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Evaluation of the effect of different herbicides and herbicidal combinations on mixed weed flora and *Vicia ervilia* L. yield

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Abstract

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The effect of different herbicides and herbicidal combinations on mixed weed flora and bitter vetch yield is studied. In each plot, except weedy check the herbicides and herbicide combinations are used in pre-emergence applications at different doses and in different mixtures in order to assess weed control ability and selectivity to the crop. Efficiency against major weeds showed the use of clomazone + pendimethalin – 200 ml/da, as well as a herbicide combination – beflubutamide – 50 ml + S-metolachlor – 120 ml/da. During the studied period, in the weed population predominate *Amaranthus caudatus* L.. This weed together with *Convolvulus arvensis* L. determines the total weeding. With the increase of the total number of weeds in 1 m^2 plot, the bitter vetch yield decreases in linear dependence.

Kewwords: Vicia ervilia; weeds; herbicides; herbicide combinations; selectivity

Introduction

Bitter vetch (*Vicia ervilia* L.) is one of the main crops in the Middle East. Originally grown by humans for food, this crop has great importance to humans before other cereals. After domestication of the animals, the bitter vetch is grown as a forage plant. Its popularity is diminishing and nowadays it is grown mainly for forage and green fertilization (Townsend & Guest, 1980). There are ancient texts about the medical use of bitter vetch (Luce, 2000).

Even as a less desirable crop, it has characteristics relevant to global climate change. The bitter vetch is a low, bushy grain legumes plant grown today as animal feed, especially in areas with a Mediterranean climate. The scientists work to improve it, as well as other species of vetch (ICARDA, 2006; Larbi et al., 2011) and other forgotten early domestication crops, such as grass pea (*Lathyrus sativum* L.) (Kumar et al., 2011; Mikic et al., 2011).

In Bulgaria, bitter vetch as a cultural plant occupies relatively small areas in the southern parts of the country. It is grown as a good grass feed and for grain, especially for sheep. The grains of bitter vetch are a rich protein food for all domestic animals (Popov et al., 1957). Seeds of bitter vetch possess extremely low oil content but their is high carbohydrate and protein content. *Vicia ervilia* seeds have a high nutritional value and could be used as a valuable source of nutrients (Petkova et al., 2020).

Effective weed control plays an important role in technological solutions for growing different crops, because of which herbicides have the biggest part of used pesticides (Hoverstad et al., 2006). In recent decades, the application of herbicides has been one of the main methods for regulating weed density in different crops (Barnes & Oliver, 2005). A major problem with weeds is their large species diversity, their high biological and ecological plasticity, their resistance to herbicides, which makes it easier their rapid distribution (Heap, 2009).

The purpose of this study is to evaluation the effect of different herbicides and herbicide combinations on mixed weed flora and the bitter vetch yield.

Material and Methods

The experiment is conducted on the experimental field of the Institute of Plant Genetic Resources (IRGR) – Sadovo in 2019. The experiment is designed as a randomized block with two replicates and plot size of 10 m^2. Each plot had six rows; three central rows for measurements and three border rows on the perimeter of each plot to reduce potential border effects. In each plot (common twelve), except weedy check the herbicides are used in pre-emergence applications at different doses and in different mixtures in order to assess weed control ability and selectivity to the crop (Table 1). Eleven variants of herbicides and herbicide combinations are used and one variant as a weedy check (Table 1). The working solution of the herbicides and herbicide combinations is prepared with 400 ml of water and sprayed into 10 m^2 plot for each variant.

The economic characteristics of bitter vetch of all studied variants are made on 10 normally developed plants, by indicators – plant height (cm), height to first pod (cm), number of main branches, number of pods and number of grains per plant, number of grains per pod and mass of the grains per plant (g). The bitter vetch yield is expressed by the mass of grains per plant.

The effect of herbicides against the various weeds in the weed flora is recorded by double counting (19.04.2019 and 09.05.2019) of the weeds in 1 m^2 plot, alternately in two phases of the crop development. The single as well as the total number of weeds by variants are counted.

The bitter vetch yield reduction due to not destroyed from herbicide weed flora has been reported by one-factor dispersion analysis. The interaction of weed, herbicide and weed x herbicide with bitter vetch yield is explain by two-factor dispersion analysis. The correlation analysis is used to shows whether a single weed from weed flora has suppressing effect on the bitter vetch yield or whether the harmful effect is expressed by the total number of weeds. The analyses are conducted using the SPSS 19 statistical processing program.

Results and Discussion

The pre-emergence herbicides have varied response over broad-leaved and narrow-leaved weeds (Singht et al., 2018). During the study period are strongly multiplied two weeds: *Amaranthus caudatus* L. and *Convolvulus arvensis* L. (Table 2).

The major part of the total weeding is due to *Amaranthus caudatus* L.. The data in the table shows that except the weedy check (98 numbers/m^2) with the highest number of multiplied weeds have variants (№ 3 and 2) with to which they are applied bentazone + imazamox and beflubutamide. Their total number of weeds is 88 per 1 m^2 plot in applied 100 ml/da of the herbicide and 84 per 1 m^2 plot in applied 50 ml/da. This resultant shows the weak control of bentazone + imazamox and beflubutamide on *Amaranthus caudatus* L.. Clomazone in both doses of application (30 ml/da and 15 ml/da) also has wead control over this weed. The herbicidal combinations between beflubutamide – 50 ml + S-metolachlor – 120 ml/da and clomazone + pendimethalin – 200 ml/da control *Amaranthus caudatus* L., but in the first combination are developed other weeds. For variants with numbers – 9, 10, 11 and 12 some tested herbicidel combinations have good control over mixed weed flora. The weed number per 1 m^2 plot for tested herbicidel combinations ranges from 45 numbers/m^2 for the clomazone – 30 ml/da + S-metolachlor – 60 ml/da combination to 63 numbers/m^2 for the clomazone – 15 ml/da + S-metolachlor – 120 ml/da

Table 1. Experimental treatments on bitter vetch

№ of variant	Trade name/Tested dose	Active substance, g/l	Crop	Application time
1	Weedy check	–	bitter vetch	–
2	Beflex – 50 ml/da	500 g/l beflubutamide	bitter vetch	pre-emergence
3	Korum – 100 ml/da	480 g/l bentazone + 22.4 g/l imazamox	bitter vetch	pre-emergence
4	Sirtaki KC – 30 ml/da	360 g/l clomazone	bitter vetch	pre-emergence
5	Sirtaki KC – 15 ml/da	360 g/l clomazone	bitter vetch	pre-emergence
6	Bismarck – 200 ml/da	clomazone 55 g/l + pendimethalin 275 g/l	bitter vetch	pre-emergence
7	Bismarck – 100 ml/da	clomazone 55 g/l + 275 g/l pendimethalin	bitter vetch	pre-emergence
8	Beflex – 50 ml/da + Dual Gold – 120 ml/da	500 g/l beflubutamide + 960 g/l S-metolachlor	bitter vetch	pre-emergence
9	Sirtaki – 30 ml/da + Dual Gold – 60 ml/da	360 g/l clomazone +960 g/l S-metolachlor	bitter vetch	pre-emergence
10	Sirtaki – 15 ml/da + Dual Gold – 120 ml/da	360 g/l clomazone +960 g/l S-metolachlor	bitter vetch	pre-emergence
11	Sirtaki – 30 ml/da + Stomp Nov 330EK – 250 ml/da	360 g/l clomazone +330 g/l pendimethalin	bitter vetch	pre-emergence
12	Sirtaki – 15 ml/da + Stomp Nov 330 EK – 500 ml/da	360 g/l clomazone +330 g/l pendimethalin	bitter vetch	pre-emergence

Table 2. Number and species composition of weeds per 1 m^2 plot of bitter vetch

№ of variant	Treatment	Number and types of weeds per 1 m^2 plot				
		Amaranthus caudatus L.	*Atriplex* sp. L..	*Convolvulus arvensis* L.	Other weeds	Total number of weeds
1	Weedy check	77	2	19	0	98
2	Beflubutamide – 50 ml/da	67	5	12	0	84
3	Bentazone + imazamox – 100 ml/da	70	5	13	0	88
4	Clomazone – 30 ml/da	55	3	18	1	76
5	Clomazone – 15 ml/da	56	7	17	1	80
6	Clomazone + pendimethalin – 200 ml/da	18	8	13	0	39
7	Clomazone + pendimethalin – 100 ml/da	43	4	9	0	56
8	Beflubutamide – 50 ml + S-metolachlor – 120 ml/ da	19	3	13	2	37
9	Clomazone – 30 ml/da + S-metolachlor – 60 ml/da	24	4	17	0	45
10	Clomazone – 15 ml/da + S-metolachlor – 120 ml/da	42	5	16	0	63
11	Clomazone – 30 ml/da + pendimethalin – 250 ml/da	43	1	7	4	55
12	Clomazone – 15 ml/da + pendimethalin – 500 ml/da	43	0	14	0	57

combination. Byrd & York (1987) also reported that grasses and small-seeded dicot weed species can be controlled with the pre-emergence application of pendimethalin.

In Table 3 is shown that compared to the weedy check, for the variants with application of bentazone + imazamox – 100 ml/da, clomazone – 30 ml/da, clomazone + pendimethalin – 200 ml/da , beflubutamide – 50 ml + S-metolachlor – 120 ml/ da, clomazone – 30 ml/da + S-metolachlor – 60 ml/da , the yield of bitter vetch is proven higher. In all other variants, the weed suppressing effect is clearly expressed and reflected on the bitter vetch yield. Singh et al., (2018) also reported significantly higher yield of sesame with the application of pendimethalin.

The used two-factor analysis of variance gives an information of the effectiveness of herbicides in controlling weeds and shows the selectivity of the tested herbicides with respect to bitter vetch plants (Table 4). The reduction in bitter vetch yield is due to the total weeding. Most of the studied herbicides are tolerant, non-suppressive and show a high positive effect on bitter vetch yield, but those with little control over multiple weeds have a negative effect and this is reflected by the low value of significant. The interaction herbicide x weed is negligible (with significant 0.398) considering its effect on the bitter vetch yield.

From the analysis of the dependencies (Table 5) is evident that during the survey year, *Amaranthus caudatus* L. has a suppressive effect on the bitter vetch yield (r= -0.510) although it is not proven.The weed – *Amaranthus caudatus* L. forms the total number of weeds (r = 0.976). Through this dependence also is reported the suppressive effect of the total number of weeds on the bitter vetch yield (r = -0.466), although it is not proven. An interesting relationship is also observed between *Setaria viridis* L. and *Xanthium italicum* L. (r = 0.614). Increasing the density of the *Setaria viridis* L.

Table 3. Effect of herbicide on the bitter vetch yield

Herbicide/Dose	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
Beflubutamide – 50 ml/da	0.510	0.505	0.315	1.511	0.491
Bentazone + imazamox – 100 ml/da	1.490*	0.505	0.004	2.491	0.489
Clomazone – 30 ml/da	1.360*	0.505	0.008	2.362	0.359
Clomazone – 15 ml/da	0.380	0.505	0.454	1.381	0.621
Clomazone + pendimethalin – 200 ml/da	2.150*	0.505	0.000	3.151	1.149
Clomazone + pendimethalin – 100 ml/da	0.780	0.505	0.126	1.781	0.221
Beflubutamide – 50 ml + S-metolachlor – 120 ml/ da	1.550*	0.505	0.003	2.551	0.549
Clomazone – 30 ml/da + S-metolachlor – 60 ml/da	1.461*	0.505	0.005	2.462	0.460
Clomazone – 15 ml/da + S-metolachlor – 120 ml/da	0.000	0.505	1.000	1.001	1.001
Clomazone 30 ml/da + pendimethalin 250 ml/da	0.470	0.505	0.354	1.471	0.531
Clomazone – 15 ml/da + pendimethalin – 500 ml/da	0.030	0.505	0.953	1.031	0.971

* significant at 0.05% P – level

Table 4. Interaction of weed, herbicide and weed x herbicide with the bitter vetch yield

Source	Sum of Squares	DF	Mean Square	F	Significant
Corrected Model	82.137	23	3.571	3.008	0.000
Intercept	464.964	1	464.964	391.686	0.000
Herbicide	58.263	11	5.297	4.462	0.000
Weed	9.970	1	9.970	8.399	0.005
Herbicide*Weed	13.904	11	1.264	1.065	0.398
Error	113.960	96	1.187		
Total	661.060	120			
Corrected Total	196.096	119			

Table 5. Correlation dependencies between number and species composition of weeds and bitter vetch yield

	Amaranthus caudatus L.	*Atriplex* sp.L.	*Convolvulus arvensis* L.	*Tribulus terrestris* L.	*Setaria viridis* L.	*Xanthium italicum L.*	*Capsella bursa-pastoris L.*	Total number of weeds	Mass of grains per plant, g
Amaranthus caudatus L.	1.000	-0.194	0.164	-0.442	0.062	-0.197	0.155	0.976**	-0.510
Atriplex sp. L.		1.000	-0.055	-0.096	-0.463	-0.406	0.192	-0.086	0.489
Convolvulus arvensis L.			1.000	-0.052	-0.143	-0.590*	-0.141	0.273	-0.003
Tribulus terrestris L.				1.000	-0.135	0.237	-0.091	-0.435	0.304
Setaria viridis L.					1.000	0.614*	-0.135	0.008	0.043
Xanthium italicum L.						1.000	-0.118	-0.295	-0.061
Capsella bursa-pastoris L.							1.000	0.291	-0.203
Total number of weeds								1.000	-0.466
Mass of grains per plant, g									1.000

*correlation significant at 0.05% P – level; **correlation significant at 0.01% P – level

causes an increase in the density of the *Xanthium italicum* L. and vice versa. Another interesting relationship, which is observed is between the *Convolvulus arvensis* L. and *Xanthium italicum* L.. The increasing the density of the *Convolvulus arvensis* L. leads to decrease in the density of the *Xanthium italicum* L. (r = -0.590) and vice versa.

Conclusion

New herbicides and herbicidal combinations of bitter vetch have been studied. The control of weeds from all tested variants is the best in the application of the herbicidal combinations – clomazone + pendimethalin – 200 ml/da and beflubutamide – 50 ml + S-metolachlor – 120 ml/da. A good control of the weeds is also achieved by application of bentazone + imazamox – 100 ml/da, clomazone – 30 ml/da, clomazone – 30 ml/da + S-metolachlor – 60 ml/da. In these variants the yield of bitter vetch is proven higher. *Amaranthus caudatus* L. is a weed that determines the total weeding during the period of study. The good weed control has proven increase the yield of bitter vetch.

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