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RESEARCH REGARDING WEEDS CONTROL IN GRAIN LEGUMES CROPS

Marga GRĂDILĂ[1], Daniel JALOBĂ[1], Valentin CIONTU[1], Mihaela ŞERBAN[2], Victor PETCU[2]

[1]Research and Development Institute for Plant Protection, Ion Ionescu de la Brad Blvd, Bucharest, Romania
[2]National Agricultural Research and Development Institute Fundulea, 1 N. Titulescu Street, Fundulea, Romania

Corresponding author email: marga_gradila@yahoo.com

Abstract

Although there are quite small areas sown with grain legumes in Romania, in recent years these crops have become more attractive to farmers also due to the fact that it leaves the soil enriched in nitrogen. Dried grain legumes crops have certain peculiar features that farmers must take into account to obtain profitable harvests. One of these features refers to the sensitivity of pea and bean crops to weed infestation, especially in the early stages of vegetation. In this context, the aim of the present study was to evaluate the efficacy and selectivity of the herbicides applied in pre and post-emergence on weed control in peas and beans. To this end, three experimental fields were conducted in Ilfov, Calarasi and Bucharest during spring and summer of 2020. Assessments were made at 14, 28 and 42 days after treatments application and they aimed at the effectiveness in controlling the mono and dicotyledonous weeds and crop safety. The results obtained have shown that the effectiveness of herbicides applied in peas and beans crops depends on weed species, their density on square meter, pedoclimatic and agrophytotechnical indicators.

Key words: *effectiveness, herbicides, phytotoxicity, bean, pea.*

INTRODUCTION

Grain legumes are valuable crops, rich in proteins and essential amino acids, playing an important role in human nutrition (Esmaeilzadeh & Aminpanah 2015; Ivanov, 2019). Alone, they contribute up to 33% of the dietary protein needs of humans (Vance et al., 2002). These crops also leave the soil enriched in nitrogen and they have an important role in crop rotation (Bazitov, 2002). Peas (*Pisum sativum* L.) and beans (*Phaseolus vulgaris* L.) are crops intended for both food and fodder, being appreciated by the Romanian consumer. Romania has the largest number of grain legume farms in the EU, almost 100,000 agricultural holdings (*2017).

A Romanian farm that grows peas or beans measures an average of 1.8 hectares, being 3.5 times smaller than the European average. Pea and bean crops have become more attractive to Romanian farmers since the European Union decided to encourage these crops by providing grants, namely "payment for greening".

Weeds are one of the major biological constraint in crop production and, therefore, their control is an important component of any crop production system.

Bean and pea plants are sensitive to weed competition, mainly during the early vegetative growth stages (Blackshaw, 1991; Pynenburg et al., 2011; Teixeira et al., 2009; Vidal et al., 2010; Fontes et al., 2013), found that seed yield in dry bean was reduced up to 85% result of season-long weed competition. Also, weeds compete vigorously with pea and yield reduction of 20-40 % are common (Blackshaw & O Donovan, 1993; Wall et al., 1991). Wider spacing in peas provides ample opportunities for weed infestation resulting in 18-76% yield losses (Singh et al., 1991; Kundra et al., 1993; Banga et al., 1998). Chemical weed control is still the predominant component of weed management in crop production (Arevalo et al., 1992; Tironi et al., 2012; Aboali & Saeedipour, 2015). The objective of this research was to investigate weed control efficacy and phytotoxicity to the crop of some herbicides applied in peas and beans at different doses, with different application timings.

MATERIALS AND METHODS

For this purpose, 3 experimental fields were placed in Ilfov, Călărași and Bucharest counties during spring and summer 2020 at SC Ghinea Prod. S.R.L., Călăraşi county (N: 44°28'77.6, E: 27°02'69.0), Didactic farm Moara Domnească (N: 44°29'38.6, E: 26°14'02.0) and Research Development Institute for Plant Protection - Bucharest (N: 44°30'82.5, E: 26°04'17.8). The soils in the experimental fields were: brown redish with clay loam texture at Ilfov and Bucharest, and cambic chernozem at Călăraşi, rich in organic matters.

The trials were carried out in accordance with good experimental practices, as concerns soil tillage and seedbed preparation (Bonciarelli & Bonciarelli, 2001; Pannacci et al., 2007).

The main agronomic practices are shown in Table 1. Experimental design was always a randomised block with four replicates and plot size of 30 m². In each trial, some herbicides were used in pre or post-emergence applications in order to assess weed control ability and selectivity to the crop. Herbicides under investigation (Table 2) were: aclonifen (Challenge, 600 g a.i./L), S-metolachlor (Dual Gold, 960 g a.i./L), imazamox+ bentazone (Corum, 22.4 g a.i./L + 480 g a.i./L) and Fluazifop-P-butyl (Fusilade max, 125 g a.i./L). Untreated plots were always added as checks. Post-emergence treatments were always performed with the crop at the 2–5 leaves stage, broadleaved weeds at the 2–4 true leaves stage and grasses at the 3–5 leaves stage.

Weed density was assessed in ground % and in number of plants per square meter. Weed control (efficacy) was assessed at 10, 28, and 42 days after each application in % control in comparison with the untreated plots. In each trial, herbicide phytotoxicity was rated visually at - at each date of the efficacy assessments on a 0–10 scale (0: no visible injury; 10: plant death). Also, there were observations on the weed found in the experimental plots before treatment. Determination of segetal flora was performed on one square meter using a metric frame. Statistical data - processing of the assessments was based on the analysis of ARM-9 software (P=.05, Student-Newman-Keuls), ADC GmbH company.

Table 1. Agronomic practices in the field experiments

Location	**Călărași**		**Ilfov**		**Bucharest**	
Crops	**Bean**	**Pea**	**Bean**	**Pea**	**Bean**	**Pea**
Preceding crop	Maize	Sunflower	Wheat	Wheat	Maize	Maize
Sowing date	25.04.2020	04.03.2020	08.05.2020	13.03.2020	05.05.2020	11.03.2020
Cultivar	Rocco	Salamanca	Diva	Belmondo	Bianca	Trendy
Density (plants/m^2)	40	140	45	120	40	140
Spacing between rows (cm)	70	12.5	70	12.5	70	12.5
Fertilisation (Kg/ha)	NPK 180	NPK 180	NPK 180	NPK 180	NPK 180	NPK 180
Emergence date	06.05.2020	29.03.2020	15.05.2020	01.04.2020	12.05.2020	25.03.2020
Pre-emergence treatments date	29.04.2020	20.03.2020	12.05.2020	25.03.2020	08.05.2020	23.03.2020
Post-emergence treatments date	15.05.2020	15.04.2020	28.05.2020	18.04.2020	25.05.2020	15.04.2020
Fungicide azoxystrobin 2.5 l/ha	18.05.2020	02.05.2020	22.05.2020	01.05.2020	24.05.2020	01.05.2020
Insecticide Deltametrin 0.5 l/ha	19.05.2020	04.05.2020	30.05.2020	05.05.2020	20.05.2020	05.05.2020

Table 2. Herbicide treatments on beans and peas in 2020

Treatment	Active Subst. g/l	Formulation	Rates l/ha	Application time	Code	Water volume l/ha
Aclonifen	600	SC	3.0	Pre-emerg.	A	300
S-metolachlor	960	EC	1.5	Pre-emerg.	A	300
Imazamox +Bentazone	22.4 + 480	SC	1.25+ 0.6 Dash	Post-emerg.	B	300
Aclonifen +Fluazifop-P-butyl	600 + 125	EC	3.0 + 2.0/1.5*	Pre+Post	A+B	300

*1.5 l/ha for pea

RESULTS AND DISCUSSIONS

The segetal flora in the experimental fields was composed mainly of annual dicotyledonous and monocotyledonous weeds. The annual dicotyledonous group was the most numerous, being found: *Ambrosia artemisiifolia* L., *Amaranthus retroflexus* L., *Capsella bursa-pastoris* (L.) Medik., *Chenopodium album* L., *Datura stramonium* L., *Daucus carota* L., *Fallopia convolvulus* (L.) Á.Löve., *Galium aparine* L., *Erigeron annuus* (L.) Pers., *Fumaria officinalis* L., *Lamium purpureum* L., *Tripleurospermum inodorum* (L.) Sch.Bip., *Polygonum aviculare* L., *Portulaca oleracea* L., *Raphanus raphanistrum* L., *Sinapis arvensis* L., *Solanum nigrum* L., *Sonchus asper* (L.) Hill., *Sonchus oleraceus* L., *Stellaria media* (L.) Vill., *Tribulus terrestris* L. and *Veronica* species. Of the group of annual monocotyledonous weeds there were found the species *Echinochloa cruss-galli* (L.) Beauv., *Poa annua* L., *Panicum miliaceum* L., and *Setaria* species. Perennial species were also present like *Cirsium arvense* (L.) Scop., *Convolvulus arvensis* (L.) and S*orghum halepense* (L.) Pers., but they had a low density on square meter.

The major, dominant weeds with a % of soil cover higher than 15% at 42 days after treatments were: *Setaria* spp., 23.8%, *L. purpureum* 20%, *E. cruss-galli* 18.8%, *P. oleraceea* 16.8%, *G. aparine* 16.5%, *P. convolvulus* 16.3%, *A. retroflexus* 16.3%, *Veronica* spp., 16% and *E. annuus* 15.8%. Because the peas are sown in early spring (in the melted snow), the experimental fields were infested in the first part of the vegetation period mainly with weeds with early emergence in spring as well as with species that can overwinter: *L. purpureum*, *S. media*, *C. bursa-pastoris, F. officinalis G. aparine*, *Veronica* spp. Weeds infestation reduces the nutritional area of plants and creates conditions for the development of the diseases and pests, difficulties for the harvesting machinery and the result is strong yield reduction (Angelova & Yancheva, 1996; Dimitrova, 2000). In such conditions of weeds infestation, the herbicides provided good result in control of annual dicotyledonous and monocotyledonous weeds species in grain legumes (Tables 3, 4 and 5). The best results were obtained in the sample in which pre-emergence herbicide was performed with aclonifen followed by the post-emergence application of the herbicide Fusilade max based on Fluazifop-P-butyl in a dose of 2.0 l/ ha for beans and 1.5 l/ha for peas. Fluazifop-p-butyl is a selective aryloxyphenoxypropionate herbicide and provides excellent control of annual and perennial weeds. Fluazifop-P-butyl is quickly absorbed into the leaf surface, hydrolysed to fluazifop-P and translocated through the phloem and xylem and it is accumulated in the rhizomes and stolons of perennial weeds and the meristems of annual and perennial weeds. Weeds treated with fluazifop-p-butyl stopped growing within a few hours, showed gradual discoloration on newer growth in 3 to 4 days, and eventually necrosis, desiccation, and plant death occurs within 2 to 3 weeks (Urano, 1982; Erlingson, 1988). Thus, for *Setaria* species at pre-emergence herbicide applicaton with aclonifen and post-emergence application with fluazifop-p-butyl, the control percentage ranged from 81.5% for peas to 100% for beans in the Dâlga experimental field (Table 3). In the experimental field with beans of RDIPP Bucharest in which the *Setaria* species had a % of soil cover of 22% at 42 days after application of the treatments, % of control compared to the untreated sample was of 90.7% (Table 5).

In the experimental samples in which only pre-emergent herbicides were applied, the effect on weeds was lower, especially on species with a high degree of infestation. Thus, in Dâlga in the case of the species *E. annuus*, which had a 42% cover of the soil at 42 days after the treatment, the effectiveness in control was 48.7% in the case of application in pre-emergence of aclonifen and 66.6% for s-metolachlor. In Dâlga peas at *Veronica* species that had a 16% soil cover, the control efficacy was 30.3% for aclonifen and 60% for S-metolachlor (Table 3). Dual Gold herbicide has been shown to be more effective in controlling weeds, especially against grass weeds because it has high solubility, remains active and does not move out, even when small amounts of precipitation occur. Compared to S-metolachlor, aclonifen does not prevent germination but controls germinating weeds.

Table 3. The efficacy of herbicides in crop after 42 days of treatment (Dâlga 2020)

Weeds EPPO CODE*	Treatment name											
	Bean						Pea					
	Untreated (ground %)	Challenge	Dual Gold	Corum	Challenge + Fusilade	LSD (P=.05)	Untreated (ground %)	Challenge	Dual Gold	Corum	Challenge + Fusilade	LSD (P=.05)
	Dose L/ha											
	-	3.0	2.0	1.25	3.0+2.0	-	-	3.0	2.0	1.25	3.0+1.5	-
	Efficacy - % control in compared to the untreated plots											
ERIAN	15.8d	48.7c	66.6b	96.2a	97.2a	7.9-16	10.0d	49.8c	60.3bc	92.6a	85.7ab	24.7-30
TRBTE	7.3d	53.8c	68.8b	100a	100a	0.3-5.5	8.0c	39.5b	60.5ab	84.4a	85.8a	30.9-34
DATST	6.0d	48.7c	60.1b	100a	100a	0.5-7.2	-	-	-	-	-	-
CHEAL	11.3d	47.0c	67.1b	93.0a	92.1a	10-15	7.0b	50.0a	65.1a	70.7a	80.3a	23.7-24
SINAR	5.0d	38.3c	53.8b	95.4a	94.5a	8.6-15	-	-	-	-	-	-
AMARE	7.0d	49.9c	63.0b	100a	100a	1.6-12	5.0c	60.2b	70.2b	94.8a	90.3a	12.5-18
GALAP	10.0d	44.9c	60.2b	100a	100a	1.3-11	15.0c	39.5b	60.5ab	84.4a	85.8a	30.9-34
ECHCG	18.8c	40.8c	52.6b	89.3a	92.4a	8.5-13	6.0d	60.5c	81.5 b	100a	100a	2.9-15
SETSS	12.0c	53.9b	64.0b	100a	100a	1.0-10	10.0d	38.3c	60.9b	81.5a	80.5a	16.1-18
VERSS	4.5d	65.4c	77.1b	100a	100a	1.3-10	16.0c	40.c	55.0ab	76.3a	76.7a	20.0-21
STEME	-	-	-	-	-	-	12.0c	55.1b	65.3ab	84.4a	80.1ab	19.3-21
FUMOF	-	-	-	-	-	-	8.0c	60.9b	71.4b	100a	100a	4.6-19

*ERIAN = *E. annuus*; TRBTE=*T. terrestris*; DATST= *D. stramonium;* CHEAL = *C. album*; SINAR= *S. arvensis*; AMARE= *A. retroflexus;* GALAP= *G. aparine;* ECHCG= *E. cruss-gall;* SETSS=*Setaria* spp., VERSS= *Veronica* spp., STEME= *S. media;* FUMOF= *F. officinalis.*

Because the velocity of the effect is influenced by the available reserves of weed seeds in the soil, the effectiveness of this herbicide was lower. In such a way, at 42 days after treatments, in pea experimental field of Research Development Institute for Plant Protection - Bucharest, the erbicide Dual Gold provided a good effectiveness in weed control: *A. retroflexus* 60.6%, *C. album* 76.0%, *P. aviculare* 80.5%, *S. oleraceus* 72.3%, *Setaria* spp., 68.0%, *E. cruss-galli* 75.0% (Table 5). At Ilfov, the erbicide Dual Gold had a moderate effectiveness in control of dicotyledonous weeds in peas: *D. carota* – 65.2%, *P. convolvulus* – 51%, *G. aparine* – 50%, *S. media* – 60% and *M. inodora* –51% (Table 4). At the initial stages, due to the slower pace of development, pea and bean are suppressed by the rapidly developing of broadleaf weeds. For example, as far as concerns the invasive species *E. annuus*, the ground coverage was 15.8% in bean and 10% in peas in experimental field of Dâlga. In these conditions of infestation with this species, the herbicides applied in preemergence had a lower efficacy.

During that period especially, herbicide Corum was efficient at 1.25 l/ha, applied at stage of 2-5 leaves of crops together with the adjuvant Dach. Composed of two active substances (bentazone and imazamox), the herbicide Corum had a very good effectiveness in controlling weeds in peas and beans, the results obtained being close to those obtained in the pre-emergent version treated with aclonifen and post-emergent with fluazifop-p-butyl. Thus, at Moara Domnească, the effectiveness of herbicide Corum ranged from 90% to 100%: *D. carota* 100%, *P. convolvulus* 97%, *A. artemisiifolia* 100%, *G. aparine* 90%, *Setaria* spp. 91%, *P. annua* 100% and *P. miliaceum* 100%. Bentazone acts by contact, with an impact on the process of photosynthesis, being absorbed by leaves and other green organs. Imazamox is taken up by plants up to the growth areas where it blocks the synthesis of essential amino acids, responsible for cell growth and division, being absorbed by plants especially through the leaves, but also through the roots.

Herbicide action is enhanced by the light sunny weather, which stimulates active growth, while the cool, dark weather or prolonged drought inhibit the growth of weeds or reduces their turgor, and thus can reduce the effectiveness of the herbicide.

Table 4. The efficacy of herbicides in crop after 42 days of treatment (Moara Domnească 2020)

Weeds EPPO CODE*	Treatment name											
	Bean						Pea					
	Untreated (ground %)	Challenge	Dual Gold	Corum	Challenge + Fusilade	LSD (P=.05)	Untreated (ground %)	Challenge	Dual Gold	Corum	Challenge + Fusilade	LSD (P=.05)
	Dose L/ha											
	-	3.0	2.0	1.25	3.0+2.0	-	-	3.0	2.0	1.25	3.0+1.5	-
DAUCA	10.0d	52.5c	66.6b	100a	99.4a	1.3-11	8.0d	50.0c	65.2b	80.6a	80.2a	11.3-13
POLCO	16.3d	47.5c	61.7b	97.4a	94.5a	5.6-13	10.0d	35.0c	51.1b	70.3a	75.2a	11.1-12
AMBEL	7.0d	50.0c	63.0b	100a	100a	1.4-11	-	-	-	-	-	-
GALAP	16.3d	37.0c	58.0b	89.7a	91.9a	10-15	15.0d	29.8c	50.1b	75.4a	70.3a	12.-12.7
SETSS	23.8d	39.5c	60.5b	91.7a	92.2a	12-18	-	-	-	-	-	-
POAAN	10.0d	58.8c	71.4b	100a	100a	0.3-5.6	-	-	-	-	-	-
PANMI	12.5d	48.7c	63.0b	100a	100a	1.5-12	6.0d	60.1c	80.6b	100a	00a	0.8-8.8
STEME	-	-	-	-	-	-	12.0d	44.9c	60.1b	85.5a	80.1a	7.6-9.9
MATIN	-	-	-	-	-	-	10.0d	39.9c	51.1b	75.3a	72.2a	11.1-12
SONAS	-	-	-	-	-	-	6.0c	50.0b	65.2b	88.5a	93.0a	1.3-24.8

*DAUCA= *D. carota,* POLCO= *F. convolvulus*, AMBEL=*A. artenisiifolia.* POAAN= *P. annua*, PANMI =*P. miliaceum*, MATIN= *T. inodorum,* SONAS= *S. asper*.

The application of adjuvant results in better weed coverage with a thicker wax layer on the leaf surface and prevents the possible reduction of herbicidal action at low atmospheric humidity and high temperatures.

The combination between the herbicide Corum and the adjuvant Dach has no impact on the next crop in crop rotation, but it is not recommended to mix them with foliar fertilizers and organophosphorus insecticides (Tibets & Saskevich, 2006). No phytotoxicity symptoms have been shown in the experimental plot. No symptoms of chlorosis, necrosis, leaf deformation, height reduction, distortion and delay at flowering in plots treated with clopyralid were seen (*, 2014).

In the experimental fields were also present 4 invasive weed species: *A. artemisiifolia*, *E. annuus*, *V. persica* and *S. halepense* which were carefully monitored given the growing invasion of alien species, allogeneic in natural ecosystems and anthropogenic in our country.

Table 5. The efficacy of herbicides in crop after 42 days of treatment (ICDPP-Bucharest, 2020)

Weeds EPPO CODE*	Treatment name											
	Bean						Pea					
	Untreated (ground %)	Challenge	Dual Gold	Corum	Challenge + Fusilade	LSD (P=.05)	Untreated (ground %)	Challenge	Dual Gold	Corum	Challenge+ Fusilade	LSD (P=.05)
	Dose L/ha											
	-	3.0	2.0	1.25	3.0+2.0	-	-	3.0	2.0	1.25	3.0+2.0	-
AMARE	16.3d	45.0c	63.9b	95.4a	99.4a	4-13.8	2.0c	47.5b	60.6b	89.4a	91.a	22.2-27
CHEAL	12.0c	48.7b	58.9b	99.4a	100a	1.4-12	10.0b	56.8a	76.0a	90.6a	92.6a	27-30.8
POLAV	12.0e	42.4d	56.4c	92.5b	98.1a	5.5-14	7.0c	62.1b	80.5b	100a	100a	7.5-23.8
POROL	16.8c	44.9b	56.3b	97.1a	93.7a	6.8-14	-	-	-	-	-	-
SONOL	6.5d	50.0c	60.2b	100a	100a	0.9-9.8	5.0b	59.6a	72.5a	88.8a	89.3a	23.5-25
SETSS	22.5d	46.2c	63.9b	93.4a	90.7a	7.3-12	15.0c	53.8b	68.0ab	88.7a	82.7a	16.4-20
ECHCG	13.0d	53.8c	63.9b	100a	100a	0.6-8.0	10.0d	6.3b	75.0ab	100a	100a	23-15
LAMPU	-	-	-	-	-	-	20.0c	32.1b	51.3ab	81.2a	80.4a	32.2-34
CAPBP	-	-	-	-	-	-	8.0c	51.3b	64.4b	96.2a	96.8a	15-25.5
RAPRA	-	-	-	-	-	-	6.0c	43.7b	57.8 b	88.8a	82.4a	1.9-23.6

*POLAV=*P. aviculare*, *POROL* = *P. oleracea*, SONOL=*S. oleraceus.* LAMPU=*L. purpureum,* CAPBP= *C. bursa-pastoris,* RAPRA= *R. raphanistrum*

CONCLUSIONS

Bean and pea crops are very sensitive to weed infestation, especially at the early stages of vegetation. The annual mono and dicotyledonous weeds were dominant in the experimental fields. Herbicides applied provided good results in control of weeds in grain legumes. The post-emergence Corum herbicide applied together with the Dash adjuvant had a good efficacy in controlling the segetal flora that suppressed the experimental fields. The obtained results demonstrate that the application of pre-emergence treatments before the emergence of crops and post-emergence in vegetation is the best strategy to control weeds in pea and bean crops. No phytotoxicity symptoms have been shown in experimental plots. The results obtained have shown that the effectiveness of herbicides applied in peas and beans crops depends on weed species, their density, pedoclimatic and agrotechnical indicators.

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