Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 3, No. 5, p. 86-93, 2013
http://www.innspub.net

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RESEARCH PAPER OPEN ACCESS

Effect of weeds competition on some growth parameters of red, white and pinto bean (*Phaseolus vulgaris* L.)

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Article published on May 25, 2013

Key words: Crop growth rate (CGR), dry bean, leaf area index (LAI), total dry matter (TDM), Weed.

Abstract

In order to investigate the effect of weeds competition on growth parameters of different dry beans, an experiment was conducted at Research Station of Faculty of Agriculture at Tabriz University, Tabriz, Iran in 2011. The experiment was conducted as split plot based on randomized completely block design with three replications. The main plots were three types of dry bean including red bean, white bean and pinto bean and the two sub plots were weed free and weed infested treatments. The results indicated that interaction effect of weed treatment × dry bean type on plant height was significant. Weed infested treatment had not significant effect on red bean plant height but reduced the plant height of white and pinto bean. The effect of dry bean type and weed treatment was significant on leaf area index (LAI). The LAI of weed infested treatment was significantly lower than that of weed free. Also the LAI of red and white bean was significantly higher than that of pinto bean. The effect of dry bean type was not significant on dry bean total dry matter (TDM) and crop growth rate (CGR). Weed infested treatment reduced TDM and CGR of dry bean significantly. Among the growth parameters, the LAI was the best index for competitiveness of dry bean against weeds.

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Introduction

Grain legumes are a major source of proteins in human and animal nutrition and play a key role in crop rotation in most parts of the world (Bakhsh *et al.,* 2007). Dry bean (*Phaseolus vulgaris* L.) is one of the most important leguminous crops. The grains of dry bean contain a great amount of protein and carbohydrates. So that dry bean is considered as one of the most important sources in human food nutrition for such nutrients (El-Desuki *et al.,* 2010; Amini and Ghanepour, 2013). Different external stresses influence on dry bean and it needs management for optimal growth and yield (Pynenburg et al., 2011). Competition from weed and growth interference reduced dry bean yield significantly (Sikkema et al., 2008; Amini *et al.,* 2013). The population of weeds was increased in case of lack of control in dry bean fields and the seeds reminded in the soil cause to infestation in the next season and influenced on dry bean yield, considerably (Lutman *et al.,* 2011). Cultivating the high competitive cultivars is useful for weed control so identification of tolerant cultivars and effective physiologic characteristics are considered for weed management (Armin *et al.,* 2007).

Several parameters have been identified as being important for plants in competition with weeds. Such factors are early season height (Olesen *et al.,* 2004), leaf inclination (Drews *et al.,* 2009), leaf area index (Namuco *et al.,* 2009) and grain yield (Saito *et al.,* 2010). Leaf area expansion rate, maximum leaf area index and leaf area duration are important factors in light interception and dry matter accumulation in plant canopy and competitiveness (Valentinuz and Tolennar, 2006). Also crops indicate phenotype flexibility in competition with other plants such as change in canopy structure, dry matter accumulation, plant height and specific leaf area (Lamer *et al.,* 2001).

Previous studies showed that increase of competition with weed reduced crop height (Sowanton, 2003). Kavurmaci *et al.,* (2010) reported that competition with weed reduced dry bean height significantly. According to Knezevic *et al.,* (2004) leaf area index is one of the main factors in weed interference and it is indicator for competitiveness and it can be used as a parameter for estimation of crop yield loss. Generally, increasing of plant density in unit area causes increase in total dry matter and leaf area, but reduces the leaf area of one each plant. Although the leaf area index is increased under competition between crop and weed but the leaf area index is reduced in weed-infested fields due to reduction in leaf area per plant by interference and competition between crop and weed. Isalmi *et al.,* (2006) reported that increase of wheat density reduced the effects of weeds on this crop as the total dry matter (TDM), leaf area index (LAI) and seed production of weeds were reduced. In order to improve the competitiveness of dry bean against weeds, identifying the growth parameters that affect on weed suppression is necessary. Such growth indices of dry bean could affect on competitive ability of this crop against weeds. Amini and Fateh (2010) observed that LAI and CGR were determinant parameters for selecting red kidney bean (*Phaseolus vulgaris* L.) cultivars with high competitive ability against redroot pigweed (*Amaranthus retroflexus* L.). Therefore, identifying the growth parameters of dry bean that could improve its competitiveness help us to select dry bean type with high competitive ability. So the aim of this research was to investigate the effect of weeds competition on some growth parameters of different dry bean types.

Materials and methods

Plant materials

The three dry bean types including red bean (cultivar Gholi), white bean (cultivar Shokoufa) and pinto bean (cultivar Sadry) were obtained from National Bean Research Institute in Arak, Iran. The all dry beans had intermediate growth pattern and were climbing cultivars.

Site description

This study was carried out at the Research Farm of Tabriz University, Tabriz, Iran (latitude 38.05 ºN, longitude 46.17 ºE, Altitude 1360 m above sea level) in 2011. The climate is characterized by mean annual precipitation of 245.75 mm, mean annual temperature of 10 ºC, mean annual maximum and minimum temperature were 16.6 ºC and 10ºC, respectively. The pH of soil ranges from weak to medium and there is no considerable salinity in the soil.

Experimental design

The experiment was conducted as split plot based on randomized completely block design with three replications. The main plots were three types of dry bean including red bean (cv. Gholi), white bean (cv. Shokoufa) and pinto bean (cv. Sadry) and the two sub plots were weed free (the weeds were removed by hand hoeing during growth season) and weed infested (no weed control was done during growth season) treatments. The plot size was 5 × 3 meter and the spacing between rows was 50 cm and the seeds were planted in two rows with density of 40 plants/m^2 with spacing 10 cm.

Data collection

In order to measure the growth indices, the destructive sampling was carried out since July 25, 2011 every 10 days from 50 cm of row in each plot. All dry bean plants were harvested by cutting at the soil surface and the plants height were measured. Plants were then divided into leaf and stem. The areas of green leaves were measured using a Delta-T leaf area meter (Delta-T Devices, Cambridge, England). Then the samples including stems and leaves were dried in a forced-air oven at 80 °C for 48 h and after witch total dry matter (TDM) was measured. Leaf area index (LAI) and crop growth rate (CGR) were calculated for all growth stages according to Hunt (1990):

$$LAI = LA/GA$$

$$CGR = (W_2 - W_1) / [GA (T_2 - T_1)]$$

where LA is leaf area, GA is ground area, W_1 is dry weight at a given sampling date, W_2 is dry weight at the next consecutive sampling date, and $T_2–T_1$ is the number of days between the two sampling dates.

Data analysis

By using data obtained from leaf are and above ground total dry matter (TDM) the parameters of LAI, CGR and RGR were measured. Analysis of variance was carried out as randomized complete block design with three replications by SAS Ver. 6.12 and the graphs were prepared by EXCEL. The mean comparison was done by Duncan test in probability level of %5.

Results and discussion

Plant height

According to results of analysis of variance (Table 1) weed treatment (weed infested and weed free) had significant effect on dry bean plant height. Also the interaction of dry bean type × weed (infested and free) on plant height was significant.

Table 1. Analysis of variance for dry bean plant height.

		MS
S.O.V	df	Plant height
Block	2	19.792
Dry bean type	2	118.815
Error	4	22.803
Weed (infested and free)	1	311.676**
Dry bean × weed	2	155.576**
Error	6	10.383

*and ** significant difference at 5 and %1 probability level, respectively.

Mean comparison of interaction of dry bean and weed treatments showed that among three dry bean types, the red bean plant height was not affected by weed infested treatment. The plant height of white and pinto bean was affected significantly by weed infested treatment (Fig. 1). Among the dry bean types the plant height of red bean was not affected by weed competition.

Cousens *et al.* (2003) showed that access to light plays determinant role in wheat final yield in competition with weed and more weed height reduced crop production. Because of low plant height of lentil the light penetration into canopy was reduced 38% in interference with amaranth (*Amaranthus hybridus* L.) and purslane (*Portulace oleracea* L.) and (Bielinski, 2003).

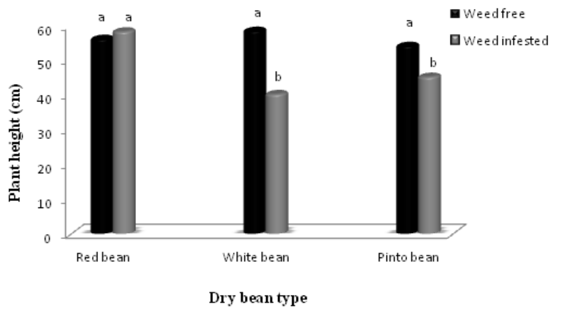

Fig. 1. The effect of weed treatment on plant height of different dry bean types (Different letters indicate the significant difference at $p \leq 0.05$).

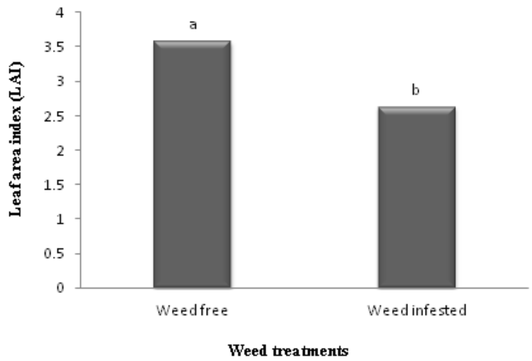

Fig. 2. The effect of weed treatment (weed free and infested) on dry bean leaf area index (Different letter in each treatment indicate significant difference at $p \leq 0.05$).

Leaf Area Index (LAI)

According to the results of analysis of variance (Table 2) the effect of dry bean type was significant on LAI_3 (60 days after emergence) and LAI_4 (70 days after emergence) ($P \leq 0.05$). Also the effect of weed treatment (infested and weed free) was significant on LAI_5 of dry bean. The interaction effect of dry bean type × weed treatment was not significant on LAI (Table 2).

Mean comparison of weed infested and weed free treatments on LAI at the final growth stage (LAI_5) indicated that weed infested treatment reduced dry bean LAI significantly (Figure 2). The leaf area expansion of dry beans reduced because the limited resources were utilized by weeds. Among the dry beans, the red bean had highest LAI that was not significantly different with white bean. The pinto bean produced the lowest LAI among the dry beans that was significantly lower than other two dry beans (Fig. 3).

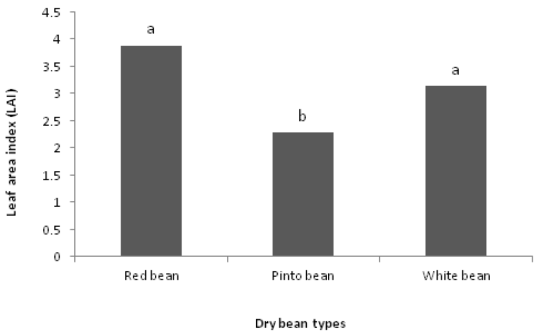

Fig. 3. The effect of weed dry bean types on dry bean leaf area index (Different letter in each treatment indicate significant difference at $p \leq 0.05$).

Soybean expands all its LAI at higher canopy layers in order to intercept more light and reduce light interception by weeds. Change in vertical destruction of leaf area influenced on absorption and utilization of light in canopy and as a result increased accumulation of dry matter and yield (Valentinuz and Tolennar, 2006). Zand and Beckei (2006) reported that weed competition caused reduction of LAI in canola cultivars. The change in LAI of canola cultivars showed that charlock (*Sinapis arvensis* L.) had significant reduction effect on canola LAI in growth season and this reduction was different; so that significant reduction in leaf area index and as a consequence total dry matter is one of the main reasons for reduction of grain yield.

Total Dry Matter (TDM)

Analysis of variance indicated that the effect of dry bean type was not significant on total dry matter (Table 3). The weed treatment significantly affected the TDM of dry bean at all stages except TDM_3 (60 days after dry bean emergence). The interaction effect of dry bean type ×weed on total dry matter of dry bean was not significant.

Table 2. Analysis of variance of dry bean LAI at different growth stages (LAI_1, LAI_2, LAI_3 LAI_4 and LAI_5 are LAI at 40, 50, 60, 70 and 80 days after dry bean emergence).

S.O.V	df	MS				
		LAI_1	LAI_2	LAI_3	LAI_4	LAI_5
Block	2	0.001	1.050	0.158	0.209	1.046
Dry bean type	2	0.001	0.974	1.425**	1.018*	3.854
Error	4	0.001	0.792	0.059	0.108	0.897
Weed (infested and free)	1	0.000	2.746	0.120	0.562	4.099**
Dry bean × weed	2	0.000	1.221	0.040	0.762	0.211
Error	6	0.000	0.521	0.100	0.212	0.240

*and ** significant difference at 5 and %1 probability level, respectively.

Table 3. Analysis of variance of dry bean TDM at different growth stages (TDM_1, TDM_2, TDM_3 TDM_4 and TDM_5 are TDM at 40 , 50, 60, 70 and 80 days after dry bean emergence).

S.O.V	df	MS				
		TDM_1	TDM_2	TDM_3	TDM_4	TDM_5
Block	2	12.054	27.076	35.978	57.828	20.533
Dry bean type	2	0.844	13.390	110.874	56.229	311.144
Error	4	2.666	18.851	66.638	162.523	180.799
Weed (infested and free)	1	13.330*	53.354*	92.208	1269.576**	2095.850**
Dry bean × weed	2	1.973	13.791	20.385	133.262	122.265
Error	6	1.201	5.096	17.756	39.891	144.851

*and ** significant difference at 5 and %1 probability level, respectively.

Table 4. Analysis of variance of dry bean CGR at different growth stages (CGR_1, CGR_2, CGR_3 CGR_4 and CGR_5 are CGR at 40 , 50, 60, 70 and 80 days after dry bean emergence).

S.O.V	df	Mean squares				
		CGR_1	CGR_2	CGR_3	CGR_4	CGR_5
Block	2	0.309	0.088	0.089	0.383	0.815
Dry bean type	2	0.022	0.226	1.211	3.255	6.514
Error	4	0.068	0.198	1.324	1.027	7.109
Weed (infested and free)	1	0.341*	0.341	0.135	17.344*	2.637
Dry bean × weed	2	0.050	0.427	0.026	1.318	0.794
Error	6	0.031	0.137	0.591	2.449	6.274

*and ** significant difference at 5 and %1 probability level, respectively.

The mean comparison of dry bean TDM for weed infested and weed free treatment indicated that dry bean TDM of weed infested treatment was significantly lower than that of weed free treatment (Figure 4). The weeds competition caused reduction in LAI and thereafter reduced photosynthesis and growth.

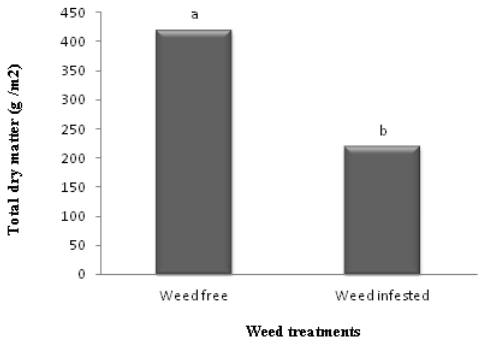

Fig. 4. The effect of weed treatment (weed free and infested) on dry bean total dry matter (TDM) (Different letter in each treatment indicate significant difference at $p \leq 0.05$).

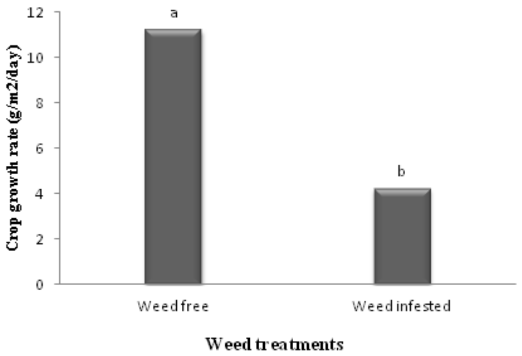

Fig. 5. The effect of weed treatment (weed free and infested) on dry bean crop growth rate (CGR) (Different letter in each treatment indicate significant difference at $p \leq 0.05$).

Mohammadi *et al.,* (2004) suggested that the TDM is more efficient parameter for evaluating the competitive ability in comparison with weed density. By delay in emergence of the weeds the TDM and competitive ability of them was reduced, significantly (Hook *and et al.,* 2006). Cox *et al.,* (2006) also indicated that the dry matter accumulation of corn was reduced due to interference of weed.

Crop Growth Rate (CGR)

Results of analysis of variance (Table 4) indicated that weed treatments had significant effect on dry bean CGR_1 (CGR at 40 days after emergence) and CGR_4 (CGR at 70 days after emergence) ($P \leq 0.05$). The effect of dry bean type and interaction of dry bean type × weed treatment on CGR was not significant at all growth stages. The mean comparison of dry bean CGR indicated that CGR in weed infested treatment was significantly lower than that in weed free treatment (Figure 5). Therefore the weed competition had significant effect on growth rate of all dry beans.

Baghestani *et al.* (2006) observed that plant height, leaf area index, crop growth rate and dry matter accumylation had significant effect on wheat competitiveness against weed. Mohamamdi (2007) in a study on corn cultivars showed that among studied growth indices, relative growth rate and leaf area index are better predicators of corn cultivars competitiveness against the weed so that by increasing the competitive ability these indices are increased.

According to these results in competition of weeds and dry bean types the weed infested treatment reduced the plant height, LAI, TDM and CGR of all dry bean types. The response of plant height and LAI in three red bean types was different. In pther word the plant height and LAI could be used as indices for selecting the red bean with high competitiveness against weeds. These strategies can be used as cultural methods to reduce the competitive ability of weeds and maintain red bean yield at acceptable levels, which are components of integrated weed management. Identification of dry beans with high competitive ability could neutralize the negative effect of weeds and helps to achieve sustainable agriculture and reduction of environment contamination resulted from application of herbicides.

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