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Determination of critical period of weeds control in french bean (*Phaseolus* vulgaris L.) in Iran

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Abstract

An experiment was conducted in 2009-2010 to determine the critical period of weeds control in snap bean in climate conditions of Iran. The experimental design was a completely randomized block with 16 treatments and 3 replications. Treatments were divided into two groups based on 12 days periods. First group consisted of treatments of weeds competition with interested plant from the emergence of snap bean to 12, 24, 36, 48, 60, 72 and 84 days after emergence along with control treatment. Second group consisted of weeds free treatments in above stages. The results showed that with the increase of the length of weeds competition periods the performance of green pod decreased significantly so that the highest performance was seen in throughout season control treatment by 1990.38 gm^{-2}.The lowest performance was seen in throughout season interference control treatment by 334.27 gm^{-2}. On the other hand, wide leaf weeds had more effects on snap bean than narrow leaf weeds. Finally, with acceptance of 5 and 10 percent yield reduction, a period of 61 days from 10 to 71 days after emergence (2-6 leaf stage up to 50% pod production) and a period of 51 days from 13 to 63 days after emergence (6-10 leaf stage up to 50% flowering) of French bean were determined as critical periods of weeds control.

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Introduction

Pulses are the second important of human food (Koochaki *et al.,* 1997). Pulses planting in agriculture systems had multiple outputs. In addition to their food importance for human and livestock, these agronomical plants play an important role in soil fertility (Rashedmohasel *et al.,* 2006). Growth and yield of French bean are substantially reduced by weed competition for nutrients, water and light. Application of pre emergence herbicides is quite common for weed control and it is often associated with post-emergence herbicide treatments. Alternatively, French bean growers rely on machine hoeing techniques, especially in organic farming systems. These techniques are often expensive, time consuming but they are not often successful or cost effective (Ngouajio *et al.,* 1997). Since weed control represents a major production cost and herbicides have a potential adverse effect to the environment, the use of integrated weed management systems (IWMS) is advisable (Swanton and Weise, 1991; Hall *et al.,* 1992; Woolley *et al.,* 1993) to develop optimum weed control strategies and efficient use of herbicides. The Critical Period of Weed Competition (CPWC) is a key consideration for IWMS programs and for the development of alternative weed management strategies (Swanton and Weise, 1991). CPWC has been defined in several ways. Zimdahl (1988, 1993) defined it as a span of time between that period after seeding or emergence when weed competition does not reduce crop yield, and the time after which weed competition will no longer reduce crop yield. Knezevic *et al.* (2002) described CPWC as a "window" in the crop growth cycle during which weeds must be controlled to prevent unacceptable yield losses. The CPWC values have been determined in various environments and for several crop species, including vegetables (Dawson, 1970; Hewson and Roberts, 1973; Schweizer, 1981; Van Acker *et al.*, 1993; Woolley *et al.,* 1993; Bairamkenga and Leroux, 1994; Bond and Burston, 1996; Evans *et al.,* 2003; Knezevic *et al.,* 2002). Particularly for leguminous crops, in white bean the CPWC was found to occur from 35 to 49 days after planting (Dawson, 1964) and 20-40 days in Canada (Woolley *et al.,* 1993). population of weeds in bean for 4-5 weeks after growth season causes the significant decrease of yield and number of pod. Burnside *et al.* (2009) emphasized careful management of bean's weeds. They noted that if weed competes with agronomical crop, production and yield of bean will decrease from 2230 to 820 $kgha^{-1}$. These researchers estimated that if the biomass of weeds to be 2.9 $kgha^{-1}$, the value of the production of bean grain will decrease by 1 $kgha^{-1}$. Moosavi (2008) stated that critical period for the loss of weeds in bean is 40 days i.e. from 10 to 50 days after germination. Zimdal *et al.* (2010) reported that the decrease of yield is 70 percent that results from the interference of weeds in bean. The objectives of this study were to determine the CPWC in French bean, to gather specific information on the competition effects of weeds to this crop, and to understand the time during which yield-reducing competition occurs.

Materials and methods

Field experiments were conducted in 2009-2010 at Azad University Shoushtar Branch Agricultural Research Station (32° 15′ N, 48° 28′ E). The soil were as follows: 42% clay, 51% silt and 7% sand, pH (H_2O) 7.8, total organic matter 0.4%. The soil was prepared according to the local practice for French bean production. Primary tillage consisted of spring chisel ploughing and it was followed by two harrowing. The trials were preceded by wheat (*Triticum aestivum* L.). French bean was sown at a rate of 40 seeds m^{-2} with the rows spaced 0.4 m apart and at a depth of 4 cm. The crop was irrigated after sowing and the Irrigation was repeated on the basis of the evapotranspiration rates. Naturally occurring weed populations were present in all trials. In local practice, mechanical means and chemicals are generally used to control weeds. However, in this study weeds were removed by hand hoeing to avoid soil disturbance.

Experimental design

A randomized complete block design with 3 replicates was used for all trials. Individual plots consisted of 4 rows of French bean plants, each 8 m long. In order to determine the critical period of weed removal, the duration of tolerated competition (DTC) and weed-

free period (WFP) were calculated (Zanin, 1989; Montemurro *et al.,* 1991; Berti *et al.,* 2008). In order to determine the DTC, plots were left weedy for 12,24, 36, 48, 60, 72 and 84 days after emergence (DAE) corresponding with 2-6, 6-10, 10-14, 14-18, 18-22 leaves, 50% flowering and 50% pod production respectively) and weed free for the rest of the growing period. To determine the WFP, plots were kept weed-free for 12, 24, 36, 48, 60, 72 and 84 DAE and weedy for the rest of the growing period. The treatments were compared with two control plots kept weed-free and weed-infested throughout the crop cycle, respectively.

Weed infestations

Were evaluated 1 and 4 weeks after emergence in the unweeded control by classifying and counting weed plants in a 0.5 m × 0.5 m quadrate per plot. To determine the effect of weed-crop competition on weed dry weight accumulation, weeds were sampled in one quadrate per plot at each weeding time in the weed interfered plots and at the end of the growing cycle in the WFP plots. Weeds were cut at the soil level and dried at 80 ^{o}C to a constant weight. An area corresponding to the central 6 m length of the middle two plant rows of each plot, was hand harvested at maturity. The number of French bean plants per m^{-2}, the number of pods per plant and the yield were determined. Yield data were expressed as a percentage of the weed-free control to allow comparison between experiments.

Statistical analysis

We used MSTAT-C software to analyze data variance from experiment. In addition, we used Duncan test to compare mean.

Results and discussion

Kind and number of weed

In this research, wide leaf weeds included *physali divaricat*, *Amaranthus viridis*, *Portulaca oleracea*, *Convolulus arvensis*, *Chenopudium murale* and *Molva sylvestris* that *Physali divaricat* and *Amaranthus viridis* has the highest density among weeds. Narrow leaf weeds included *Cleome viscose*, *Cyperus rotundus* and *Echinochloa colonum* that *Cyperus rotundus* and *Cleome viscose* had the highest number. With prolongation of interference period of weeds the number of weeds primarily showed an increasing trend, and then decreased. In interference treatments the population of broad and narrow leaves reached the highest value i.e. 45 and 49 plant m^{-2} respectively 48 days after germination of French bean (14-18 leaves stage). After that their population decreased. Finally, their density respectively reached to 26 and 28 plant m^{-2} at harvest stage (Tables 1 & 2).

Table 1. Kind and number of broad leaf weeds in interference treatments.

Treatment	*Physali divaricat*	*Amaranthus viridis*	*Portulaca oleracea*	*Convolulus arrensis*	*Chenopudiu murale*	*Molva sylvestris*	Total
up to 12 days	12	8	-	4	4	5	33
up to 24 days	16	8	-	4	5	6	39
up to 36 days	14	12	3	5	5	5	44
up to 48 days	18	18	2	4	4	3	49
up to 60 days	19	8	-	4	6	4	41
up to 72 days	17	10	-	1	4	4	36
up to 84 days	15	5	2	2	2	4	30
Complete interference	14	4	2	2	2	4	28

Dry weight of weeds

The impact of interference and interference free treatments on dry weight of broad and narrow leaf weeds was significant (Table3). With the increase of competition period length interference treatments, dry weight of weeds increased such that the highest value of aggregated dry matter in broad leaves in throughout season interference treatment was 426.67

gm^{-2}, and in narrow leaves was related to interference treatment up to 72 days after germination of French bean (50% flowering) that reached 78.34 gm^{-2}.

The reason of increasing dry weight of weeds was desirability of environmental conditions, the increase of leaf area and aerial organs of weeds. Of course, dry weight of broad leaves in interference treatments was higher than narrow leaves. Nelson *et al.* (2010) studied the relative impact of narrow leaf (*Setaria viridis*) and broad leaf (*Sinapis arvensis*) weeds on green pea yield, and reported that broad leaf weeds more decreased the yield of green pea than narrow leaf weeds so that 2 bushes of *Sinapis arvensis* in 0.1 m^2 had four times impact on the decrease of yield than *Setaria viridis*.

Table 2. Kind and number of narrow leaf weeds in interference treatments.

Treatment	*Cyperus rotundus*	*Cleome viscose*	*Echinochloa colonum*	Total
up to 12 days	20	6	3	29
up to 24 days	23	8	5	36
up to 36 days	32	8	1	41
up to 48 days	36	6	3	45
up to 60 days	29	8	2	39
up to 72 days	29	8	1	34
up to 84 days	21	7	2	30
Complete interference	19	6	1	26

French bean yield

The results showed that the impact of weed interference and weed free period treatments on the performance of green pod and biological yield of French bean is significant at 1% probability level (Table4). The comparison of green pod yield means of French bean showed that interference treatments significantly decrease yield so that the lowest yield of green pod was seen in interference treatment up to 84 days. Its value was 349.82 gm^{-2} that were located in the same statistical group with complete interference. In weed free period treatments, the highest value of yield was related to control treatment up to 84 days after germination that was 1959.45 gm^{-2}, and was located in the same statistical group with complete weed free treatment. Decreasing trend of pod yield can be attributed to weeds shade, flowers fall due to the presence of competition and more allocation of photosynthesis materials to growth. Therefore, French bean yield was decreased by increasing interference periods of weeds with French bean (Table5).

Table 3. Analysis of variance of the traits under study**.**

Variation Source	Degree freedom	Weight of broad leaf in control treatment	Weight of narrow leaf in control treatment	Weight of broad leaf in no control treatment	weight of narrow leaf in no control treatment
Replication	2	4.85^{ns}	24.153^{ns}	199.591^{ns}	30.762^{ns}
Treatment	15	88.014^{**}	70.946^{**}	60895.250^{**}	10871.366^{**}
Error	30	5.117	27.826	295.303	859.347
%CV		7.21	11.06	12.16	10.59

$^{ns, ××}$ indicate an insignificant and significant differences at the *P=0.01* level.

These results are associated with the findings Philip *et al.* (2008) based on sensitivity of grain yield to the increase of interference periods of weeds. Sadati (2005) stated that in the direction of weeds interference with French bean, yield drop of bean pod was increased due to the prolongation of interference period. Chang *et al.* (2006) studied the impact of weeds competition on pulses and stated that weeds

severely influence yield. Finally, this is possible that French bean may not be exploitable due to severe interference.

Critical period

There is difference among various kinds of plants in terms of morphology, physiology and growth. Therefore, it is expected that every plants has an unique critical period for weeds control (Balackshaw, 2005; martin *et al.,* 2010). The changes of French bean yield in different interference and weed free treatments showed that the impact of weeds presence duration is difference (Table5) so that the prolongation of weeds interference periods decreased yield while the prolongation of weed free periods increased yield.

Table 4. Analysis of variance of the Biologic and pod yield of French bean under study.

Variation Source	Degree freedom	Pod yield in weed free	Pod yield in interference	Biologic yield in weed free	Biologic yield in interference
Replication	2	1460.469 ^{ns}	591.135^{ns}	4082.822^{ns}	389.457^{ns}
Treatment	15	958645.922**	1041895.922**	32055442.864**	3438047.268**
Error	30	826.504	337.528	34559.431	801.311
%CV		12.99	11.85	8.69	6.40

$^{ns, ××}$ indicate an insignificant and significant differences at the *P=0.01* level.

The maximum of weeds interference periods that represent beginning time of weeds control (beginning of critical period) at 5 and 10% levels of acceptable drop of pod yield were respectively determined as 10 and 13 days after germination of French bean (corresponding to 2-6 leaves and 6-10 leaves).

The minimum of weeds control periods of French bean that is a criterion for considering the end of weeds control period (the end of critical period) at 5 and 10% levels of acceptable drop of pod yield were respectively determined as 63 and 71 days after germination of French bean (Corresponding to 50% flowering and 50% pod production, respectively).

Table 5. Comparison of yield of French bean under weed free periods and weed interference periods treatments.

Weed free periods	Pod yield (g m^{-2})	Biologic yield (g m^{-2})
Up to 12 days	612.22g	1177.78f
Up to 24 days	750.19f	1443.71e
Up to 36 days	1093.34e	2055.74d
Up to 48 days	1391.67d	2847.60c
Up to 60 days	1852.79c	3664.23b
Up to 72 days	1898.52b	3988.72a
Up to 84 days	1959.45a	4116.67a
Weed-free throughout the crop cycle	1990.38a	4181.67a
	Weed interference	
Up to 12 days	1811.08c	3532.6d
Up to 24 days	1603.52c	2910.55c
Up to 36 days	133.89d	2702.41c
Up to 48 days	1252.23d	2395.19d
Up to 60 days	849.56f	1765.19e
Up to 72 days	412.04f	1011.86f
Up to 84 days	349.82g	853.34g
Weed-infested throughout the crop cycle	334.27g	812.04h

The same letters in each column indicate an insignificant difference at the *P=0.01* level.

Philip *et al.* (2008) stated that with the increase of drop percent of pod yield in French bean from 5 to 10% the onset of critical period occurs later, and the end of critical period occurs sooner.

According to our research, the critical period for weeds control in French bean was determined 53 and 58 days after germination for acceptable reduction yield of 5% and 10%, respectively. The prolongation of this period in French bean can represent the weak power of this plant for competing with weeds particularly in the beginning of growth period.

Conclusion

The results revealed the sensitivity of French bean in competition with weeds. In addition, emphasizes on correct implementation of weeds control operation particularly before planting and germination.

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