonifen	48.3	20.8	28.9	15.6

An explication regarding the different weed infestation intensity is possible as result of soil weed reserve different from a parcel to other. Another explanation consists in the lack of rainfalls and high temperatures recorded in 2022. Also other authors (Skiba et al., 2021) consider that meteorological conditions in the research years turned out to be a factor that differentiated the number and floristic composition of weeds to the greatest extent.

Our results are in agreement with the previous work of Hamidullah et al. (2004) and Khan et al. (2009) that observed that weed fresh and dry biomass decreases due to herbicidal application in potato crop.

Potato yield 2022 in both locations is presented in Table 8. It was observed during the first year that yield differences among the treatments were significant statistically. The highest yield of 43.6 t/ha, respectively, 43.0 t/ha was recorded in Metribuzin + Aclonifen plots followed by the plots sprayed with Metibuzin and Aclonifen (both in Codlea) giving 37.1 and 36.3 t /ha, while the lowest yield had the Control variants - 28.4, respectivelly, 29.8 t/ha.

Table 8. Potato yield (Brasov - Codlea, 2022)

Variant	Brasov	Codlea	Brasov	Codlea	Brasov	Codlea	Brasov	Codlea
	Tub. <35 mm		Tub. 35-55 mm		Tub. >55 mm		**Total**	
Control	5.5	5.0	18.3	20.3	4.6	4.8	**28.4**	**29.8**
Metribuzin	4.5	4.0	21.0	25.1	7.2	8.0	**32.7**	**37.1**
Metribuzin + Metribuzin	4.3	4.6	21.0	23.3	8.2	8.6	**33.5**	**36.5**
Metribuzin + Aclonifen	4.1	4.7	21.8	22.4	8.7	6.9	**43.6**	**43.0**
Aclonifen	4.6	4.4	20.3	24.0	8.0	7.9	**32.9**	**36.3**
LSD (P=0.5)	1.25	1.48	4.30	4.21	8.74	8.48	18.21	19.23

In 2023 the lowest yield was obtained also in the Control variant - 25.0 t/ha in Brasov, respectivelly 29.6 t/ha in Codlea. On all variants of the application of herbicides fairly uniform yields were obtained, which ranged from 31.8 t/ha on variant Metibuzin (Brasov) to 41.6 t/ha on variant Metribuzin + Aclonifen (Codlea) (Table 9).

It should be noted that in 2022 the production from the 35-55 mm fraction (seed potato) was higher in all variants than the production of fraction >55 mm. The share of seed tubers was higher in a dry season than in 2023, in which the rainfallls was higher and better distributed.

Differences in the yield structure can be justified by changes in plants due to climatic conditions, tacking account the period of vegetation and the precipitation, this weather element presenting major influence.

Table 9. Potato yield (Brasov - Codlea, 2023)

Variant	Brasov	Codlea	Brasov	Codlea	Brasov	Codlea	Brasov	Codlea
	Tub. <35 mm		Tub. 35-55 mm		Tub. >55 mm		**Total**	
Control	3.8	4.1	10.1	11.8	10.3	13.7	**25.0**	**29.6**
Metribuzin	2.8	3.0	9.8	11.0	19.2	19.7	**31.8**	**33.7**
Metribuzin + Metribuzin	2.6	2.5	11.0	12.2	22.4	23.3	**36.0**	**38.0**
Metribuzin + Aclonifen	3.4	3.0	11.1	12.0	25.2	26.6	**39.7**	**41.6**
Aclonifen	3.2	3.0	11.1	12.7	22.2	24.8	**36.5**	**37.2**
LSD (P=0.5)	1.17	1.02	3.73	3.54	9.49	8.45	18.71	17.84

All the weed control treatments significantly reduced the weed density and dry weight during both the year of experiments as compared to the Control (untreated) variant. Among the herbicides, metribuzin applied fractional or in combination with aclonifen gave very good control of broadleaf weeds and the highest marketable

potato yields. Chemical weeds control has proven high efficiency in reducing the number and biomass of weeds.

Similar findings were reported by other authors (Yadav et al., 2015), higher yields in potato crop were mainly due to the better growth and development under low crop weed competition and greater availability of soil nutrients and light.

CONCLUSIONS

In a two-year field trial, selected herbicide active ingredients were used against weeds pre-emergently (metribuzin, metribuzin + metribuzin, metribuzin + aclonifen, aclonifen).

The weed flora in the experimental plots comprised of by both broadleaved and grass weeds, predominating green foxtail.

The combination of preemergence applied active ingredients Metribuzin + Aclonifen had the highest efficacy on present species. Also the combination of Metribuzin + Aclonifen provided a significant effect on the potato yield.

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