Research Journal of Environmental Sciences

ISSN 1819-3412

Academic Journals Inc.

www.academicjournals.com

Research Journal of Environmental Sciences 3 (4): 456-460, 2009
ISSN 1819-3412

Evaluation of Yield and Yield Components of Lentil Genotypes under Drought Stress

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Abstract: To evaluate the yield and yield components of lentil genotypes under drought stress conditions, an experiment was conducted in Ardabil Agricultural Research Station during 2005 in a split-plot experimental design based on Completely Randomized Block Design (CRBD) with four replications. The treatments included four irrigation levels [(I_1) irrigation on the basis of 60 mm evaporation, (I_2) irrigation on the basis of 80 mm evaporation, (I_3) irrigation after 100 mm evaporation from basin class A, and (I_4) no irrigation] as the major factor and three lentil genotypes (Ardabil local variety, ILL4400 and ILL6212) as the minor factor. The results showed that irrigation water deficit during lentil flowering led to the decrease in pod number, grain number per plant, grain weight, grain yield and harvest index, so that I_2 level of genotype ILL4400 had the highest yield followed by ILL 6212 and Ardabil local variety and I_4 had the lowest yield. I_3 level of ILL6212 had the highest harvest index and genotypes ILL4400 and ILL6212 had the highest grain number per plant.

Key words: Pod number, harvest index, lentil, grain weight, genotype

INTRODUCTION

Lentil is well-adapted to low-rain regions with an annual precipitation of less than 400 mL which are mainly implanted by wheat (Koochaki and Sarmadnia, 2001). When the plants start their reproductive growth and proceed towards maturity, complementary irrigation increases their yields (Sarker *et al*., 2003). As an indeterminate plant, lentil can have longer vegetative and reproductive growth provided that having access to required moisture. Drought stress during its flowering stage shortens this stage (Kusmenglu and Muehlbauer, 1998). The yields of cereals vary in different years and water deficit is a factor affecting this variation (Ferguson *et al*., 1998). Water deficit chiefly affects lentil yield components, e.g. It decreases pod number per plant, grain number per pod and 100 grain weight. Hudak and Patterson (1995) showed that one irrigation during grain filling period increased lentil yield. In another study, it was reported that irrigating lentil during grain filling period three times increased the yield (Eskine and Ashkar, 1993). In soybean, drought decreases flower number, pod number, pod size and grain number per pod and grain weight (Desclaus *et al*., 2000). Plants experiencing stress in their vegetative stage have lower grain weight (Katerji *et al*., 200).

The objective of the study was to evaluate the yield and yield components of lentil genotypes under drought stress and to determine the best irrigation level and lentil genotype for Ardabil region.

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MATERIALS AND METHODS

To evaluate the yield and yield components of lentil genotypes under drought stress conditions, an experiment was conducted in Ardabil Agricultural Research Station during 2005 in a split-plot experimental design based on Completely Randomized Block Design (CRBD) with four replications. The treatments included four irrigation levels [(I_1) irrigation on the basis of 60 mm evaporation, (I_2) irrigation on the basis of 80 mm evaporation, (I_3) irrigation after 100 mm evaporation from basin class A, and (I_4) no irrigation] as the major factor and three lentil genotypes (Ardabil local variety, ILL4400 and ILL6212) as the minor factor. Ardabil climate is semi-arid and semi-humid with a very cold winters and moderate springs and summers. Its altitude is 1350 m and its mean annual precipitation is about 400 mm which provides a desirable condition for cultivating lentil. Evaporation measurement was begun after planting on 16th April. Then the plots were irrigated according to evaporation. The amount of water used in irrigation was 80% of evaporated water from each basin. To measure grain yield and yield components, plots were separately harvested considering the effect of margins. Afterwards they were threshed and winnowed and grain yield of each plot was measured. Data was analyzed using software SAS and means were compared by Duncan Test on the probability level of 5%. In addition, software Excel was used for drawing the diagrams.

RESULTS AND DISCUSSION

Pod Number

The results of variance analysis showed that the cultivars had significant differences in pod number, so that genotypes ILL4400 and ILL6212 (with 2660 and 2572 pods per unit area, respectively) stood in the superior class A and local genotype of Ardabil (with 2196 pods/unit area) stood in the next class. Treatment I_1, I_3 and I_4 (with 2123, 2237 and 1929 pods, respectively) stood in same class and I_2 (with 3545 pods per unit area) stood in the superior class. The interaction between genotype and irrigation was significant on the probability level of 1% and means comparison of the interaction between irrigation levels and genotype showed that I_2 irrigation treatment in genotype ILL6212 had the highest pod number (4530) and I_3 irrigation treatment in genotype ILL6212 had the lowest one (Table 2). This results matches the results of previous experiments (Koochaki and Mohassel, 2001; Desclaus *et al*., 2000).

Grain Number

According to variance analysis, there was a significant difference in grain number between genotypes and moisture regime on the probability levels of 5% and 1%, respectively. Genotypes ILL6212 and ILL4400 stood in superior class a (19.08 and 20.31 grains per plant, respectively) and Ardabil local variety stood in the next class. I_2 irrigation level (26.72 grains per plant) stood in superior class and I_3, I_1 and I_4 (16.61, 15.08 and 13.9 grains per plant, respectively) stood in next classes. I_2 level of genotype ILL6212 and I_4 level of genotype ILL6212 had the highest (37.06) and lowest (9.3) grains per plant, respectively (Table 1). With the increase in grain number per plant and the number of filled pods, the yield increased. Desclaus *et al*. (2000) reported that with the increase in drought stress intensity, grain number per plant decreased. Intensification of water deficit led to the decrease in grain number per plant mainly due to the increase in pods without kernel and the shattering of flowers and decrease in grain number per pod.

Grain Weight per Plant

The results of variance analysis showed that there was a significant difference in grain weight per plant ($\alpha = 0.05$) between cultivars. The effect of irrigation treatment was also significant on the

Table 1: Effect of irrigation and genotype on means of traits associated with the yield of lentil

	Pod No. per unit area	Grain No. per plant	Grain weight per plant (g)	100-grain weight (g)	Harvest index (%)	Yield (kg ha^{-1})
Irrigation levels						
I_1	2123b	15.08c	0.86b	5.3a	22.53c	869c
I_2	3545a	26.72a	1.20a	5.9a	27.76b	1340a
I_3	2237b	16.61b	1.12a	5.6a	30.61a	1100b
I_4	1929b	13.90d	0.82b	5.0a	26.63b	893c
Genotypes						
V_1	2196b	14.85b	0.83c	5.66ab	24.92c	836b
V_2	2572a	20.31a	0.98b	4.8b	28.81a	1098ab
V3	2660a	19.08a	1.40a	6.0a	26.55b	1308a

Values with same letter(s) in each column, have no significant differences to each other

Table 2: Means of traits associated with yield in relation with the interaction between genotype and irrigation level in lentil

Genotype	Irrigation level	Pod No. per unit area	Grain No. per plant	Grain weight per plant (g)	100-Grain weight (g)	Harvest index (%)	Yield (kg ha^{-1})
V_1	I_1	1800fg	11.16e	0.863e	5.7abc	19.6f	863e
	I_2	2956b	18.1c	1.07cd	5.9abc	26.4de	1071cd
	I_3	1816de	15.13d	0.668f	6.0abc	27.0d	668f
	I_4	1846fg	15.0d	0.743f	4.8c	26.5de	744f
V_2	I_1	2300cd	17.66c	0.749f	3.9d	28.8bc	749f
	I_2	4530a	37.06a	1.45b	6.3a	29.0bc	1459b
	I_3	15313ef	17.23c	1.12c	5.3b	29.5b	1126c
	I_4	1936g	93.0f	0.65f	3.6d	27.8cd	658f
V_3	I_1	2271cde	16.43cd	0.99d	6.2a	17.7g	996d
	I_2	3140b	25.0b	2.92a	5.7ac	17.8d	2921a
	I_3	2450c	17.46c	0.64f	5.4bc	35.6a	646f
	I_4	2563cd	17.43c	1.06cd	6.7a	25.5a	1063cd

Values with same letter(s) in each column, have no significant differences to each other

probability level of 1%. The interaction between cultivar and irrigation was significant as well, so that the cultivar ILL4400 with 1.4 g grain per plant stood in the superior class A and ILL 6212 and Ardabil local variety (with 0.98 and 0.83 g grain per plant, respectively) stood in classes B and C, respectively. Among different irrigation levels, I_2 (1.2 g grain per plant) and I_3 (1.12 g grain per plant) were ranked in the same class, and I_1 (0.86 g grain per plant) and I_4 (0.82 g grain per plant) jointly stood in the second class. The interaction between cultivar and I_2 irrigation level (Table 2) indicated that in I_1 irrigation level, cultivars ILL4400 and ILL6212 had the highest and lowest grain weight per plant, respectively; in I_2 level, cultivar ILL4400 with 0.99 g grain per plant stood in superior class followed by ILL6212 and Ardabil local variety. In I_4 irrigation level, the highest grain weight per plant was observed in cultivar ILL4400 and there was no considerable difference between cultivar ILL6212 and Ardabil local variety and they stood in the same class. These results match the results of Desclaus *et al*. (2000).

100-Grain Weight

This trait is one of grain yield components but it was not so effective in yield variation. In this research, there was a significant difference in 100-grain weight among cultivars on the probability level of 1%. Irrigation level did not significantly affect 100-grain weight but the interaction between cultivar and irrigation levels was significant. Means comparison showed that different irrigation levels were in the same class (Table 1), i.e., despite exerting stress in different levels, 100-grain weight was not considerably affected. Among the cultivars, ILL4400 stood in class A with a grain yield of 0.06 g and the cultivar ILL6212 and Ardabil local variety stood in classes AB and B, respectively with grain weights of 0.056 and 0.046 g. These results match the results of Eskine and Ashkar (1993). Generally lentil genotypes with low 100-grain weights are considered as microsperm genotypes and they usually have higher yield than macrosperm ones.

Harvest Index

There was a significant difference on the probability level of 1% in harvest index among irrigation levels as well as among genotypes. The interaction between genotype and irrigation was significant, too. The genotype ILL6212 had the highest harvest index (28.81%) and genotype ILL4400 and Ardabil local variety were in the next classes (with harvest indices of 26.55 and 24.92%, respectively). I_3 irrigation treatment with a harvest index of 30.61% stood in class A followed by I_2, I_4 and I_1 (27.76, 26.63 and 22.53%, respectively) (Table 1). The interaction between I_2 level and ILL4400 had the highest harvest index (27.8%) and that between I_1 and ILL4400 had the lowest one (17.7%). ILL6212 harvest index did not considerably vary in different irrigation levels (Table 2). Among the genotypes, ILL6212 had lower biological yield than other cultivars due to its semi-bunch style, so it had the highest harvest index. Ardabil local genotype had higher biological yield and chlorophyll growth duo to wider canopy and bunch style and had lower harvest index. I_3 irrigation level had higher yield because of concurrence with pod set and grain filling period and stood in superior class due to its higher biological yield. It had higher harvest index, too. These results match the results of Khajehpour (2004).

Grain Yield

Irrigation treatment had a significant effect on grain yield and I_2 irrigation level had the highest grain yield (Table 1). In I_2 treatment, the plots were irrigated twice from the beginning of grain-filling to the end of flowering. In I_1 irrigation treatment, due to 5 times irrigation enough water was supplied in the early stages of vegetative growth and hence the number of auxiliary branches and pods increased, but partial irrigation led to the shattering of many pods, smallness of grains and eventually the decrease in yield. I_2 treatment had the highest yield (1340 kg) and I_3 treatment with a yield of 1100 kg stood in the next class. I_1 and I_4 treatments had the lowest yield (869 and 893 kg ha^{-1}, respectively). In I_4 treatment, because of the concurrence of grain-filling period with early hot days of summer, reproductive growth was disrupted and the flowers shattered and caused that just a few grains were filled. Among the genotypes, ILL4400 had the highest yield (1308 kg ha^{-1}) and ILL6212 and Ardabil local varieties (1098 and 836 kg ha^{-1}, respectively) were in the next ranks. The highest yield (2921 kg ha^{-1}) was obtained with the interaction between ILL4400 and I_2. I_3 irrigation level in genotype ILL4400 and I_4 in ILL6212 had the lowest yields (668 and 744 kg ha^{-1}, respectively) and stood in same class (Table 2). Among irrigation levels, I_2 had the highest yield due to the foregoing reasons (more filled pods, more pod number and higher grain weight per plant). The decrease in grain yield due to water deficit has been reported by others in the case of groundnut, beans and corn (Sarmadnia and Koochaki, 1997) and in the case of lentil (Hudak and Patterson, 1995).

CONCLUSION

Generally, it can be said that water deficit during lentil flowering led to the decrease in pod number, grain number per plant, grain yield and harvest index, so that I_2 level of genotype ILL4400 had the highest yield, I_3 level of genotype ILL6212 had the highest harvest index, and genotypes ILL4400 and ILL6212 had the highest grain number per plant. Thus, despite lentil is mainly a plant for dry farming, applying water during grain filling in regions where irrigation is possible can increase its grain yield; under this condition, genotype ILL4400 will had the highest yield. In region where irrigation is not possible, genotype ILL4400 can be used because it has the highest yield in dry farming due to its resistance against drought.

ACKNOWLEDGMENTS

This study was supported by the Central Laboratory of Agricultural Faculty, University of Mohaghegh Ardabili. Valuable experimental support by Aziz Jamaati-e-Somarin and Rogayyeh Zabihi-e-Mahmoodabad is greatly appreciated.

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