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ORIGINAL PAPER

Effect of some herbicides on the productivity of common dry bean (*Phaseolus vulgaris* L.)

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Abstract

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The investigations were carried out during 2016–2017 at Dobrudzha Agricultural Institute – General Toshevo (DAI). The aim of this investigation was to determine the effect of the treatment with herbicides in varieties common dry bean on the productivity. The following herbicides combinations were used: 1 variant: petoxamide (200 ml)+linuron (300 ml)+cikloksidim (200 ml); 2 variant: petoxamide (200 ml)+bentazon (200 ml)+cikloksidim (200 ml); 3 variant: petoxamide (200 ml)+bentazon (200 ml)+ cikloksidim (200 ml); 4 variant: dimetenamid-P+pendimetalin (400 ml)+linuron (300 ml)+ cikloksidim (200 ml); 5 variant: dimetenamid-P+pendimetalin (400 ml)+bentazon (200 ml)+cikloksadim (200 ml); 6 variant: dimetenamid-P+pendimetalin (400 ml)+bentazon (200 ml)+cikloksidim (200 ml). The vegetation herbicides were applied separate at variant 2 and 5 but at variant 3 and 6 – combined. The herbicides were applied at stage 01 (BBCH), and bentazon (200 ml) and cikloksidim (200 ml) at stage 12 (BBCH) on three varieties common dry bean "GTB-Usrtem", "GTB-Blijan" and "GTB-Elixir". The herbicide effect was determined by the quantitative weight method and evaluated by the EWRS scale. These were the followed parameters: productivity (kg/da), number of pods per plant, number of grains per plant, weight of grain per plant (g), weight of 1000 grains (g). Variety "GTB-Elixir" has the highest productivity of the three varieties studied in all tested variants. Herbicide combinations for variant 5. Dimethenamid-P+pendimetalin-400 ml/da+bentazon-200 ml/da+cikloksidim-200

ml/da-separate application and variant 4. Dimethenamid-P+pendimetalin-400 ml/da+linuron-300 ml/da+cikloksidim-200 ml/da achieved the highest productivity, respectively 236.9 kg /da and 209.1 kg /da, average over the investigated period. The productivity of the tested herbicides in varieties "GTB-Ustrem" and "GTB-Blijan" is much lower. The correlation between most biometric parameters is positive and strongly expressed in the studied varieties. Negative and weakly correlated relationships between some biometric parameters have been established of variety "GTB-Ustrem".

Key words: Common dry bean, Herbicides, Weeds, Productivity, Structural elements of productivity

Introduction

Weeds, depending on the degree of competition with crops, reducing crop yield at least 10 to over 50% (Karimi, 1998). Several methods for weed control in beans like weed fire control, and mechanical cultivation is common.

Herbicides trifluralin, etafluralin, setoxidim, bazagran kill weeds thus increasing the competitiveness and growth of the bean plant has grown so out of control in the presense of weed plant. Herbicides kill weeds in beans, enhanced competitiveness and growth, provided time for grain filling and grain weight increased. Herbicide tested each of them, are effective on specific weed, thus beans are slightly increased. Without their use reduced yields. Broadleaved weeds had more negative impact on bean. The greatest bean seed yields were noted in plots treated with bazagran alone (Jafari et al., 2013).

Mechanical cultivation does not remove weeds within the row and may damage bean plants and reduce yields (Clay et al., 2005). Previous research has indicated that bazagran may have a benefical effect on bean yields beyond that of weed control, possibly inducing deeper rooting (Burnside et al., 1998). Seed yield in dry bean (*Phaseolus vulgaris* L.) was reduced up to 85% as a result of season-long weed competition. Chemical weed control is still the predominant component of weed management in crop production (Pynenburg, 2011). The use of herbicides has already led to serious problems such as environmental pollution and evolution of resistance to herbicides in weed species (Rao, 2007).

Crop spatial pattern is another agronomic factor that can affect grain yield and crop competitiveness against weeds (Olsen, 2012). The losses of grain yield in common bean genotypes due to weed interference ranged from 30. 8% to 54. 9% (Vogt, 2013). All treatments increased yield compared with the weedy check except for cloransulam-methyl. Cloransulam-methyl, halosulfuron, clorasulam-methyl plus fomesafen decreased yield 34, 21, 17% compared with the untreated weed-free control (Soltani et al., 2013). In other studies, cloransulam-methyl reduced

yield of white bean 36 to 54%. (Soltani et al., 2012). Similar yield reductions have been reported in dry bean cultivars in response to ALS – inhibiting herbicides such as thifensulfuron, chlorimuron and imazethapyr (Soltani et al., 2008). Clorasulam-methyl and halosulfuron have potential to cause unacceptable crop injury and reduction in yield of white bean. The additions of bentazon or fomesafen can safen clorasulam-methyl or halosulfuron in dry bean. The safening effects do not always provide an adequate margin of crop safety for white bean (Soltani et al., 2013).

One time early weeding at 25 days after crop emergence resulted in 70% yield increase of common bean compared to no weeding (Rezine and Kedir, 2008). Uncontrolled population of weeds reduced yields of bean by 75% (Ghadiri and Bayat, 2004). Furthermore, unrestricted weed growth significantly reduced common bean grain yield by 58% and the yield of white bean by 70% as compared to weed-free treatment (Mukhtar, 2012). Uncontrolled weed populations can reduced the yield of common bean up to 90% (Mengesha et al., 2013). The number of pods per plant was higher in the narrow – row planting pattern than in the wide-row planting pattern (Dusabumuremyi, 2014). It was reported that season - long weed competition significantly reduced the number of pods per plant for white bean (Ghadiri and Bayat, 2004).

Regardless of planting date and special arrangement, pod number per plant was significantly compared to weedy condition. Pod number per plant reduced 10% due to weed interference. Seed number per pod was significantly lower for plants grown under weedy condition compared to those grown under weed-free condition. Weed management regime and spatial arrangement x planting date interaction had significant effect on 1000 seeds weight. Weed competition reduced significantly 1000 seeds weight by 6.5% as averaged across planting date and spatial arrangement. Due to weed competition, seed and pod yields were reduced by 11.6 and 7.6% , respectively. Weed control, as well as square planting pattern, are recommended for obtaining the highest seed and pod yields in common bean (Esmaeiladeh and Aminpanah, 2015). Season-long weed competition significantly reduced seed weight of white bean (Ghadiri and Bayat, 2004).

The aim of this investigation was to determine the effect of the treatment with herbicides in common dry bean on the productiviry.

Material and methods

The investigations were carried out during 2016 – 2017 at Dobrudzha Agricultural Institute – General Toshevo (DAI). The field trial was designed according to the block method in three replications, the size of the trial area being 10.5 m^2 and crop density 35 g.s. /m^2. One control is included: K_2 - weeded control until the end of the crop's vegetation (Table 1).

Table 1. Variants

Variants	Active substance	Doses (ml/da)
1.Sucssesor 600EK+ Kalin Flo+Stratus Ultra	petoxamide+linuron +cikloksidim	200+300+200
2.Sucssesor 600EK+ Basagran 400SL+Stratus Ultra-separated application at vegetation herbicides	petoxamide+bentazon +cikloksidim	200+200+200
3.Sucssesor 600EK+ Basagran 400SL+Stratus Ultra-combined at vegetation herbicides	petoxamide+bentazon +cikloksidim	200+200+200
4.Uing P+Kalin Flo+ Stratus Ultra	dimetenamid-P +pendimetalin + linuron+cikloksidim	400+300+200
5.Uing P+Basagran 400SL+Stratus Ultra- separated application at vegetation herbicides	dimetenamid-P +pendimetalin + bentazon+cikloksidim	400+200+200
6.Uing P+Basagran 400SL+Stratus Ultra- combined at vegetation herbicides	dimetenamid-P +pendimetalin + bentazon+cikloksidim	400+200+200
7.Weeded check	-	-

The herbicides were applied at stage 01 (BBCH) (Meier, 2001) and bentazon (200 ml) and cikloksidim (200 ml) at stage 12 (BBCH) (stage 1st -2nd shamrock) on three varieties common dry bean, "GTB-Usrtem", "GTB-Blijan" and "GTB-Elixir". Relying on natural weed infestation from grassy weeds: green hides - *Setaria viridis* L. and cockspur - *Echinochloa crus-galli* L. and broadleaved weeds: wild mustard - *Sinapis arvensis* L., thorn-apple - *Datura stramonium* L., rough cocklebur - *Xanthium strumarium* L., common amaranth - *Amaranths retroflexus* L., black-bindweed - *Polygonum convolvulus* L., fat-hen - *Chenopodium album* L., water papper - *Polygonum hydropiper*, field bindweed - *Convolvulus arvensis* L., creeping thistle - *Cirsium arvense* (L.) Scop and hemp - *Canabis sativa* L. Weed density was measured quantitatively per unit area by species using ¼ frame in four replications prior to introduction of herbicides.

The herbicide efficiency was estimated 25-30 days after the use of the preparations according to species, by amount and weight, using ¼ frame in four replications, measuring the weight of the weeds in fresh and dry condition. The effect was evaluated according to the 9-degree scale of EWRS for reading

of the herbicide activity and selectivity, 1 corresponding to 100 % efficiency of the preparation, without symptoms of phytotoxicity on the cultural plants; and 9 corresponding to 29.9 % - 0 % effect of the preparation and complete perishing of the plants (Table 2).

Table 2. Herbicide activity and selectivity according to 9-degree scale of EWRS

Rank	Herbicide effect, %	Damage symptoms	General evaluation
1	100	No symptoms – healthy plants	Excellent
2	99.9-98	Very weak symptoms – slight stunt effect	Very good
3	97.9-95	Weak but discernable symptoms	Good
4	94.9-90	Better expressed symptoms (eg. chlorosis) which do not affect yield	Satisfactory
5	89.9-82	Thinning of the crop, strong chlorosis or stunt. Lower yield expected	Indefinitely
6	81.9-70		Unsatisfactory
7	69.9-55		Poor
8	54.9-30		Very poor
9	29.9-0	Heavy damage or perishing of plants	Extremely poor

In 2016 the highest average monthly temperature in July is established (22.8 ^{0}C) (Table 3). The vast amount of precipitation (117.1 mm) during the month of May were good for intensive growth and development of the hybrid in the initial stages. The months July and August are dry compared to the multi-annual period. 2017 is characterized also with favorable weather conditions. Monthly temperature is highest during the month of August (22.8 ^{0}C). In June recorded the greatest amount of precipitation (87.7 mm) compared to multi-annual data.

Variety ”GTB-Ustrem” is suitable for direct harvesting. The main stem and branches of the cultivar end with vegetative bud. The plant is without tendril and lodging (II a type). The plant height depending on environmental conditions is within 40-60 cm. The pods are located in the upper 4/5 of the plant. The seeds are white, with medium veining and weak glossines. Longitudinal shape is elliptic, and cross shape – wide elliptic. The weight of 1000 seeds is 320 g. The protein content is 19.0%.

Variety ”GTB-Blijan” is suitable for direct harvesting. The main stem and branches of the cultivar end with vegetative bud. The plant is without tendril and lodging (II a type). The plant height depending on environmental conditions is within 40-50 cm. The pods are located in the upper 4/5 of the plant. The seeds are

white, with medium veining and weak glossines. Longitudinal shape is elliptic, and cross shape – wide elliptic. The weight of 1000 seeds is 330 g. The protein content is 20.9%.

Table 3. Air temperature and rainfalls during the period 1960-2017

Period	Period of vegetation				Average for V – VIII. t^0 C
	The average monthly temperature of the air. t^0C				
	V	VI	VII	VIII	
2016	14.7	20.9	22.8	22.2	20.2
Deviation ^0C	-0.4	-1.5	1.6	1.4	0.3
2017	15.2	20.2	21.8	22.5	19.9
Deviation ^0C	0.1	-2.2	0.6	1.7	0.1
Average 50 years (1960 – 2010)	15.1	22.4	21.2	20.8	19.9
Period	Monthly rainfall. *mm*				Amount for V – VIII. *mm*
	V	VI	VII	VIII	
2016	117.1	55.7	2.8	5.0	180.6
Deviation.%	233.7	98.6	5.2	11.9	349.5
2017	29.0	87.7	66.3	12.4	195.4
Deviation.%	57.9	155.2	124.2	29.6	366.9
Average 50 years (1960 – 2010)	50.1	56.5	53.4	41.9	201.9

Variety ”GTB-Elixir” is suitable for two-phase harvesting. The main stem and branches of the cultivar end with vegetative bud. The plant is lodging and climbing (III b type). The plant height depending on environmental conditions is within 100-160 cm. The pods are located in the lower 1/3 of the plant. The seeds are white, with medium veining and glossines. The seeds are kidney-shaped. The weight of 1000 seeds is 410 g. The protein content is 21.5%.

These were the followed parameters: productivity (kg/da), number of pods per plant, number of grains per plant, weight of grain per plant (g), weight of 1000 grains (g).

Results and discussion

Strong positive correlation was found between the number of pods per plant and the number of grains per plant (r=0.971) (Table 4). As the number of pods per plant

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increases, so does the weight of the grain per plant (r=0.947). The same relationship was found for the number of grains per plant and the weight of the grain per plant (r=0.978). Negative dependencies are also observed for some parameters.

Table 4. Correlation of biometrical parameters of variety "GTB-Ustrem".

Parameters	productivity, kg/da	number of pods per plant	number of grains per plant	weight of grain per plant, g	weight of 1000 grains, g
productivity, kg/da	1				
number of pods per plant	-0.073	1			
number of grains per plant	-0.132	0.971***	1		
weight of grain per plant, g	-0.071	0.947***	0.978***	1	
weight of 1000 grains,g	0.750	0.119	0.167	0.127	1

*** - $p \leq 0,01$; ** - $p \leq 0,05$; * - $p \leq 0,1$; n.s. – non significan

The correlations between all biometric parameters of variety "GTB-Blijan" are highly expressed (Table 5). No negative dependencies are observed.

As the number of pods per plant increases, so does the number of grains per plant (r=0.982) (Table 6). The same relationship was found for the number of pods per plant and the weight of the grain per plant (r=0.959). A strong positive correlation was found between the number of grains per plant and the weight of the grain per plant (r=0.959). Weak correlations were found between the other parameters. No negative dependencies are observed.

Table 5. Correlation of biometrical parameters of variety "GTB-Blijan".

Parameters	productivity, kg/da	number of pods per plant	number of grains per plant	weight of grain per plant, g	weight of 1000 grains, g
productivity, kg/da	1				
number of pods per plant	0.910***	1			
number of grains per plant	0.917***	0.983***	1		
weight of grain per plant, g	0.901***	0.977***	0.997***	1	
weight of 1000 grains,g	0.523	0.494	0.412	0.443	1

*** - $p \leq 0,01$; ** - $p \leq 0,05$; * - $p \leq 0,1$; n.s. – non significan

Table 6. Correlation of biometrical parameters of variety "GTB-Elixir".

Parameters	productivity, kg/da	number of pods per plant	number of grains per plant	weight of grain per plant, g	weight of 1000 grains, g
productivity,kg/da	1				
number of pods per plant	0.780	1			
number of grains per plant	0.801	0.982***	1		
weight of grain per plant, g	0.802	0.959***	0.959***	1	
weight of 1000 grains, g	0.569	0.232	0.235	0.271	1

*** - $p \leq 0,01$; ** - $p \leq 0,05$; * - $p \leq 0,1$; n.s. – non significan

Conclusion

1. Variety "GTB-Elixir" has the highest productivity of the three varieties studied in all tested variants. Herbicide combinations for variant 5. Dimethenamid-P+pendimetalin-400 ml/da+bentazon-200 ml/da+cikloksidim-200 ml/da-separate application and variant 4. Dimethenamid-P+pendimetalin-400 ml/da+linuron-300 ml/da+cikloksidim-200 ml/da achieved the highest productivity, respectively 236.9 kg /da and 209.1 kg /da, average over the investigated period.

2. The productivity of the tested herbicides in varieties "GTB-Ustrem" and "GTB-Blijan" is much lower.

3. The correlation between most biometric parameters is positive and strongly expressed in the studied varieties.

4. Negative and weakly correlated relationships between some biometric parameters have been established of variety "GTB-Ustrem".

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