

# Effect of Weeds and Some Methods for their Control in Seed Production Stands of Sainfoin (*Onobrychis viciifolia* Scop.)

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Tsvetanka Dimitrova

*Institute of Forage Crops, 89 Gen. Vl. Vazov Street, 5800 Pleven, Bulgaria  
(tsv\_dimitrova @ abv.bg)*

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## SUMMARY

During the 2007-2009 period in the experimental field of the Institute of Forage Crops a study was conducted with the purpose of investigating the effect of weeds and some methods for their control in seed production stands of sainfoin (*Onobrychis viciifolia* Scop.). The trial was carried out on a slightly leached chernozem on an area with a natural background of weed infestation. As a result of the study it was found:

Establishment of very uniform and productive seed production stands of sainfoin required effective weed control concentrated mainly in the first year when the degree of weed infestation was the highest and reached to a number of 245 plants/m<sup>2</sup> and the fresh weed biomass to 1311 g/m<sup>2</sup>.

The chemical control method showed the highest efficacy had the highest efficiency when, in the year of stand establishment at the stage of second-fourth true leaf of sainfoin, the treatment was conducted with imazamox 40g/l (Pulsar 40) at the dose of 48 g a.i./ha or with the system of Bentazon 600 g/l (Basagran 600 SL) – 900 g a.i./ha – fluzifop-P-butyl g/l (Fusilad Forte) – 120 g a.i./ha. In the years of seed production in spring at the beginning of vegetation, the treatment was conducted with imazamox 40 g/l (Pulsar 40) at the dose of 20 g a.i./ha + adjuvant DESH at the dose of 1000 ml/ha.

An alternative to the chemical method is to sow sainfoin under cover of spring barley achieving more complete use of the area in the first year, a weed suppressive and ecological effect, but some negative residual effect on the crop was also observed;

The pure stands of sainfoin with chemical control of weeds had the highest seed productivity, exceeding the zero check by 24 to 28%, followed by the stands with spring barley as a cover crop with an increase of 12% and the mixed stands of sainfoin with crested wheatgrass had the lowest productivity.

**Keywords:** Sainfoin; Weeds; Chemical control; Cover crop; Mixed stand; Seed productivity

## INTRODUCTION

Sainfoin is a perennial legume herbaceous forage and traditional crop for Bulgaria. It develops very well on calcareous, dry and stony soils (Kyuchukova and Ilieva, 2008). Owing to its valuable qualities as a forage plant and the fact that it has no requirements with respect to the conditions of growing, the interest for it has increased continuously during the last years (Kostov and Pavlov, 1999).

One of the main reasons for yield decrease, for quick stand thinning and for quality deterioration of the obtained output from the seed production stands is their high degree of weed infestation. As a result of the negative influence of weeds, the decrease of seed yield reached to 65% depending on the species and degree of weed infestation and the practice of growing (Dimitrova, 1995).

During the last several decades, the chemical method has been a key component in the strategy for weed control unsurpassed at this stage with regard to its efficacy easy applicability and quick effect. The use of selective and efficient herbicides leads to establishment of very uniform and persistent stands and to increase of seed yield (Benkov and Prodanov, 1974; Waddington, 1978; Mayer, 1979; Dimitrova and Benkov, 1984; Lyubenov, 1987).

With the compensation changes having occurred in the weed communities and the multiplication of resistant weeds, in order to eliminate some ecological problems arising when using herbicides, it is necessary to develop new agrochemical and technological criteria for application of the weed control measures (Nikolova, 2003). An important moment is also the use of some cultural practices having a significant place in the systems of ecological farming (Stopes and Millington, 1991; Bond and Lennartsson, 1999). Production of high-quality seeds and establishment of weed-free stands of sainfoin requires to improve some plant protection practices for weed control and to search for new ones.

The objective of this study was to investigate the effect of weeds and some methods for their control in seed production stands of sainfoin (*Onobrychis viciifolia* Scop.).

## MATERIAL AND METHODS

The study was conducted during the 2007-2009 period in the experimental field of the Institute of Forage Crops, Pleven on a slightly leached medium-deep chernozem with pH 7.3-7.6 under nonirrigated conditions. The trial was laid out on an area with a natural back-

ground of weed infestation and a size of harvest plot of 5 m<sup>2</sup> including the following variants: V<sub>1</sub> – sainfoin pure stand (SPS) - check zero; V<sub>2</sub> – SPS - check weed-ed; V<sub>3</sub> – SPS with chemical control (CC<sup>a</sup>); V<sub>4</sub> – SPS with chemical control (CC<sup>b</sup>); V<sub>5</sub> – Sainfoin + cover of Spring barley (*Hordeum sativum*); V<sub>6</sub> – Sainfoin + Crested wheatgrass (*Agropyron cryctatum* (L). Gaerth.).

Sowing was conducted in spring at the sowing rate of sainfoin of 50 kg/ha unhusked seeds at 36 cm interrow spacing. Spring barley and wheatgrass were sown in a perpendicular direction to sainfoin at sowing rates of 80 and 20 kg/ha, respectively. Soil tillage included autumn deep ploughing, twofold cultivation with harrowing and rolling before and after the sowing. Fertilizing with P<sub>2</sub>O<sub>5</sub> – 200 kg/ha and N 120 kg/ha (1/2 in spring + 1/2 in autumn) was conducted.

In the year of stand establishment, the weed control was conducted as follows: in V<sub>3</sub> – treatment with imazamox 40 g/l (Pulsar 40) at the dose of 48 g a.i./ha at the stage of second-fourth true leaf of sainfoin; in V<sub>4</sub> – treatment with Bentazon 600 g/l (Basagran 600 SL) at the dose of 900 g a.i./ha in a system with fluazifop-P-butyl 150 g/l (Fusilad Forte) at the dose of 120 g a.i./ha; in V<sub>5</sub> – no chemical control was conducted in order to determine the weed suppressive capacity of spring barley as a biological means of control; in V<sub>6</sub> – treatment with Bentazon 600 g/l (Basagran 600 SL) at the dose of 900 g a.i./ha.

During the years of seed production, a treatment was conducted only in the stands with chemical control (V<sub>3</sub> and V<sub>4</sub>) in spring at the beginning of vegetation with imazamox 40 g/l (Pulsar 40) at the dose of 20 g a.i./ha + adjuvant DESH at the dose of 1000 ml/ha. The herbicides were applied with a working solution of 500 l/ha.

In the first year the trial was harvested for forage and in the second and third year for seeds (from first cut).

The most unfavorable meteorological conditions were those in the year of stand establishment (2007) due to insufficient amount of rainfall in the period after sowing. Nevertheless, two cuts for forage were formed in the presence of 202.2 mm rainfall. In the years of seed production, the formation of first cut for seeds took place under more favourable conditions, using the moisture during the winter-spring period – 253.2 mm (2008) and 264.2 mm (2009). Due to the subsequent summer droughts, only one cut for forage was harvested after the cut for seed.

The observed characteristics in the study were as follows: species and quantitative composition of weeds; phytotoxic effect of herbicides; botanical analysis of sward; productivity of seeds and dry biomass; seed qualities (1000-seed weight, germination energy and germination).

## RESULTS AND DISCUSSION

It is evident from data in Table 1 that the degree of weed infestation was the highest in the year of stand establishment when sainfoin is greatly vulnerable to competitive effect of weeds. Their number in the zero

check ( $V_1$ ) reached 245 plants/m<sup>2</sup> at fresh weight of aboveground biomass of 1311 g/m<sup>2</sup>. The annual dicotyledons had the greatest participation in the weed association – 72.5% followed by annual monocotyledons – 21.7%, perennial dicotyledons – 4.9% and perennial monocotyledons – 0.9%.

**Table 1.** Degree of weed infestation of sainfoin stands in the year of their establishment

Weeds/m <sup>2</sup>	Variants*									
	$V_1$		$V_3$		$V_4$		$V_5$		$V_6$	
	nm	g	nm	g	nm	g	nm	g	nm	g
<b>Annual monocotyledonous</b>	179	284	9	14	4	7	40	65	121	143
<i>Setaria spp.</i>	158	246	7	9	2	3	36	52	103	111
<i>Panicum crus galli</i> L.	21	38	2	5	2	4	4	13	18	32
<b>Annual dicotyledonous</b>	42	951	10	44	9	43	23	82	23	68
<i>Sinapis arvensis</i> L.	11	750	–	–	–	–	3	11	–	–
<i>Amaranthus retroflexus</i> L.	13	40	2	2	1	3	5	16	3	8
<i>Chenopodium album</i> L.	6	121	4	30	3	28	6	24	3	24
<i>Capsella bursa pastoris</i> (L.) Medic	4	8	1	2	–	–	2	3	1	2
<i>Polygonum aviculare</i> L.	6	12	2	4	4	8	5	10	8	16
<i>Solanum nigrum</i> L.	2	20	1	6	1	4	2	18	2	18
<b>Perennial monocotyledonous</b>	6	12	2	3	–	–	4	6	3	9
<i>Sorghum halepense</i> (L.) Pers (from seed)	6	12	2	3	–	–	4	6	3	9
<b>Perennial dicotyledonous</b>	18	64	7	18	6	16	13	34	11	41
<i>Convolvulus arvensis</i> L.	13	28	5	9	4	8	11	24	8	19
<i>Cirsium arvense</i> (L.) Scop.	5	36	2	9	2	8	2	10	3	22
<b>Total</b>	245	1311	28	79	19	66	80	187	158	268
<b>% of <math>V_1</math></b>	100	100	11	6	8	5	33	14	64	20

\*Variants of the trial:  $V_1$  – Sainfoin pure stand (SPS) – check zero;  $V_2$  – SPS – check weeded;  $V_3$  – SPS – with chemical control (CC<sup>a</sup>);  $V_4$  – SPS – with chemical control (CC<sup>b</sup>);  $V_5$  – Sainfoin + cover of Spring barley (*Hordeum sativum*);  $V_6$  – Sainfoin + Crested wheatgrass

The applied herbicides for chemical control (imazamox 40 g/l, Bentazon 600 g/l and fluzifop-P-butyl) showed a high selectivity towards sainfoin.

The highest efficacy with regard to the weeds was obtained as a result of the applied system of Bentazon – fluzifop-P-butyl ( $V_4$ ), where their number was 8% and their weight was only 5%, as against the zero check ( $V_1$ ). Similar efficacy to the abovementioned one was obtained also in the stand treated with imazamox, 11% and 6% respectively ( $V_3$ ). A considerably lower degree of weed infestation, as compared to the zero check was obtained as a result of the weed suppressive role of the cover crop ( $V_5$ ) with values of 33% with regard to the number and 14% with regard to the weight of weeds. The lowest results in the first year were obtained in the mixed stand ( $V_6$ ) – 64% and 20% respectively. They were due to the slow growth and development of the

two components after sowing and due to the compensation process taking place at the expense of the monocotyledonous weeds.

The weed control and stand type showed direct relation to the participation of cultivated components in the sward. Sainfoin in the pure stands with chemical control ( $V_3$  and  $V_4$ ) had the highest weight participation (90-92%). Its participation in the mixed stand ( $V_6$ ) was 48%, wheatgrass – 18% and weeds – 34%. In the stand with a cover crop ( $V_5$ ), sainfoin had the lowest participation – 14%, at the expense of the cover crop – 73% and the weeds were 13%. In the zero check ( $V_1$ ), sainfoin participated with 28% and the weeds reached 72%. That confirmed the need to conduct weed control when establishing seed production stands.

In the years of seed production, the degree of weed infestation was considerably lower compared with the

first year in terms of quantity as well as weed species composition (Table 2). In the second year, the annual dicotyledonous weeds (*Capsella bursa pastoris* (L.) Medic, *Thlaspi arvense* L.) participated with 30% and the perennial dicotyledonous weeds (*Convolvus arvensis*

L., *Cirsium arvense* (L.) Scop.) participated with 70% in the weed association. The degree of weed infestation had the lowest values (28-29%) in the stands with chemical control ( $V_3$  and  $V_4$ ), as a result of the treatment at the beginning of vegetation with imazamox.

**Table 2.** Degree of weed infestation of sainfoin stands in the years of seed production

Variants*	Weeds / m <sup>2</sup>							
	2008				2009			
	number	% $V_1$	weight, g	% $V_1$	number	% $V_1$	weight, g	% $V_1$
$V_1$	22	100	69	100	40	100	131	100
$V_3$	6	27	19	28	8	20	40	31
$V_4$	8	36	20	29	10	25	45	34
$V_5$	29	132	68	99	39	98	164	125
$V_6$	14	64	28	41	5	13	18	14

\*Variants as in Table 1

In the third year of growing and the second year of seed production, higher values of weed infestation were recorded, as compared to the previous one. However the mixed stand ( $V_6$ ) was the sole exception, where the fresh weed weight was only 14%. That was due to the denser sward of the grass component, whereas in the pure stands some plants of sainfoin dropped out in a natural way and the free spaces were occupied by weeds. According to data of Vasilev (2008), the mixed stands of sainfoin with ryegrass and cocksfoot are infested more slightly by weeds, as compared to the pure stands.

The weed density in the zero check ( $V_1$ ) reached a number of 40 plants/m<sup>2</sup> and their fresh biomass 131 g/m<sup>2</sup>. The annual dicotyledons (*Capsella bursa pastoris* (L.) Medic, *Sonchus oleraceus* L., *Papaver rhoeas* L., *Lactuca scariola* L.) had also predominant participation, reaching 69%. The presence of the perennial dicotyledons (*Sonchus arvensis* L., *Lepidium draba* L., *Cirsium arvense* L.) was 14% and that of the annual monocotyledons (*Bromus arvensis* L.) was 17%. The degree of weed infestation was the highest in the stand with a cover crop ( $V_5$ ), due to its negative residual effect expressed in some thinning of the stand. As a result of the chemical treatment at the beginning of the growing season the values of this character were within the range of 31-34% ( $V_3$  and  $V_4$ ).

The results of seed productivity showed direct relation to the weed influence and the effect of their control, as well as to the practice of growing of the stand (Table 3). In the first year of seed production, the seed yield varied from 1207 ( $V_1$ ) to 1432 ( $V_2$ ) kg/ha and the increase, as against the zero check was by 6 to 19% at

good (for  $V_6$ ) and very good significance of the differences (for  $V_2$ ,  $V_3$ ,  $V_4$  and  $V_5$ ). The highest seed yields and similar to those from the weeded check ( $V_2$ ) were harvested from the pure stands with chemical control ( $V_3$  and  $V_4$ ).

Evidence of high competition of the weeds also in the second year of seed production was the increase of the seed yield from the weeded check ( $V_2$ ) by 48%, as against the zero check ( $V_1$ ). The increase of the seed yield from the stands with chemical control ( $V_3$  and  $V_4$ ) was by 35 and 42%, respectively and from the stand with a cover crop ( $V_5$ ) by 16% at very good significance. However the great reduction of the seed yield from the mixed stand ( $V_6$ ) made an impression, being even lower by 17% than that from the zero check ( $V_1$ ) at very good negative significance. That was due to the more strongly expressed competitive influence of the grass component, as a result of which the sainfoin participation in the sward was lower, as compared to the previous year.

The seed productivity, on average for the experimental period, showed the same tendency as in the second year for seed production. The negative influence of the weeds on this character found expression in the 32% higher seed yield from the weeded check ( $V_2$ ), compared with the zero one ( $V_1$ ). The seed yields from the pure stands with chemical control ( $V_3$  and  $V_4$ ) had very good significance of the differences, exceeding the zero check ( $V_1$ ) by 24 to 28% and the stand with a cover crop by 12%. The mixed stand ( $V_6$ ) had the lowest productivity and its seed yield was 4% lower at very good negative significance, as against the zero check.

**Table 3.** Effect of weeds and their control on the seed productivity of sainfoin

Variants*	Seeds								
	2008			2009			Average (2008-2009)		
	kg/ha	% V <sub>1</sub>	% V <sub>2</sub>	kg/ha	% V <sub>1</sub>	% V <sub>2</sub>	kg/ha	% V <sub>1</sub>	% V <sub>2</sub>
V <sub>1</sub>	1207	100	84	957	100	67	1082	100	76
V <sub>2</sub>	1432	119	100	1419	148	100	1426	132	100
V <sub>3</sub>	1395	116	97	1288	135	91	1342	124	94
V <sub>4</sub>	1413	117	99	1363	142	96	1388	128	97
V <sub>5</sub>	1304	108	91	1113	116	78	1209	112	85
V <sub>6</sub>	1282	106	90	799	83	56	1041	96	73
GD P <sub>5%</sub>	42.4			20.5			19.0		
P <sub>1%</sub>	58.6			28.3			26.2		
P <sub>0.1%</sub>	81.1			39.1			36.2		

\*Variants as in Table 1

It is evident from the structural analysis of productivity elements (Table 4) that there was interrelationship between seed yield and weed influence and weed control efficacy on their development. In the first year of seed production, the maximum number of repro-

ductive stems (464/m<sup>2</sup>) was formed in the stand with complete elimination of weed influence (V<sub>2</sub>), whereas in the zero check their number was 17% lower. As a result of the conducted chemical control, the number of reproductive stems reached 450-457/m<sup>2</sup>.

**Table 4.** Structural analysis of productivity elements of sainfoin

Variants*	Reproductive stems, number/m <sup>2</sup>	Height cm	Inflorescences, number/stem	Seeds per stem g	1000-seed weight g
V <sub>1</sub>	387	115.3	5.9	2.9	22.60
V <sub>2</sub>	464	119.6	6.7	3.3	23.26
V <sub>3</sub>	450	119.8	6.9	3.1	23.28
V <sub>4</sub>	457	119.0	6.7	3.3	23.24
V <sub>5</sub>	425	116.4	6.1	3.0	22.85
V <sub>6</sub>	413	114.7	6.2	2.7	22.62
average	433	117.5	6.4	3.1	22.98
min	387	114.7	5.9	2.9	22.60
max	464	119.8	6.9	3.3	23.28
2009					
V <sub>1</sub>	306	110.3	4.5	1.4	21.51
V <sub>2</sub>	454	115.8	6.0	1.9	21.13
V <sub>3</sub>	412	115.9	5.9	1.8	21.58
V <sub>4</sub>	436	114.7	6.2	1.9	22.42
V <sub>5</sub>	356	112.5	5.2	1.6	21.67
V <sub>6</sub>	252	106.8	4.0	1.2	21.63
average	369	112.7	5.3	1.6	21.66
min	252	106.8	4.5	1.2	21.13
max	454	115.9	6.2	1.9	22.42

\*Variants as in Table 1

The lowest values of this character after those in the zero check were recorded in the mixed stand ( $V_6$ ), to which the lowest seed yield was due. There was also a difference in the height of reproductive stems within the range from 114.9 to 119.8 cm, in the formed inflorescences per stem – from a number of 5.9 to 6.9, as well as in the seed weight per stem – from 2.9 to 3.3 g. In the second year of seed production, in spite of the lower values of these characteristics, the tendency between the different variants was the same. The mixed stand ( $V_6$ ) made an impression with sharply deviating values of these characteristics, which was a result from the

stronger aggressive influence of the grass component.

With regard to the character of 1000-seed weight, a regular tendency between the variants in the same year was not found and the differences during the particular years were also nonsignificant (22.60-23.28 g and 21.13-22.42 g).

The seed production stands produce also dry biomass as additional output (Table 5). In the year of stand establishment, it was formed from two cuts harvested for forage and in the years of seed production from the crop residues of first cut harvested for seeds and one cut for forage.

**Table 5.** Yield of dry biomass from sainfoin grown for seed production

Variants*	Dry biomass							
	2007		2008		2009		Average 2007-2009	
	kg/ha	% $V_1$	kg/ha	% $V_1$	kg/ha	% $V_1$	kg/ha	% $V_1$
$V_1$	3430	100	10360	100	11040	100	8280	100
$V_2$	4710	137	15290	148	16010	145	12000	145
$V_3$	4690	137	14750	142	15440	140	11630	140
$V_4$	4690	137	14200	137	15410	140	11430	138
$V_5$	4680	136	13530	131	12490	113	10230	124
$V_6$	2910	85	13780	133	12170	110	9620	116
GD $P_{5\%}$	298.7		432.1		275.8		226.2	
$P_{1\%}$	413.1		597.6		381.4		312.8	
$P_{0,1\%}$	571.0		825.9		527.1		432.3	

\*Variants as in Table 1

The productivity of dry biomass from the swards with chemical control and with a cover crop exceeded that from the zero check by 37% and by 36% respectively – at very good significance of the differences. The yield from the mixed stand was 15% lower at good negative significance. In the first year of seed production the increase of the yields of dry biomass, as against the zero check was by 31 to 42% and in the weeded check ( $V_2$ ) it reached to 48%. In the second year the increase of the values of this character was by 16 to 40% and by 45% in the weeded check. In both cases the differences had very good positive significance. On average for the three-year period the dry biomass yield was within the range from 8280 kg/ha ( $V_1$ ) to 12000 kg/ha ( $V_2$ ), the increase varying from 16 to 45% also at very good significance.

## CONCLUSIONS

Establishment of very uniform and productive seed production stands of sainfoin required effective weed control concentrated mainly in the first year when the degree of weed infestation was the highest and reached to a number of 245 plants/m<sup>2</sup> and the fresh weed biomass to 1311 g/m<sup>2</sup>;

The chemical method for control had the highest efficacy when, in the year of stand establishment at the stage of second-fourth true leaf of sainfoin, the treatment was conducted with imazamox 40 g/l (Pulsar 40) at the dose of 48 g a.i./ha or with the system of Bentazon 600 g/l (Basagran 600 SL) – 900 g a.i./ha – fluazifop-P-butyl g/l (Fusilad Forte) – 120 g a.i./ha. In the years of seed production in spring at the beginning

of vegetation, the treatment was conducted with imazamox 40 g/l (Pulsar 40) at the dose of 20 g a.i./ha + adjuvant DESH at the dose of 1000 ml/ha.

An alternative to the chemical method is to sow sainfoin under cover of spring barley achieving more complete use of the area in the first year, a weed suppressive and ecological effect, but some negative residual effect on the crop was also observed;

The pure stands of sainfoin with chemical control of weeds had the highest seed productivity, exceeding the zero check by 24 to 28%, followed by the stands with spring barley as a cover crop with an increase of 12% and the mixed stands of sainfoin with crested wheatgrass had the lowest productivity.

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# Uticaj korova i metoda njihovog suzbijanja na proizvodnju semena esparzete (*Onobrychis viciifolia* Scop.)

## REZIME

U periodu 2007-2009. godine na eksperimentalnim parcelama Instituta za krmno bilje, Pleven, Bugarska, ispitivan je uticaj korova i nekih metoda njihovog suzbijanja na proizvodnju semena esparzete (*Onobrychis viciifolia* Scop.). Istraživanja su obavljena na zemljištu tipa degradirani černo zem pri zatečenom nivou zakorovljenosti parcela. Na osnovu rezultata istraživanja može se zaključiti sledeće:

- zasnivanje uniformnih i visokoproduktivnih useva za proizvodnju semena esparzete zahtevalo je efikasno suzbijanje korova, prvenstveno u prvoj godini, kada je stepen zakorovljenosti bio najveći i dostizao 245 biljaka/m<sup>2</sup>, a sveža biomasa korova 1311 g/m<sup>2</sup>;

- hemijsko suzbijanje korova je bilo najefikasnije u godini zasnivanja useva i u fazi kada je esparzeta imala 2-4 lista, tretiranjem imazamoksom 40 g/l (Pulsar 40) u količini 48 g a.m./ha ili mešavinom Bentazon 600 g/l (Basagran 600 SL) – 900 g a.m./ha – fluzifop-P-butyl g/l (Fusilad Forte) – 120 g a.m./ha. U godinama proizvodnje semena, na početku vegetacije u proleće, hemijsko suzbijanje je rađeno imazamoksom 40 g/l (Pulsar 40) u količini od 20 g a.m./ha + okvašivač DESH u količini od 1000 ml/ha;
- alternativa hemijskoj metodi suzbijanja korova je setva jarog ječma kao pokrovnog useva. U ovom slučaju je postignuto suzbijanje korova ali su zabeleženi negativni rezidualni efekti na usevu;
- produktivnost proizvodnje semena je bila najveća (24-28%) pri hemijskom suzbijanju korova u usevu esparzete, nešto manja (12%) pri setvi jarog ječma kao pokrovnog useva, a najmanja u usevu esparzete i češljaste pirovine.

**Ključne reči:** Esparzeta; korovi; hemijsko suzbijanje; pokrovni usev; produktivnost semena