



Study on efficiency of some herbicides for fight against weeds in birdsfoot trefoil (*Lotus corniculatus* L.) seed production

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ABSTRACT

The study was conducted during the period of 2010-2012 in the experimental field of RIMSA-Troyan on light grey pseudopodsolic soil. The aim of study is to determine the efficiency of herbicides Stratos Ultra (100 g/l cycloxydim) and Pulsar 40 (40 g/l imazamox) and their use in seed production of birdsfoot trefoil. The highest efficiency against weeds showed the treatment of birdsfoot trefoil crops with herbicide Pulsar 40 at a dose of 1200 ml/ha, applied in the year of sowing at the phase of 2-4 leaf of birdsfoot trefoil. The herbicide treatment restricted the opportunity to increase the population density of weeds and led to increase in seed yield by 30.2%. The high seed production under treatment with that herbicide determined also the high values of the structured elements of seed production. In the treatment by herbicide Stratos Ultra high seed production was also realised, which exceeded the control by 8.7% at a dose of 1000 ml/ha and 11.7% at a dose of 2000 ml/ha.

Key words: birdsfoot trefoil; weeds; herbicides; seed production.



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INTRODUCTION

The ordinary birdsfoot trefoil (*Lotus corniculatus* L.) is perennial legume species, having ecological and biological characteristic that gives it a priority over all other legume grasses in the establishment of artificial swards. It is a fodder crop, which combines high productivity and nutritional value (Marley et al., 2006; Radovic et al., 2003). The seed production areas with these species are sown in greater interrow spacing than areas for fodder, something which explains their high weed infestation (Kudsk and Streibig, 2002). The slow growth and development of birdsfoot trefoil in the year of sowing determined the strong competitive influence of weeds over this species. Weeds had a negative influence both over growth and development of plants, and over decreased seed production, determined by difficulties with the harvesting technique. Well maintained areas, clean of weed during the initial stages of this culture development, had a positive influence over the amount and quality of obtained seeds of birdsfoot trefoil in the following years (Maslinkov and Kostov, 1966; Radionov, 1966). These circumstances determine the fight against weeds in birdsfoot trefoil crop as an important element of the technology of growing seed production crops (Dimitrova, 1984; 1987). Under the circumstance of organic farming and growing environmental requirements, the constantly changing weed associations and the emergence of new pesticide products imposes the introduction of new approaches in herbicides application. Optimizing doses of applied herbicides, the searching of new active substances without negative consequences (Cook and Clark, 1997) are ways for increasing their adverse effect over environment.

During the recent years the studies on fight against weeds in seed production crop of birdsfoot trefoil have not been numerous. Michev and Dimitrova (1986) followed the efficiency of herbicide Balagrin over birdsfoot trefoil fodder yield and found decrease to the minimum level of weed infestation with *Echinochloa crus-galli* (L.), *Setaria*, *Alopecurus myosuroides* Huds., *Apera spica-venti* (L.), *Bromus*, *Sorghum halepense* L., and *Cynodon dactylon* (L.) Herbicides SIS-67B and SIS-67MB were applied with a success against dycotyledonous weeds (Dimitrova, 1984). Roux and Howe (1985) also found favourable effect over growth and development of birdsfoot trefoil after application of Tetrapon herbicide. Significant effect in treatment of birdsfoot trefoil crop showed herbicides Oxadiazon (Calkins u Swanson, 1995) and Imazethapyr (Nagy, 1995). Successful application in treatment with Dikvat + Reglon forte + Glyphosate was found in the fight with *Erigeron canadense* L. in seed production crop of birdsfoot trefoil (Dimitrova, 2007).

The aim of study was to determine the efficiency of herbicides Stratos Ultra and Pulsar 40 and their use in seed production of birdsfoot trefoil.

MATERIALS AND METHODS

The study was conducted in the experimental field of the IMSA - Troyan during the 2010-2012 period. The trial was carried out on light grey pseudopodzolic soil by the block method with 4 replications and harvest plot size of 5 m² in the following variants: 1 – control (C); 2. Stratos Ultra (100 g/l cycloxydim) - 1000 ml/ha; 3. Stratos Ultra - 2000 ml/ha; 4. Pulsar 40 (40 g/l imazamox) – 1000 ml/ha; 5. Pulsar 40 - 1200 ml/ha. All herbicides were chosen from the "List of the plant protection products, registered fertilizers and adjuvants authorized to placing on the market and use" (Yordanova and Tasheva, 2000) as of the date 22.01.2009. They both are selective vegetation herbicides, suitable for use against annual and perennial grass and broad-leaved weeds. We conducted soil tillage by the generally adopted technology in the IMSA – Troyan for establishment of artificial swards. Sowing was performed in spring at the sowing rate of 0.009 t ha⁻¹ and 60.0 cm interrow spacing with rolling of the area before and after sowing. We applied nitrogen fertilizer before sowing at the dose of 0.60 kg ha⁻¹ active ingredient and phosphorus and potassium fertilizer as reserve application at the doses of 0.40 kg ha⁻¹ for each. We performed the herbicide application at the 2-4 leaf stage of birdsfoot trefoil with a 500 l/ha working solution.

In the first year the experiment was harvested for the need of forage, and in the second and third one for seeds. The seeds were harvested from second cuttings as 65-70% of them became ripen.

As favourable year in relation to the meteorological conditions, when the rainfall was distributed equally during the months of the vegetation period, is viewed 2010. The average daily air temperature of 10.8 °C and the amount of precipitation 112.6 l/m² in April in the year of sowing influenced favourably the normal sprouting of birdsfoot trefoil. Phenophase 2-4 leaf occurred as normal in the middle of April, and the stage of budding in the middle of June, when the first cutting was harvested. The high soil humidity due to precipitation amount in the range of 76.7 and 132.7 l/m² in June and July provided fast growing and development of birdsfoot trefoil after its mowing and the formation of good second cutting.

The second year was characterised with comparatively higher amount of precipitation in June (98.4 l/m²), July (72.9 l/m²) and August (96.8 l/m²), when the seed cutting was formed. The higher air humidity delayed harvesting of seeds, which was performed in the final decade of August, but it did not obstruct to obtain high seed production of this sward.

The agrometeorological characteristic of the third year of sward development was rather different than the other two. The uneven distribution of precipitation in months was well pronounced, as humidity sufficiency was recorded in May (174.1 l/m²) and lack of rainfall in July. That was a prerequisite for obtaining of lower seed yield from the second cutting and poorer effect in the application of herbicides.

The following indicators are studied: weed infestation degree in the sward in the year of sowing and the years of seed production - the weed species composition was determined according to the quantitative and weight method in nb/m² and g/m², seed yield in both seed production years (2011 and 2012 in t ha⁻¹) and averagely for the period, structural analysis of seed yield including: number of pods per racemes; number of racemes per stem; number of seeds per pod and the weight of 1000 seeds. Data processing was performed according to the method of disperse analysis (Lidanski, 1988).

RESULTS AND DISCUSSION

Weed Infestation Degree. In the year of sward creation the degree of weed infestation was comparatively higher, which was due to slow growth rate and development of birdsfoot trefoil and the higher competitiveness of weeds (Table 1).

Table 1. Degree of weed infestation of birdsfoot trefoil crops in the year of its creation

Weeds	Variants									
	V ₁		V ₂		V ₃		V ₄		V ₅	
	pt/m ²	g/m ²	pt/m ²	g/m ²	pt/m ²	g/m ²	pt/m ²	g/m ²	pt/m ²	g/m ²
<i>Cichorium intybus</i> L.	5	40	4	45	2	10	3	15	2	10
<i>Plantago lanceolata</i> L.	11	10	5	5	5	5				
<i>Euphorbia cyparissias</i> L.	14	30	2	1	3	5			1	2
<i>Polygonum lapathifolium</i> L.	5	5			2	1	2	6		
<i>Polygonum aviculare</i> L.	15	20	6	15	13	30				
<i>Convolvulus arvensis</i> L.	2	2								
<i>Rumex acetosella</i>	1	5								
<i>Cardaria draba</i> L.							2	5		
<i>Potentillae reptans</i> folium L.					9	5			7	5
<i>Daucus carota</i> L.			11	15	2	5				
<i>Setaria verticillata</i> L.	3	5		2	5	4	2	1	7	5
Total	56	107	28	81	41	65	9	27	17	22
% in relation V ₁	100	100	50.0	75.7	73.2	60.7	16.1	25.2	30.3	20.6
<i>Lotus corniculatus</i> L., %										
	66.3		77.4		93.2		88.0		95.0	

Variations of experience:

V₁ – control – zero; V₂ - Stratos Ultra - 1000 ml/ha; V₃ - Stratos Ultra - 2000 ml/ha; V₄ - Pulsar 40 - 1000 ml/ha; V₅ - Pulsar 40 - 1200 ml/ha

Weeds reached 56 pt/m² in the untreated control, and their fresh biomass was 107 g/m². *Euphorbia cyparissias* L. had a predominant participation in the sward with 14 pt/m² and 30 g/m² fresh biomass. *Polygonum aviculare* L. had higher density (15 pt/m² and 20 g/m²). Higher is the participation of *Cichorium intybus* L. in relation to weight, respectively 40 g/m². The higher weed density in untreated control (V₁) specified also the comparatively low percentage participation of birdsfoot trefoil in the sward - 66.3%. As a result of application of Pulsar 40 in both doses of 1000 ml/ha and 1200 ml/ha the slightest degree of weed infestation was achieved, as the total amount of weeds was 9 pt/m² and 27 g/m² (variant 4) and 17 pt/m² and 22 g/m² (variant 5). In crop treatment by Pulsar 40 at a dose of 1000 ml/ha (variant 4), weeds were represented by the species of *Cichorium intybus* L. (3 pt/m² and 15 g/m²), *Polygonum lapathifolium* L. (2 pt/m² and 6 g/m²), *Cardaria draba* L. (2 pt/m² and 5 g/m²) and *Setaria verticillata* (2 pt/m² and 1 g/m²) participated with separate pieces and in insignificant amount in the sward. The higher dose of Pulsar 40 (variant 5) considerably decreases both the species composition and the quantitative and weight participation of weeds in the crop, which were represented by *Cichorium intybus* L. (2 pt/m² and 10 g/m²), *Euphorbia cyparissias* L. (1 pt/m² and 2 g/m²), *Potentillae reptans* folium L. (7 pt/m² and 5 g/m²) and *Setaria verticillata* (7 pt/m² and 5 g/m²). The wide range of action of the herbicide Pulsar 40 defines the manifested positive effect, as a result of which the birdsfoot trefoil participated in the sward with 88.0 (variant 4) and 95.0% (variant 5). Less pronounced is the effect of the application of herbicide Stratos Ultra in both doses (var. 2 and 3), which is evident both from more diverse species composition and from their greater number and weight. The weed weight in var. 2 is 75.7%, and in var. 3 is 60.7%, compared to the control. In the first seed production year (Table 2), the degree of weed infestation was considerably lower than the year of sowing.

Table 2. Degree of weed infestation of birdsfoot trefoil crops in the first year of seed production

Weeds	Variants									
	V ₁		V ₂		V ₃		V ₄		V ₅	
	pt/m ²	g/m ²	pt/m ²	g/m ²	pt/m ²	g/m ²	pt/m ²	g/m ²	pt/m ²	g/m ²
<i>Cichorium intybus</i> L.			1	1	1	2			1	4
<i>Plantago lanceolata</i> L.	4	5	1	2			1	1	1	1
<i>Euphorbia cyparissias</i> L.	4	3			4	4	2	4	1	1
<i>Cynodon dactylon</i> L.			3	2			1	1	1	1
<i>Taraxacum officinale</i> L.			1	3						
<i>Dianthus caryophyllus</i> L.	5	6								
<i>Rumex tenuifolium</i> L.	1	6			9	8				
<i>Cardaria draba</i> L.	3	5			1	1				
<i>Setaria verticillata</i> L.			7	3	3	1	3	1		
Total	17	25	13	11	9	8	7	7	4	7
% in relation V ₁	100	100	76.5	44.0	52.9	32.0	41.2	28.0	23.5	28.0
<i>Lotus corniculatus</i> L., %										
	89.3		94.7		95.8		97.3		97.2	

Variations of experience:

V₁ –control; V₂ - Stratos Ultra - 1000 ml/ha; V₃ - Stratos Ultra - 2000 ml/ha; V₄ - Pulsar 40 - 1000 ml/ha; V₅ - Pulsar 40 - 1200 ml/ha

That is due to the maximum growth rate and development of birdsfoot trefoil in that year, to its higher competitiveness in comparison to weeds and to the manifested after-action of herbicides that were applied in the previous year. In the untreated variant, the weeds decreased both in species composition and in quantitative relation. The reported total number of weeds was 17 pt/m², and the fresh biomass was 25 g/m². The application of the chemical method for fight against weed contributed for the increase in share participation of birdsfoot trefoil in the sward, which reached 94.7 and 95.8% in var. 2 and 3, and 97.3 and 97.2% in var. 4 and 5. Again the slightest is degree of weed infestation in treatment with herbicide Pulsar 40 (var. 4 and 5) as the total number of reported weeds under treatment at a dose of 1000 ml/ha was 7 pt/m², (var. 4), and at a dose of 1200 ml/ha - 4 pt/m² (var. 5). The sward consists mainly of the weeds *Setaria verticillata* L., *Cynodon dactylon* L., *Plantago lanceolata* and *Euphorbia cyparissias* L., which could be found in insignificant amount. The low degree of weed infestation under application of herbicide Pulsar 40 is due to its selectivity towards birdsfoot trefoil, which was found by Churkova (2013). In that case the dose of herbicide does not influence the degree of sward infestation. This also applies to the applied herbicide Stratos Ultra. Thus in its application at a dose of 1000 ml/ha, the total number and weight of fresh biomass of weeds was 13 pt/m² and 11 g/m² (var.2), and at a dose 2000 ml/ha - 9 pt/m² and 8 g/m² (var.3).

In the third seed production year (Table 3) was reported higher percentage of weeds under treatment with herbicide Stratos Ultra in comparison with Pulsar 40.

Table 3. Degree of weed infestation of birdsfoot trefoil crops in the second year of seed production

Weeds	Variants									
	V ₁		V ₂		V ₃		V ₄		V ₅	
	pt/m ²	g/m ²	pt/m ²	g/m ²	pt/m ²	g/m ²	pt/m ²	g/m ²	pt/m ²	g/m ²
<i>Plantago lanceolata</i> L.	10	14	2	1	5	4	1	1		
<i>Euphorbia cyparissias</i> L.	5	5	5	3			4	2	6	2
<i>Taraxacum officinale</i> L.			6	4						
<i>Hypericum perforatum</i> L.					2	1				
<i>Convolvulus arvensis</i> L.										
<i>Agropirum repens</i> L.					4	2	3	1		
<i>Cardaria draba</i> L.					8	8	1	8		
<i>Potentillae reptans</i> folium L.	20	5								
<i>Convolvulus arvensis</i> L.									6	4
Total	35	24	13	8	19	14	9	12	12	6
% in relation V ₁	100	100	37.1	33.3	54.3	58.3	25.7	50.0	34.2	25.0
<i>Lotus corniculatus</i> L., %										
	90.9	90.9	95.6	97.6	97.6	97.9				

Variations of experience:

V₁ –control; V₂ - Stratos Ultra - 1000 ml/ha; V₃ - Stratos Ultra - 2000 ml/ha; V₄ - Pulsar 40 - 1000 ml/ha; V₅ - Pulsar 40 - 1200 ml/ha

The weed participation as a result of treatment by Stratos Ultra at a dose 100 ml/ha (var. 2) according to number and weight was respectively 37.1 and 33.3%, and at a dose of 2000 ml/ha (var. 3) - 54.3 and 58.3%. The weed species composition is of interest. In treatment with one and the same herbicide only *Plantago lanceolata* L. presented in the sward in two variants, respectively with 2 nb/m² and 1 g/m² (var. 2) and 5 pt/m² and 4 g/m² (variant 3). In variant 2, weeds were represented by *Euphorbia cyparissias* L. (5 pt/m² and 3 g/m²) and *Taraxacum officinale* L. (6 pt/m² and 4 g/m²), and in variant 3 by *Cardaria draba* L. (8 pt/m² and 8 g/m²), *Hypericum perforatum* L. (2 and 1 g/m²) and *Agropirum repens* L. (4 nb/m² and 2 g/m²). Herbicide Pulsar 40 showed better effect in relation to weeds in the third year as well. Reduction of weed species composition in the sward was observed in variant 5, as they were represented by *Euphorbia cyparissias* L. (6 nb/m² and 2 g/m²) and *Convolvulus arvensis* L. (6 nb/m² and 4 g/m²). The slight degree of weed infestation in application of herbicide Pulsar 40 is due to its controlling effect in relation to the one-year monocotyledonous and dycotyledonous weeds, which has been confirmed by Dimitrova (2010). As a result of its application, the participation of birdsfoot trefoil in the sward increased up to 97.6 (variant 4) and 97.9 (variant 5).

Influence of weeds and fight against them over the structural elements of seed yields of birdsfoot trefoil. In relation to structural elements of seed yield (Table 4) was found a tendency toward higher values of the different indicators in treatment with herbicide Pulsar 40. Number of pods per raceme in treatment of birdsfoot trefoil crops by herbicide Pulsar 40 was 3.9 and 4.0 (var. 4 and 5), compared to 3.4 and 3.1 after treatment with Stratus Ultra (var.2 and 3). The same tendency was found in relation to number of racemes per stem. Thus their number grew from 12.3 to 13.0 in 2011 and from 11.2 to 11.8 in 2012 in treatment of plants by herbicide Stratus Ultra. Higher were values of number of racemes per stem after treatment by Pulsar 40, respectively 13.2 and 13.8 in 2011 and 12.1 and 12.7 in 2012. The number of seeds per pod also increased after treatment of the sward by Pulsar 40, as in variant 4 they were 21.2 and 22.3 (2011) and 21.2 and 22.3 (2012). The mass of 1000 numbers of seeds is an indicator, which is not influenced by the herbicide dose. For the treated variants in the first seed production year it varied from 1.2 to 1.4 g, and for 2012 from 1.1 to 1.8g. The values of indicators that characterised the structural elements of seed yield are in a direct dependence on the obtained seed yields in the different variants.

Table 4. Structural elements of the seed yield

Variants	Number of pods per racemes		Number of racemes per stems		Number of seeds in pod		1000 seed weight	
	2011	2012	2011	2012	2011	2012	2011	2012
Control	3.0	2.9	11.5	10.5	18.2	17.2	1.0	1.0
Stratos Ultra - 1000 ml/ha	3.4	3.3	12.3	11.2	19.7	18.4	1.2	1.1
Stratos Ultra - 2000 ml/ha	3.1	3.5	13.0	11.8	20.5	18.9	1.3	1.7
Pulsar 40 - 1000 ml/ha	3.9	3.8	13.2	12.1	21.2	19.8	1.4	1.6
Pulsar 40 - 1200 ml/ha	4.0	4.5	13.8	12.7	22.3	20.1	1.4	1.8
X	3.4	3.6	12.7	11.7	20.4	18.9	1.3	1.4
Min	3.0	2.9	11.5	10.5	18.2	17.2	1.0	1.0
Max	4.0	4.5	13.8	12.7	22.3	20.1	1.4	1.8

Influence of weeds and fight against them over the seed productivity of birdsfoot trefoil. Weeds and fight against them have a positive influence over the seed productivity of birdsfoot trefoil (Table 5). The above is confirmed from the highly pronounced difference in the obtained seed yield by years and averagely for the period.

In the first year of seed production, the seed yield was within the limit from 0.28 t ha^{-1} (var. 1) to 0.35 t ha^{-1} (var. 4). The highest seed yield was harvested in the crop that was treated with herbicide Pulsar 40 at a dose of 1000 ml/ha (var. 4), as the exceeding compared to the control was by 27.6% at a very good mathematical evidence of the differences. The higher dose of that herbicide (var. 5) also showed high seed productivity, respectively 0.33 t ha^{-1} and an increase compared to the control by 19.4%. Lower yield compared to those treated by Pulsar 40, but higher than that of the control was obtained after treatment by herbicide Stratos Ultra (var. 2 and 3) in both doses. The fulfilled seed yield was 0.31 t ha^{-1} (var. 3), and the exceeding compared to the control was by 9.3 and 11.2% at a positive evidence for differences.

In the second seed production year in the seed yield from the control 0.27 t ha^{-1} (var. 1) the productivity reached up to 0.36 t ha^{-1} under treatment by herbicide Pulsar 40 (var. 4). The treatment in that variant showed the highest seed productivity with a very good positive evidence of the differences and an exceeding compared to the control by 32.6%. The lowest seed yield was harvested from the variant treated by Stratos Ultra at a dose of 1000 ml/ha (var. 2), but the exceeding compared to the control was by 8.3% and was statistically well proved. With the exception of the variant treated by the herbicide Pulsar 40 at a dose of 1000 ml/ha (var. 4), the seed yield was lower than the yield obtained in the first year. This is due to the decreased number of racemes per stem and number of seeds per pod. The humidity sufficiency in July and the high average daily temperatures, which contributed for the uneven seed ripening and their cracking were a prerequisite for the obtained lower seed yield. The fulfilled seed yield defines the herbicide Pulsar 40 as effective for overcoming the problem of fighting against weeds in birdsfoot trefoil crop.

Table 5. Influence of weeds and weed control them on the seed yield of birdsfoot trefoil, t ha⁻¹

Variants	2011		2012		Mean for the period	
	t ha ⁻¹	%	t ha ⁻¹	%	t ha ⁻¹	%
Control	0.28	100.0	0.27	100.0	0.28	100.0
Stratos Ultra - 1000 ml/ha	0.31	109.3 +	0.29	108.3 ++	0.30	108.7 ++
Stratos Ultra - 2000 ml/ha	0.32	111.2 +	0.30	112.5 +++	0.31	111.7 +++
Pulsar 40 - 1000 ml/ha	0.35	127.6 +++	0.36	132.6 +++	0.36	130.2 +++
Pulsar 40 - 1200 ml/ha	0.33	119.4 +++	0.32	117.1 +++	0.33	118.4 +++
LSD 5%	0.02	8.5	0.01	8.54	0.02	5.9
LSD 1%	0.03	12.0	0.02	12.0	0.02	8.3
LSD 0.1%	0.05	16.9	0.03	16.9	0.03	11.7

Average for the period of study, the seed yield followed the tendency during both years at a very good evidence of differences in treatment with Pulsar 40 in both doses (var. 4 and 5) and with Stratos Ultra at a dose of 2000 ml/ha (var. 3). The elimination of the harmful effects of weed in these variants led to obtainment of seed yield that exceeded the control, respectively by 30.2% (var. 4), 18.4% (var. 5) and 11.7% (var.3). In the sward treated by Stratos Ultra at a dose of 1000 ml/ha (var. 2), the seed yield also exceeded the control by 8.7 and had a good mathematical evidence for the differences. The obtainment of higher yield of seeds in the variants with chemical control against weeds was an evidence for the need to lead a fight against weeds in seed production crops of birdsfoot trefoil.

CONCLUSION

Biological characteristics of birdsfoot trefoil are a prerequisite for the high degree of weed infestation of the seed production crops in the year of sowing, when weeds reached 56 nb/m² and 107 g/m² fresh biomass. This imposes the necessity to lead an efficient fight against the weeds in the seed production crops of birdsfoot trefoil. The highest effect against the available weeds had the herbicide Pulsar 40, applied in the phase 2-4 leaf of birdsfoot trefoil at a dose of 1200 ml/ha. The treatment with herbicide restricted the opportunity to increase the population density of weeds and led to increase in seed yield by 30.2% The high seed production in case of treatment with that herbicide determined also the high values of structured elements of seed production. In the treatment by herbicide Stratos Ultra high seed production was also realised, which exceeded the control with 8.7% at a dose of 1000 ml/ha and 11.7% at a dose of 2000 ml/ha.

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