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Determining the Critical Period of Lentil Weeds

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ABSTRACT

In order to determine critical period of lentil weeds, an experiment based on full-randomized blocks plan with four replications was conducted in Varzaghan, East Azarbaijan province during 2014. Treatment of weed-infested periods included interference of weeds (during growth period), until 7,14,21,28,38 days after planting, control and weed-free period, and interference from 7, 14, 21, 28, & 35th day afterward. This research studied yield and yield components of lentil. According to results, most traits were affected by weeds such that treatment until 35 weed-free days highly affected the traits in the first group and increase of yield components, e.g., number of pods per bush (n=86.22) and number of beans per pod (n=91.78) resulted in increase of yield as 53.10 gram per bush. In the second treatment group (from specified weed-free days afterward), the control treatment (weed-free during growth period) highly affected the traits and resulted in increase of yield and yield components. Comparing with other treatments, traits such as number of pods per bush (n=120.08) and number of beans were at their maximum value in this group and it led to increase of bean yield as 75.36 gram per bush. Thus, the more weed-free the farm, the higher the yield of the agricultural plants. To have appropriate yield, weeds may be controlled and removed from middle of germinative growth. It was confirmed by logistic and Gompertz equations, too.

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INTRODUCTION

Weed interference is an important restriction in lentil planting. Due to its relatively short length and slow initial growth, lentil demonstrates weakly competition with weeds [5]. Young lentil is a very weak competitor for weed and does not cover soil level for a long time after being planted [2]. In this stage, quick growth of root and shoot of weeds leads to their easy dominance on agricultural plants if they are not controlled. Thus, it is necessary to study weeds control methods in farms to promote lentil crop yield. To obtain humidity, nutrition, light, and space, weeds compete with agricultural plants and affect quality and quantity of crops [14]. Therefore, they should be controlled in lentil farms. Some factors including more persistence against herbicides, more area of farming lands, attention of consumers to herbicides left over in foodstuff and pastures, more economical costs, environmental pollutions resulting from chemical control of weed, and lack of selected herbicides for most weeds emphasize on necessity of using alternative methods for herbicides consumption such as prevention, mechanical control, management of nutrition, increasing of plant density, and using varieties with high competitive power with weeds [3]. Integrated management of weeds trying to minimize bad effects of weeds control on environment [10] includes several methods such as weeds control during critical period, i.e. period of maximum loss to weeds and minimum bad effect to agricultural plants. Critical period is the best time interval to effectively and appropriately control weeds in an agricultural plant since early control before this period leads to less efficiency of control and increase of loss due to regrowth of weeds. Also, late control after this period is not much effective considering more growth of weeds and increase of loss of agricultural plants [17].

The present research aims at determining critical period of weeds control in planting lentil of Ziba variety and studying effect of interference and weeds control on yield and yield components of lentil at farm conditions in Varzaghan.

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METHODS AND MATERIALS

The experiment was conducted in a farm in Varzaghan, East Azaerbaijan Province, during spring 2014. With a 1360m altitude, Varzaghan is located at East longitude of 46° 17' and North latitude of 38° 5'. Average annual precipitation is 271.3mm. Soil of the location was of loam type consisting of sand (52%), silica (34%) and argil (14%) with pH of 7.28. The experiment was conducted using full-randomized blocks plan with 12 treatment groups and 4 replications.

The understudy factors were as follows:

1) weed-infested treatment in six levels:

a_1: control treatment of weeds interference until end of lentil growth period

a_2: until 7 days after planting

a_3: until 14 days after planting

a_4: until 21 days after planting

a_5: until 28 days after planting

a_6: until 35 days after planting

2) Weed-free treatments in six levels:

a_1: control treatment without weeds until end of lentil growth period

a_2: until 7 days after planting

a_3: until 14 days after planting

a_4: until 21 days after planting

a_5: until 28 days after planting

a_6: until 35 days after planting

To prepare the land, the location was ploughed during autumn 2013 and disking operation was done in the next spring. According to results of soil test, the required fertilizers were mixed with the soil.

The farm was planted with lentil of Ziba variety on 11 Apr., 2014. The lentil was provided by Agricultural Jihad of Varzaghan and the seeds were planted in rows at the depth of 5-6cm and distance of 10cm. In this study, the seeds were planted in rows (6 rows), with rows distance of 50cm and dimension of plots was 4*3m. Distance between replications and plots was considered 1m and the farm was irrigated only when the seeds were planted since dry farming is common farming method in the region.

When the crop was ripen, 10 samples were taken from every plot and the traits including total number of pods, number of beans in pods, weight of one hundred beans, wet weight of bush, and dry and wet weight of weed were measured. Observing the margin, $2m^2$ was harvested from every plot to determine bean yield. MSTAT-C software was used to analyze data variance and the means were compared using Duncan's method at probability level of 5%.

The relation between lentil yield and duration of control period was fitted using Gompertz equation. Additionally, the relation between decrease of lentil yield and duration of interference period of weeds was fitted using logistic equation and nonlinear regression method relying on Sigma Plot software. Finally, these two curves were used to estimate critical period of weeds control using permitted decrease of the yield at the level of 10%.

Logistic equation $Y=c+d/(1+\exp(-a+bx))$

Where "Y" stands for yield (a percentage of competition-free control group), "a" for constant of the equation, "b" for relative speed of decrease, "c" for intercept, "d" for maximum height of constant values, and "x" for duration of interference period with weeds after planting (in days).

Gompertz equation $Y=a\exp(-b\exp(-kt))$

Where "Y" stands for yield (a percentage of competition-free control group), "a" for asymptote of yield (a percentage of competition-free control group), "T" duration of weeds control after planting (in days), "K" for relative speed of decrease, "b" for constant of the equation [12,7]

Discussion and Conclusion:

Table 1 demonstrates results of variance analysis of the understudy traits affected by weeds treatment. According to the results, weeds treatment significantly affected the traits of number of full pods, total number of pods, number of lateral branches, beans yield, and weight of 100 beans in both weed-infested and weed-free conditions. Number of beans in pods was only affected in weed-infested conditions and dry weight of weed was meaningful in weed-infested conditions.

Table 1: Variance analysis of the understudy traits

Variation origin	Degree of freedom	No. of full pods (WI)	No. of full pods (WF)	No. of bean in pod (WI)	No. of bean in pod (WF)
Replication	3	189.637*	405.888*	357.935*	733.192*
Weed treatment	5	502.130**	293.408*	669.382**	197.265^{ns}
Error	15	38.826	96.708	870.29	445.197

Variation coefficient	1.014	10.35	8.1	13.67

Table 1: (continued)

Variation origin	Degree of freedom	Total No. of pods (WI)	Total No. of pods (WF)	No. of lateral branches (WI)	No. of lateral branches (WF)
Replication	3	249.504*	525.014*	11.205*	5.438ns
Weed treatment	5	421.779**	342.433*	13.895**	7.172*
Error	15	47.469	102.894	405.2	836.1
Variation coefficient		9.98	9.64	10.76	7.26

Table 1: (continued)

Variation origin	Degree of freedom	Bean yield (WI)	Bean yield (WF)	Weight of 100 beans (WI)	Weight of 100 beans (WF)
Replication	3	165.715**	262.251**	0.626ns	0.212ns
Weed treatment	5	116.962*	151.765**	0.86*	1.680*
Error	15	30.523	31.503	0.214	0.432
Variation coefficient		12.97	8.62	6.94	9.28

Table 1: (continued)

Variation origin	Degree of freedom	Dry weight of weed
Replication	3	121.036ns
Weed treatment	5	511.594**
Error	15	88.261
Variation coefficient		24.02

Number of full pods:

Comparing mean effect of weed on number of full pods of lentil (at weed-infested conditions) demonstrated that there was high number of full pods in weed-free treatment group until 35 days after planting with the mean number of 80.57. The minimum number of full pods was observed in control treatment (weed-infested until end of growth period) with the mean value of 47.52% (Table 4). The rest treatments demonstrated average level considering number of full pods. Comparing treatments, it was made clear that weed control during initial days of lentil growth did not affect number of full pods and positive effect of weed control on generative parts and, thus, flowering and having more full pods was appeared through passing of growing days and beginning of inter-species competition (Figure 1). There was a difference of 41.02% between maximum and minimum number of full pods.

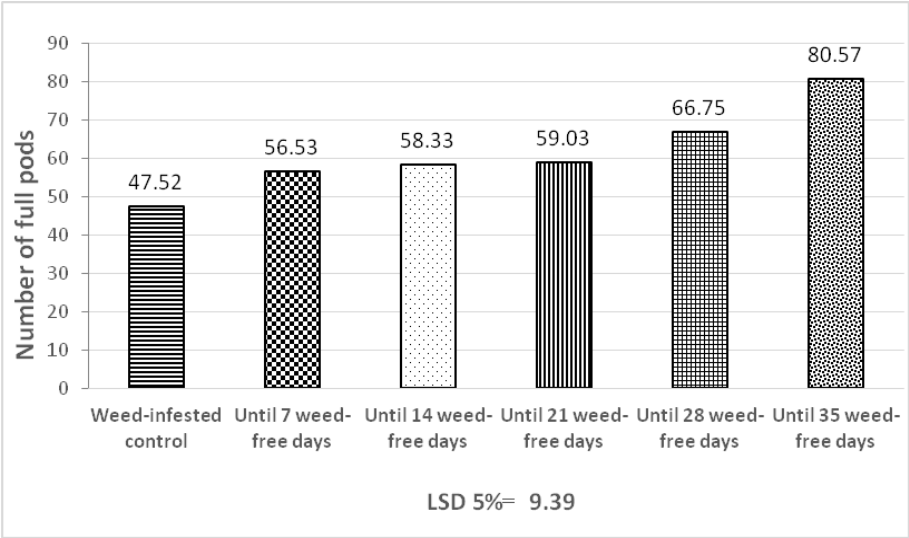

Fig. 1: Effect of weed-free periods on number of full pods in lentil

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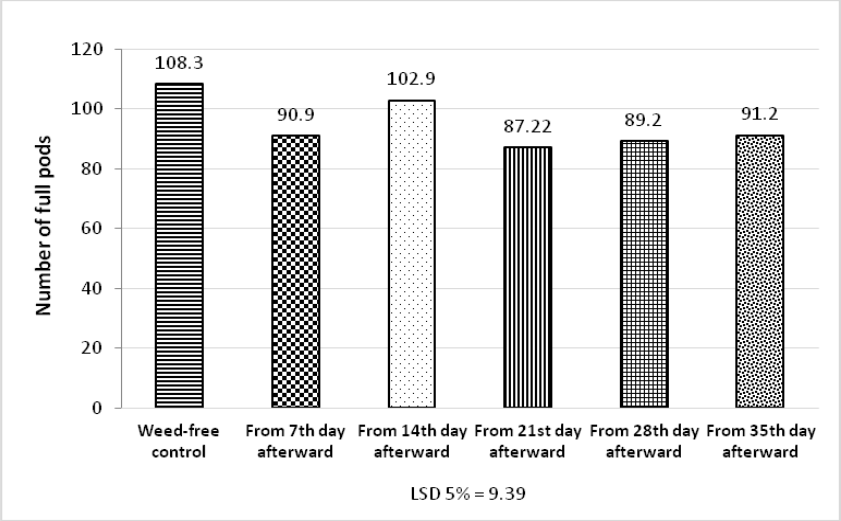

Fig. 2: Effect of weed-infested periods on number of full pods in lentil

Comparing mean weeds at control conditions (weed-free) and weed-free group from 7, 14, 21, 28, and 35th day afterward demonstrated that control treatment (weed-free) had maximum number of full pods (n=108.3). The second maximum number of full pods related to weed-free treatment group from 14th day afterward with 102.9 full pods. The minimum number of full pods was for weed-free treatment group from 21st day afterward with mean number of 87.22 (Table 5). It may be stated that the closer the weeding time to generative growth times, the more the positive effects on pollination and, thus, number of full pods.

Total number of pods:

According to variance analysis results, total number of pods was affected by weed treatment in both weed-free and weed-infested conditions (Table 1).

Comparing mean effect of weed on total number of pods indicates to positive effect of weed control from 21st day afterward such that weed-free treatment group until 35 days after planting had maximum number of full pods with the mean of 86.22 pods (Table 4). It seems that weed control during initial days of lentil growth does not affect total number of full pods. Since there is not any competition for growth space, nutrition resources and light during initial stages, weed control will not significantly affect generative growth. When growth reaches its middle stages (35 days) and competition begins for more growth and having appropriate yield, weed control demonstrates its positive effect.

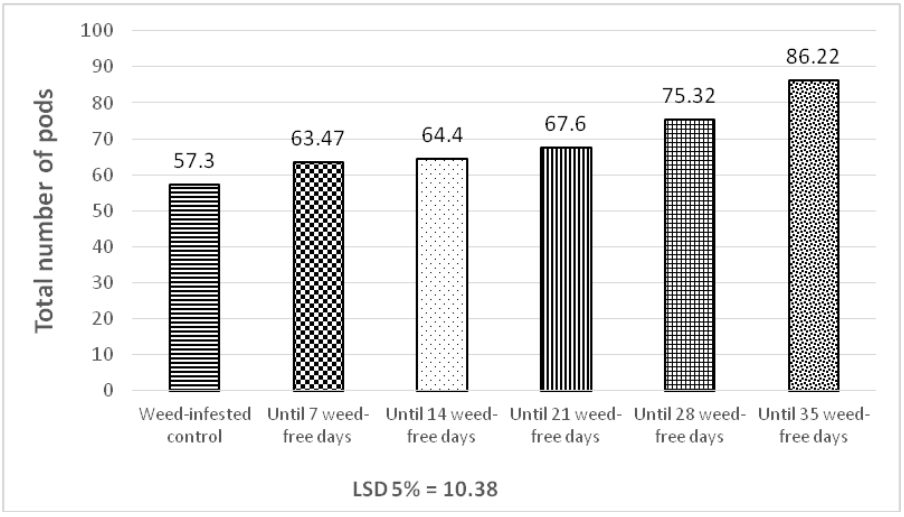

Fig. 3: Effect of weed-free periods on total number of full pods in lentil

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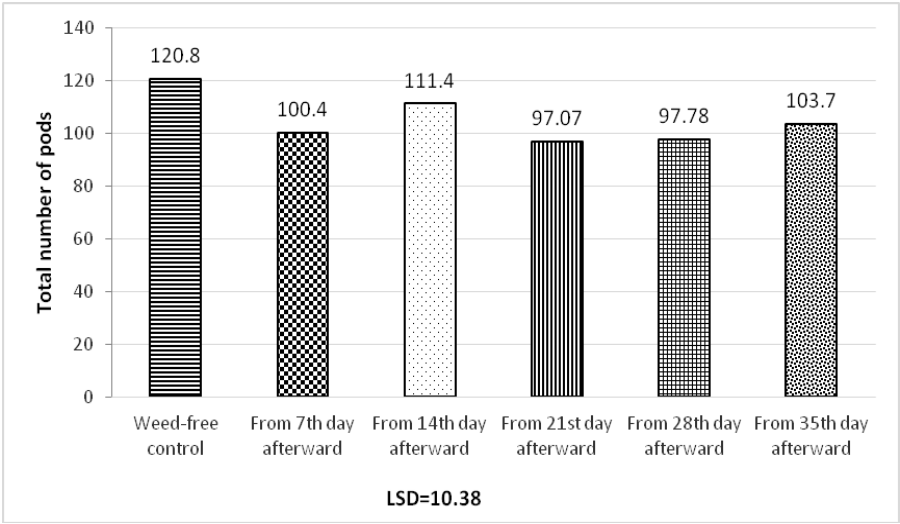

Fig. 4: Effect of weed-infested periods on total number of full pods in lentil

Control treatment had maximum total number of full pods while maximum total number of pods in the weed-free group until 7,14,21,28 and 35 days was observed in the weed-free treatment group until 35 days after planting (Table 5). Thus, removing of weeds during total period will be most effective way. The more close the weed control to generative growth, the more appropriate its effect in pollination, production of pods and beans.

Yield components have the highest rate of sensitivity to compete with weeds during critical periods of growth. Considering yield components, number of pods per bush is the most important trait affected by weeds competition [15].

Number of beans per pod:

Comparing mean number of beans in pods demonstrated that maximum number of beans was observed in the weed-free treatment group until 35 days (WF35) with 91.78 beans. Minimum number of beans in pods belonged to control treatment (weed-infested until end of the growth period) with 54.03 beans (Table 5 & Figure 6).

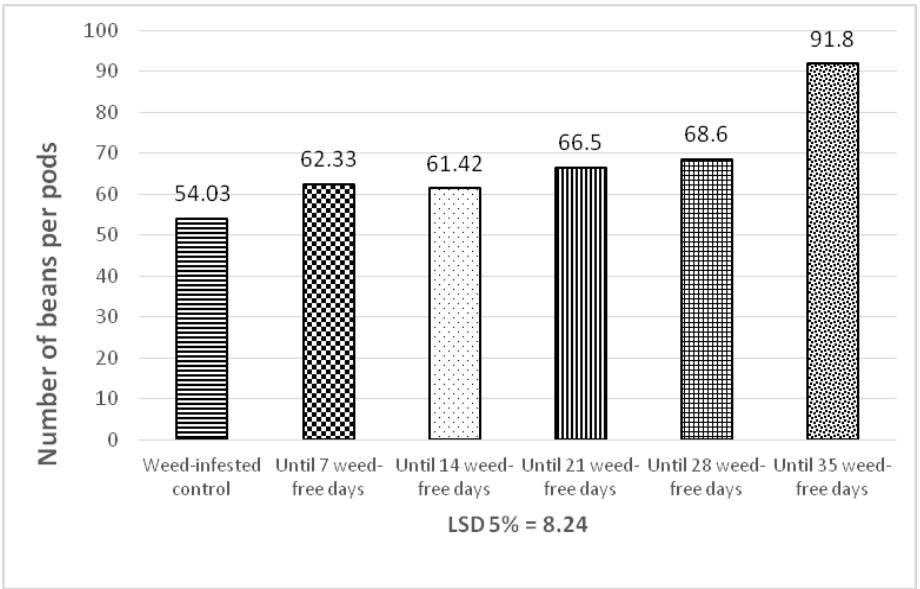

Fig. 5: Effect of weed-free periods on number of beans per pods in lentil

According to Aghaalikhani et al [1], increase of weeds in wax bean farms for 40 and 50 days after planting resulted in 87.7% decrease of its yield which can be attributed to casting shadow of weed, falling of flowers due to competition, decrease of yield components, and allocation of more photosynthesis materials to germinative growth. Eftekhari et al [4] suggested that maximum permitted period of weeds competition in soya farm varies

from appearing of third leaflet to beginning of flowering. If weeds are not controlled, a 51.02% decrease will be seen in beans yield. There is a negative relation between accumulation of dried material of weeds and that of soya, i.e. decrease of one results in increase of another.

Number of lateral branches:

Comparing mean effect of weed treatment (weed-infested) on number of lateral branches demonstrated that maximum number of lateral branches in lentil bush was observed in weed-free treatment group until 35 days with the mean of 17.95 branches per bush. It refers to positive effect of weed control at this time interval and prepares appropriate space required for lentil bush growth. Minimum number of branches per bush was seen in other treatment groups (weed-infested control group until end of the period 14, 7, 21& 28 weed-free days) with the mean of 12.40, 14, 13.68, 14.32, 14.13 branches per bush. There was a difference of 23.67 between maximum and minimum number of branches per bush (Figure 6).

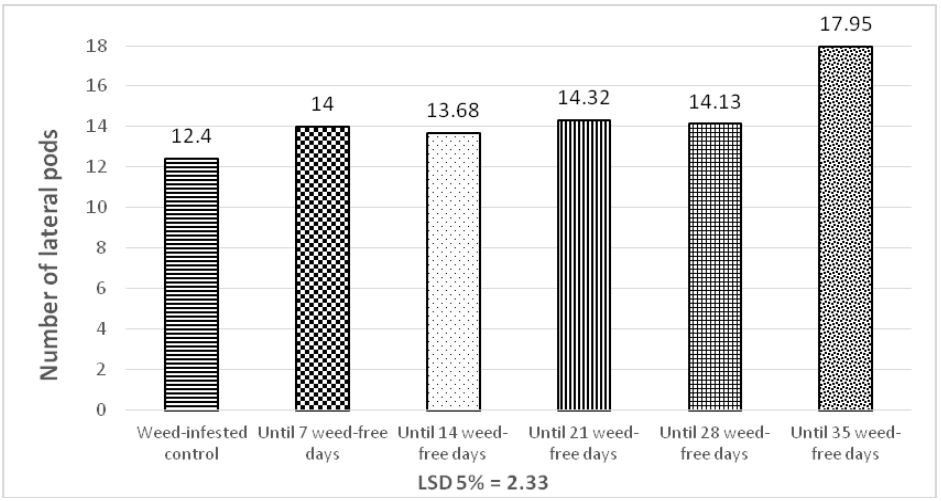

Fig. 6: Effect of weed-free periods on number of lateral branches in lentil

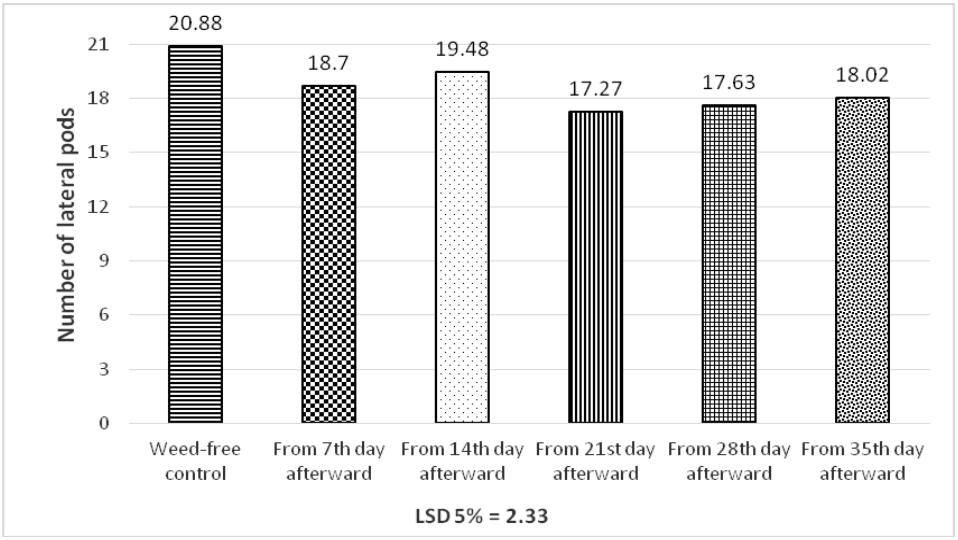

Fig. 7: Effect of weed-infested periods on number of lateral branches in lentil

Comparing mean of effect weed treatment (weed-free) on number of lateral branches demonstrated that maximum number of lateral branches was observed in weed-free treatment group with the mean of 20.88 branches. Weed-free treatment group from 14th day afterward occupied the second rank considering production of lateral branches with trivial difference from control treatment and mean of 19.48 branches (Figure 7).

It may be stated that removing of weeds provides appropriate space to lentil to have more branches. For this purpose, 14 days after planting is the best time to remove weeds in this treatment group. In the weed-infested group, 35 days after planting is the most appropriate time to remove weeds and have the maximum lateral

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branches. It is necessary to control weeds of lentil since it is not able to suppress weeds during initial stages of growth and is of less-competitive nature [8]. According to Eftekhari et al [4], increase of competition periods resulted in decrease of lateral branches in bushes of interference treatment groups and reached to its minimum number in the control treatment (weed-infested during all growth periods, 1.5 branches per bush). Additionally, increase of competition period of weeds led to decrease of lateral branches as well as pods in the bushes. Finally, severe decrease of biologic yield was observed.

Beans yield:

Comparing mean effect of weed treatment (weed-infested) on beans yield demonstrated that maximum yield was observed in weed-free treatment group until 35 days with the mean of 53.10 gram per bush. It refers to positive effect of removing of weeds at this time interval and increases competition for nutrition, space, and light in favor of lentil. There was a difference of 23.74% between maximum and minimum yield (Figure 8).

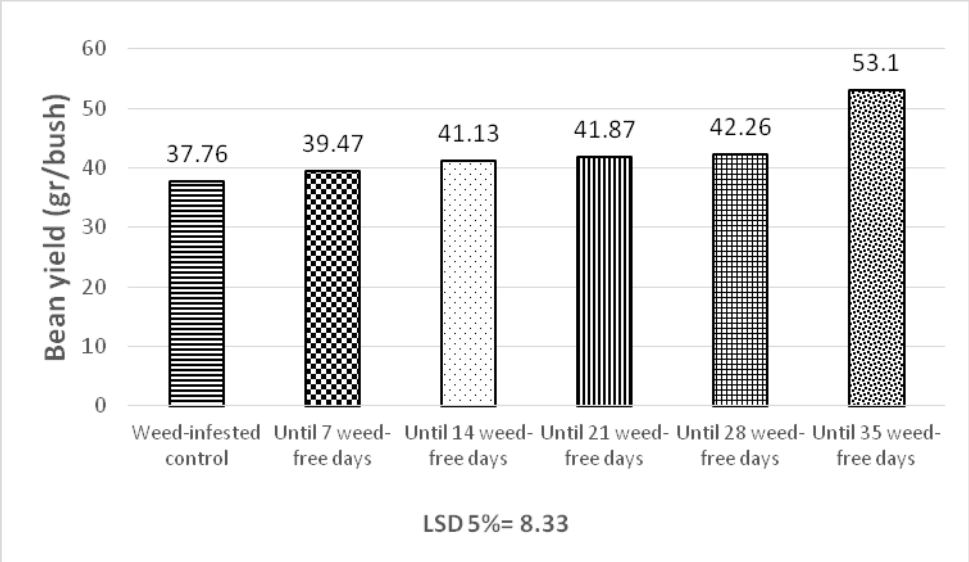

Fig. 8: Effect of weed-free periods on beans yield in lentil

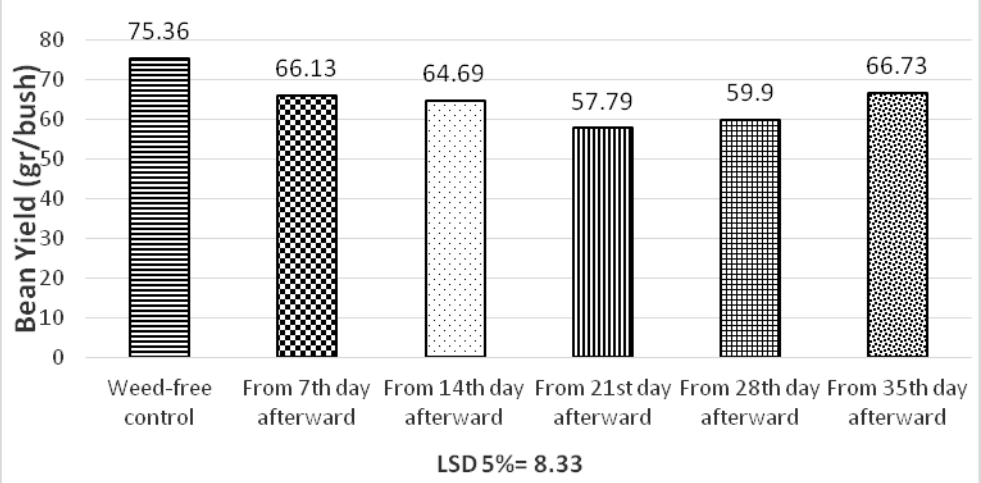

Fig. 9: Effect of weed-infested periods on beans yield in lentil

Comparing mean effect of beans yield, it was made clear that control group (weed-free) demonstrated higher yield (with 75.36 gram per bush) than other treatment groups. It was a predictable process since appropriate space, light, and nutrition were provided for the bush without any inter-species competition. Considering appropriate beans yield, the second rank was allocated to weed-free treatment group from 35th day afterward with the mean of 66.73 gram/bush (Figure 9).

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Comparing two treatment groups suggested that weed-free treatment groups from 7, 14, 21, 28 & 35th day afterward demonstrated high beans yield than the weed-infested treatment group and weed-free group until 7, 14, 21, 28 & 35 days.

Mousavi [9] stated that weed control results in 46.7% increase of lentil yield. According to Pourtaher et al (2012), weed control positively affects the yield. Also, 84% decrease of lentil yield was reported due to weed competition [16].

Dry weight of weed:

Comparing mean effect of weed treatment on dry weight of weed demonstrated that maximum dry weight was observed in control treatment (weed-infested until end of the growth period) with mean weight of 61.59 gram per bush. The rest treatment groups (weed-free 7,14,21,28 & 35 days) demonstrated minimum dry weight of weed without any significant difference. In spite of lack of any significant difference in these treatment groups, numerical comparison suggested that the more the weed-free days, the less the dry weight of weed such that minimum weight was observed in the weed-free treatment group until 35 days. It refers to positive effect of removing of weeds (Figure 12). Lak et al [6] demonstrated that prolong of interference period from beginning of growth season resulted in increase of dry weight of weeds. In interference treatment of weeds during growth season (all season competition control group), dry weight of legume was reported as 275.81 and 168.14 g/m2 for 2001 and 2002, respectively. The more the weed-free days, the less the dry weight of weeds. Mousavi [9] stated that weeding leads to 9.2% increase of production of dried materials of lentil.

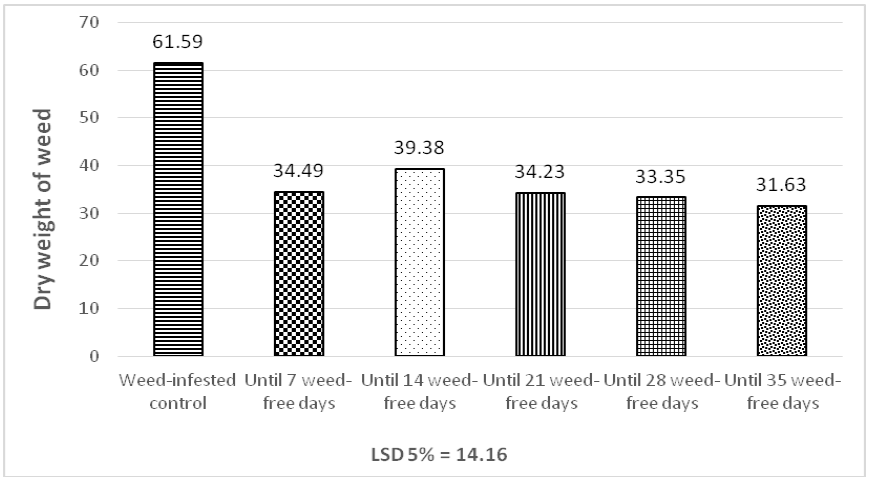

Fig. 10: Dry weight of weeds in weed-free periods until the specified days in lentil

Weight of one hundred beans:

Comparing mean effect of weed treatment on weight of 100 beans demonstrated that maximum weight of 100 beans was observed in weed-free treatment group until 35 days with the weight of 7.45g. Next, weed-free treatment group until 28 days produced appropriate weight of 100 beans with the weight of 6.81g. It refers to positive effect of removing of weeds during the mentioned periods (Figure 11).

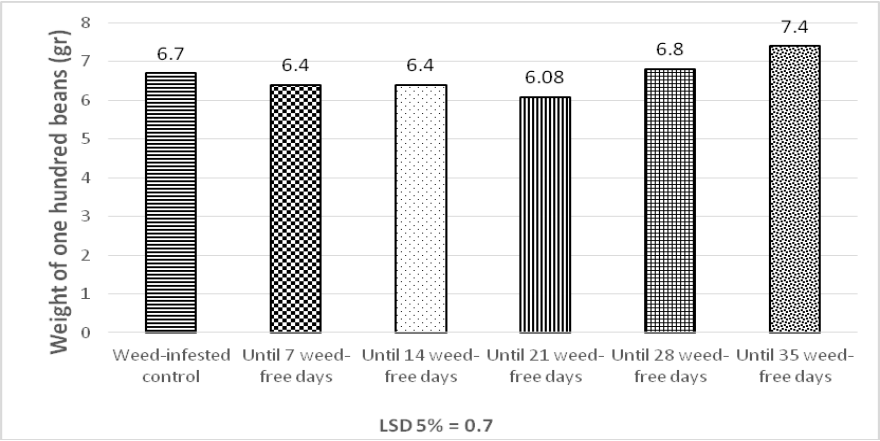

Fig. 11: Effect of weed-free periods on weight of one hundred beans in lentil

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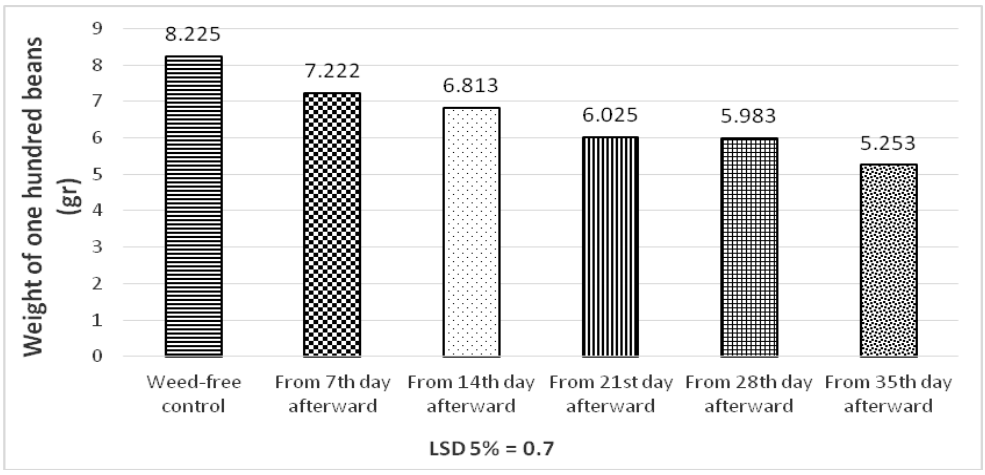

Fig. 12: Effect of weed-infested periods on weight of one hundred beans in lentil

Comparing mean effect of weed treatment on weight of 100 beans demonstrated that maximum weight of 100 beans was observed in weed-free treatment group until end of growth period with the weight of 8.22g. The rest treatment groups demonstrated less weight of 100 beans, i.e. 7.22, 6.81, 7.02, 6.98 & 6.25g, without any statistical difference (Figure 12).

According to Eftekhari et al [4], weight of 100 beans was not meaningful in interference and weed control treatment groups since weeds demonstrate their main loss as less number of pods per bushes and, therefore, it increases share of every bean from photosynthesis materials.

Determining critical period using logistic equation:

In this experiment, critical period of weeds control was 18-28 days considering acceptable 10% decrease of yield and other environmental conditions governing the location. Thus, concentration of weed management plans in this period may result in less herbicides consumption rate, preventing from decrease of lentil yield in addition to saving time and control costs.

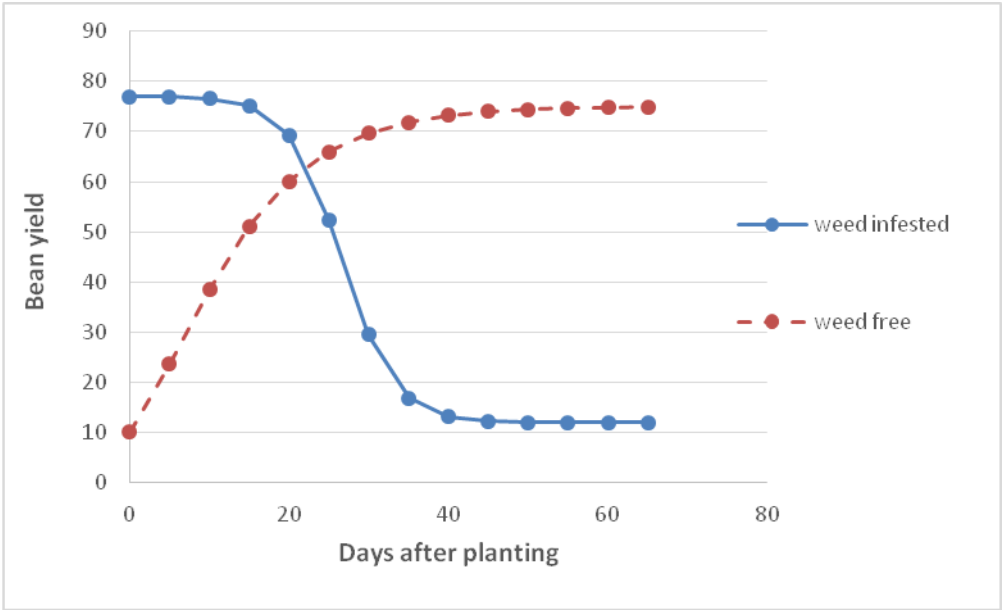

Fig. 20: Diagram of logistic equation

Table 2: Estimated values of coefficients for logistic function considering after-planting days

Coefficient	a	b	c	d	R2
Estimated value	8 (1.84)	0.3 (0.089)	12 (2.87)	65 (22.1)	0.98

Standard errors are written in parenthesis.

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Table 3: Estimated values of coefficients for Gompertz function considering after-planting days

Coefficient	a	b	k	R^2
Estimated value	75 (6.39)	2 (0.072)	0.11 (0.046)	0.94

Standard errors are written in parenthesis.

Table 4: Comparing mean effect of weed treatment (weed-infested control group until end of the growth period, weed-free 7, 14, 21, 28 & 35 days) on measured traits

Treatments	No. of full pod	Total No. of pod	No. of beans in pod	No. of lateral branches	Beans yield (g/m^2)	Dry weight of weed (g/m^2)	Weight of 100 beans (g)
Weed-infested control	47.52	57.30	54.03	12.40	37.76	61.59	6.738
Weed-free until 7 days	56.53	63.47	62.33	14.00	39.47	34.49	6.430
Weed-free until 14 days	58.33	64.40	61.42	13.68	41.13	39.38	6.475
Weed-free until 21 days	59.03	67.60	66.50	14.32	41.78	34.23	6.080
Weed-free until 28 days	66.75	75.32	68.60	14.13	42.26	33.35	6.815
Weed-free until 35 days	80.75	86.22	91.8	17.95	53.10	31.63	7.450
LSD 5%	9.39	10.38	8.24	2.33	8.33	14.16	0.7

Table 5: Comparing mean effect of weed treatment (weed-free control group until end of the growth period, weed-free from 7, 14, 21, 28 & 35^{th} day afterward) on measured traits

Treatments	No. of full pod	Total No. of pod	No. of lateral branches	Beans yield (g/m^2)	Weight of 100 beans (g)
Weed-free control	108.3	12.08	20.88	75.36	8.225
Weed-free until 7 days	90.90	100.4	18.70	66.13	7.222
Weed-free until 14 days	102.9	111.4	19.48	64.69	6.813
Weed-free until 21 days	87.22	97.07	17.27	57.79	7.025
Weed-free until 28 days	89.20	97.78	17.63	59.90	6.983
Weed-free until 35 days	91.20	103.7	18.02	66.73	6.253
LSD 5%	14.82	15.29	2.044	8.46	0.99

Conclusion:

According to results of data variance analysis, traits such as number of full pods, total number of pods, number of beans per pod, number of lateral branches, wet and dry weight of weed, wet weight of beans and bushes, bean yield, and weight of one hundred beans were affected by weeds treatment at weed-infested and 7, 14, 21, 28, and 35 weed-free days condition. It refers to different varieties of these traits which can be used in deciding about weed potential varieties.

- According to results of data variance analysis, traits such as number of full pods, number of empty pods, total number of pods, number of lateral branches, wet weight of beans and bushes, biological yield, bean yield, and weight of one hundred beans were affected by weeds treatment at weed-free and from 7^{th}, 14^{th}, 21^{st}, 28^{th}, and 35^{th} weed-free days afterward condition. It refers to different varieties of these traits.

- According to results, conditions including weed-infested, 7, 14, 21, 28, and 35 weed-free days, and until 35 weed-free days highly affected the traits and increased their quantity and yield. Thus, the weed-free period provides suitable opportunity and brings appropriate and economical yield for lentil. In this group, control treatment (weed-infested during growth period) demonstrated the minimum yield and yield component. Maximum and minimum wet and dry weight of weed was observed in the control treatment and until 35 weed-free days of treatment, respectively.

Results suggested that control treatment (weed-free during growth period) demonstrated maximum yield and yield components in weed-free and from 7^{th}, 14^{th}, 21^{st}, 28^{th}, and 35^{th} weed-free days afterward conditions. It refers to negative effect of weeds in other treatments. In this group, the closer the weed control to generative growth time, the less the final yield of the plant.

1. According to the results and considering 10% yield decrease, 18 to 28 days after planting were determined as critical period of weed control.
2. Constant interference of weeds and lentil during growth season leads to less bean yield.

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