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Response of morphological traits of lentil (*Lens culinaris* Medik.) to water deficit and cultivar

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ABSTRACT: In order to investigate the effects of different irrigation and cultivar on morphological traits of lentil (*Lens culinaris* Medik.), an experiment was carried out as split-plot based on randomized complete block design with three replications at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran. Irrigation treatments (I1, I2, I3and I4: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively) were assigned to main plots and three lentil cultivars (Kimia, Gachsaran and Local Kermanshah) were allocated to the sub plots. The results showed that among irrigation treatments, the highest values of plant height, number of branches per plant, leaf number per plant, leaf dry weight, stem dry weight, pod dry weight and grain yield were observed in I1 treatment. Among cultivars, Gachsaran had the highest leaf number per plant, stem dry weight, pod dry weight and grain yield, compared to those of Kimia and Local cultivars. Kimia cultivar had the highest plant height, number of branches per plant and leaf dry weight, in comparison with other those of cultivars. The irrigation × cultivar interaction for plant height and grain yield was also significant. In general, it was become clear that Kimia and Gachsaran were more tolerant to water deficit than that of Local Kermanshah and had suitable morphological traits and grain yield under these conditions.

Keywords: lentil cultivars, morphological traits, water deficit

INTRODUCTION

Water is one of the most important environmental factors regulating plant growth and development. The sensitivity of crops to water stress is acknowledged a major constrain in crop production. Water deficit affects many morphological features and physiological processes associated with plant growth and development (Toker and Cagirgan, 1998). In drought stress conditions, plants close their stomata to avoid further water loss. Decreasing internal CO_2 concentration and inhibition of ATP synthesis lead to a decrease of net photosynthetic rate under drought stress (Dulai *et al.,* 2006). The effect of drought stress on CO_2 assimilation rate, transpiration rate and water use efficiency has been investigated in many crops such as *Zea mays* L. (Ashraf *et al.,* 2007), *Brassica napus* L. (Kauser *et al.,* 2006) and mung bean genotypes (Ahmed *et al.,* 2002). Plant responses to drought stress are very complex and include adaptive changes or deleterious effects (Chaves *et al.,* 2002). The effects of drought stress are observed in the form of phonological responses, morphological adaptations, physiological changes and biochemical adaptations. Plant reactions are affected by the amount of soil water directly or indirectly. All physiological processes like photosynthesis, transpiration, cell turgidity, and cell and tissue growth in plants are directly affected by water availability (Sarker *et al.,* 2005).

For achieving high yield, an adequate water supply is required during the growing season. The period at the beginning of the flowering stage is most sensitive to water shortage, while maximum yield and yield components were obtained with full irrigation, almost the maximum yield generally were obtained when irrigation was made to provide adequate water during flowering and grain formation periods (Blum, 2005).

Lentil (*Lens culinaris* Medick.) is a lens-shaped grain legume well known as a high nutritious food. It grows as an annual bushy leguminous plant typically 20-45 cm tall. Lentil seed is a rich source of protein, minerals (K, P, Fe and Zn) and vitamins (Bhatty, 1988).Under drought stress, a plant's ability to absorb and to transfer materials is disturbed which affects the access to food (Lauer, 2003).

At present, there is no method for increasing atmospheric precipitation during drought periods. Therefore, the best way for counteracting drought is to use suitable cultivation operations and drought-tolerant cultivars (Rahba and Uprety, 1998). Also, the selection of appropriate varieties for drought tolerance has been the main challenge of agricultural scientists throughout these years. A study was therefore carried out to investigate the effects of drought stress on morphological traits of three lentil cultivars.

MATERIALS AND METHODS

A. Site description and experimental design

The field experiment was conducted in 2012 at the Research Farm of the University of Tabriz, Iran (latitude 38°05 N, longitude 46° 17E, altitude 1360 m above sea level). The climate of research area is characterized by mean annual precipitation of 285 mm, mean annual temperature of 10°C, mean annual maximum temperature of 16.6°C and mean annual minimum temperature of 4.2°C. The experiment was arranged as split-plot design with three replications. Irrigation treatments (I1, I2, I3 and I4: irrigation after 70, 100, 130 and 160mm evaporation from class A pan, respectively) were assigned to main plots and three lentil cultivars(Kimia, Gachsaran and Local Kermanshah) were allocated to the sub plots. All plots were irrigated immediately after sowing. Irrigation treatments were applied after seedling establishment. Hand weeding of the experimental area was performed as was required.

B. Measurement of traits

To specify plant height, number of branches per plant, leaf number, leaf dry weight, stem dry weight and pod dry weight, ten plants were selected from the middle of the plots and then, they were measured. Also, to determine of grain yield, an area equal to 1 m^2 was harvested from the middle part of each plot considering marginal effect. Harvested plants were dried in 25°C and under shadow and air flow then grains were separated by threshing.

C. Statistical analysis

Statistical analysis of the data was performed with MSTAT-C software. Duncan multiple range test was applied to compare means of each trait at 5% probability.

RESULTS AND DISCUSSION

Irrigation regime and cultivar and interaction between irrigation and cultivar had significant effect on plant height of lentil (Table 1). Plant height was reduced as irrigation intervals increased. The highest plant height (44.3 cm) was observed under I1 (70 mm evaporation from class A pan) treatment in all cultivars (Fig. 1). Previous results clearly indicated that the reduction of in the amount of irrigation water from optimum level resulted in the reduction of plant height of soybean (Mustapha, 2005) and wheat (Blum *et al*., 1999). Thompson and Chase (1992) reported that plant height was increased by applying irrigation which might be due to the sufficient availability of nutrients having no moisture stress.

Table 1: Analysis of variance of morphological traits of lentil affected by irrigation and cultivar.

S.O.V	df	Plant height	Number of branches	Leaf number	Leaf dry weight	Stem dry weight	Pod dry weight	Grain yield
Block	2	1.028	2.528	233.3 **	0.002	0.001	0.003	11.08 *
Irrigation	3	598.03 **	82.02 **	1477.2 **	0.04 **	0.07 **	0.98 **	2319.5 **
Error	6	1.731	0.75	16.102	0.011	0.001	0.01	2.79
Cultivar	2	80.77 **	42.11 **	1411.69 **	0.01 **	0.02 **	0.45 **	730.08 **
Interaction	6	2.48 *	0.333	7.542	0.001	0.001	0.001	24.79 *
Error	16	0.681	0.944	35.95	0.011	0.001	0.01	7.65

* and ** , Significant at 5% and 1% probability level, respectively.

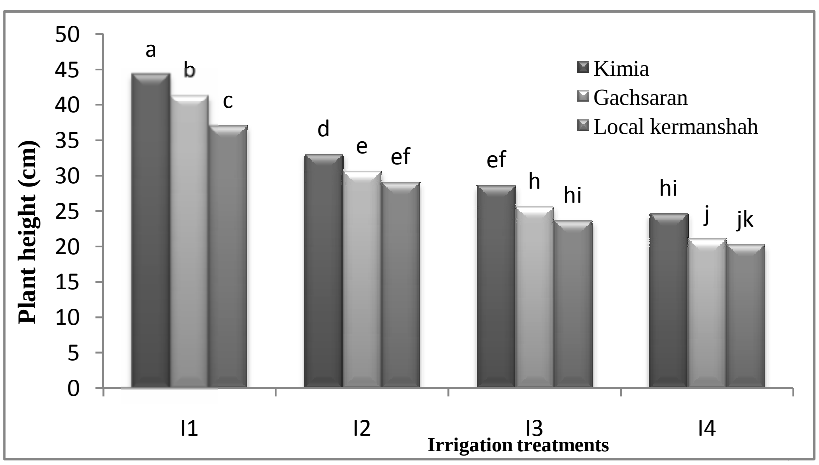

Fig. 1. Effect of different irrigation treatments (I_1, I_2, I_3 and I_4: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively) and cultivars (Kimia, Gachsaran and Local kermanshah) on plant height of lentil (Different letters indicate significant differences at p≤ 0.05).

The highest plant height was related to Kimia cultivar with significant difference with other cultivars and the lowest of plant height was related to Local Kermanshah (Fig. 1). Malik *et al*. (1993) reported similar results in the effect of drought stress on white bean cultivars in a field study evaluation. The number of branches per plant was significantly affected by irrigation and cultivar treatments, but interaction between irrigation and cultivar was not significant (Table 1). The highest number of branches per plant (13.6) was obtained in I1 (70 mm evaporation from class A pan) treatment (Fig. 2). Kimia and Gachsaran cultivars had produced more branches than that of Local Kermanshah with significant difference (Fig. 3). Increasing in irrigation period from I1 to I4 (160 mm evaporation from class A pan), resulted in significant reduction of branches per plant. This result was similar to findings of Fredric *et al.* (2001). The reduction of number of branches per plant under drought stress conditions can be attributed to stomata closure, stomata resistance (Golestani and Assad, 1998) and a decreasing in the absorption of photosynthetic active radiation (Pshibytko, 2003).

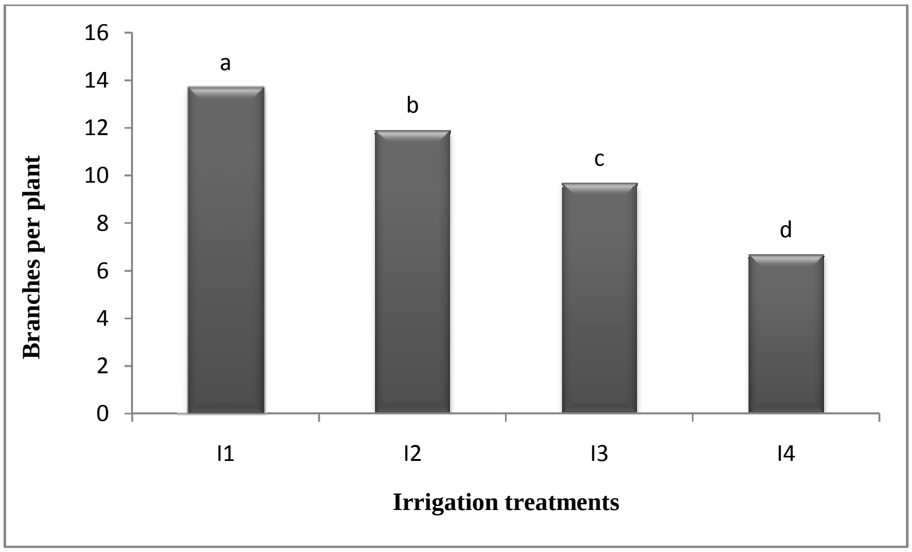

Fig. 2. Effect of different irrigation treatments (I_1, I_2, I_3 and I_4: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively) on number of branches per plant of lentil (Different letters indicate significant differences at $p \leq 0.05$).

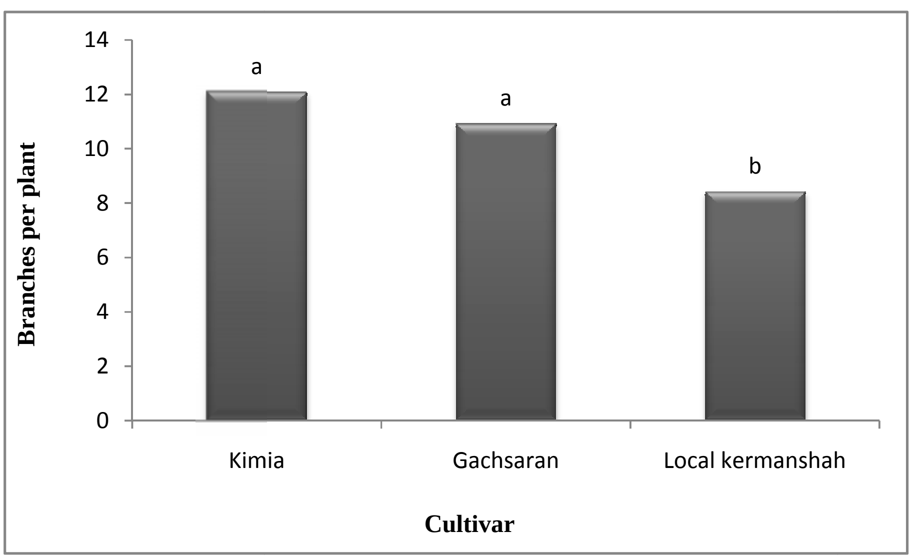

Fig. 3. Effect of different cultivars (Kimia, Gachsaran and Local kermanshah) on number of branches per plant of lentil (Different letters indicate significant differences at $p \leq 0.05$).

Irrigation and cultivar treatments had a significant effect on leaf number of lentil, but interaction of irrigation and cultivar was not significance for this trait (Table 1). The maximum leaf number per plant (99.6) was obtained from I1; Irrigation at 70 mm evaporation from class A pan, and the minimum leaf number (69.7) obtained from irrigation at 160 mm (I4) evaporation from class A pan, respectively (Fig. 4). Water deficit negatively affected leaf number of all cultivars and was significantly decreased as water deficit increased. In general, leaf number in all cultivars was considerably reduced, as the intensity of water limitation increased. Gachsaran had the highest leaf number under all irrigation treatments, compared to Kimia and Local Kermanshah (Fig. 5). The obtained findings in our research were similar to most of the previous research into determining the effects of different irrigation treatments on leaf number in various species such as rice (Boonjung and Fukai, 1996.) and alfalfa cultivars (Leport *et al,* 1998). On the basis of our results, irrigation treatments and cultivar had significant effect on leaf dry weight (Table 1). This effect was similar to other traits, as the maximum leaf dry weight (0.42 gr) was obtained from I1; Irrigation at 70 mm evaporation from class A pan, and the minimum leaf dry weight was (0.27 gr) served in irrigation at 160 mm (I4) evaporation from class A pan (Fig. 6). Among cultivars, Gachsaran and Kimia produced the higher (0.37 and 0.35gr respectively) leaf dry weight than that of Local Kermanshah (0.33 gr) (Fig. 7). Cultivar differences in the leaf dry weight are mainly correlated with differences in plant growth rates (Egli *et al*, 1981). Singh *et al.* (1987) reported that drought stress had significant effect on plant dry weight.

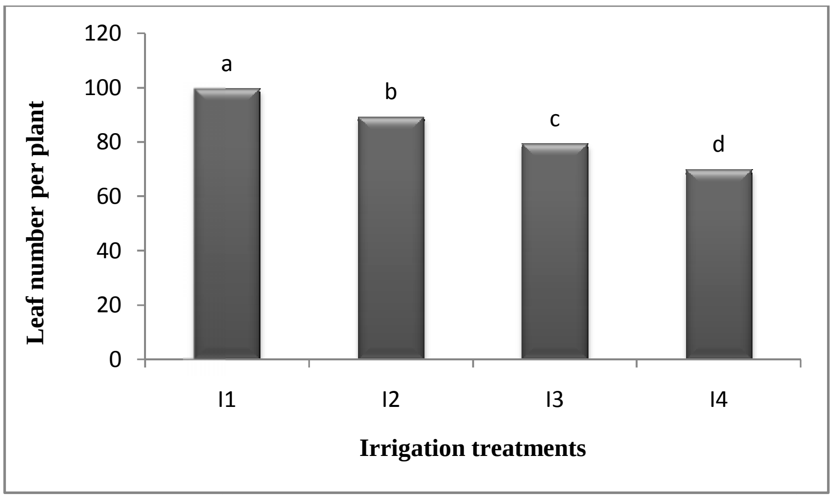

Fig. 4. Effect of different irrigation treatments (I_1, I_2, I_3 and I_4: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively) on leaf number per plant of lentil (Different letters indicate significant differences at p≤ 0.05).

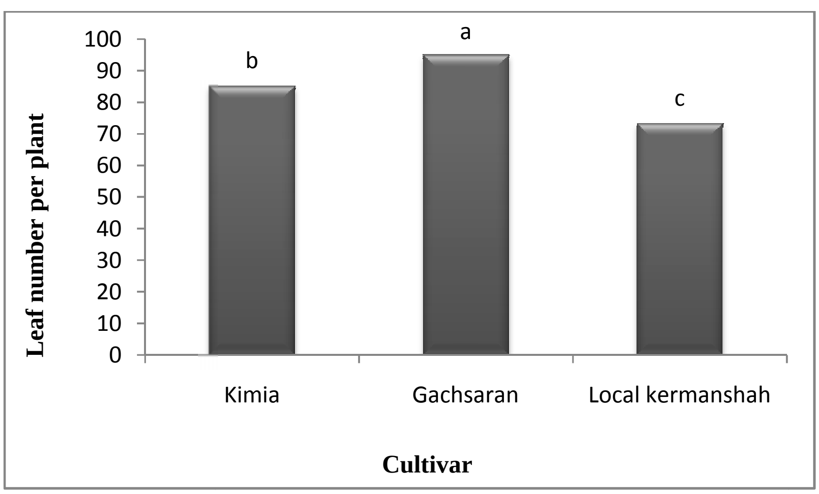

Fig. 5. Effect of different cultivars (Kimia, Gachsaran and Local kermanshah) on leaf number per plant of lentil (Different letters indicate significant differences at p≤ 0.05).

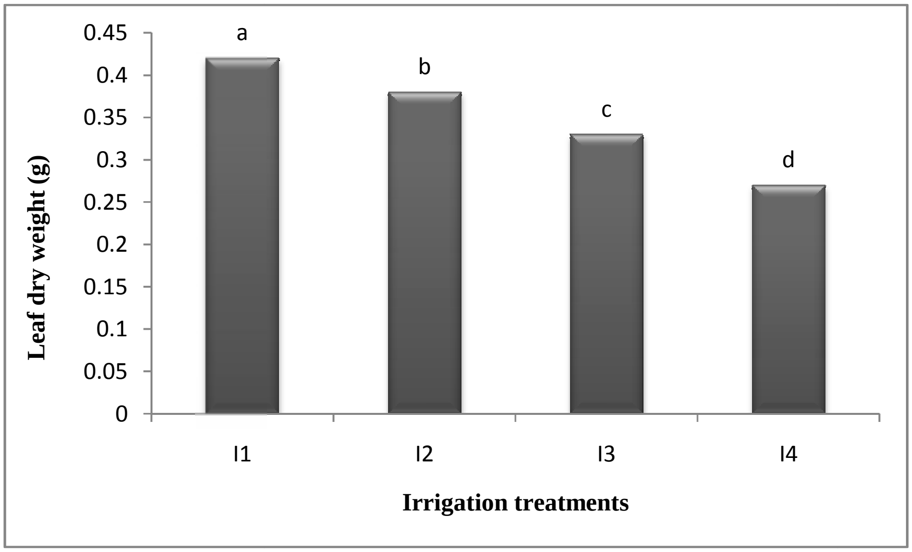

Fig. 6. Effect of different irrigation treatments (I_1, I_2, I_3 and I_4: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively) on leaf dry weight of lentil (Different letters indicate significant differences at $p \leq 0.05$).

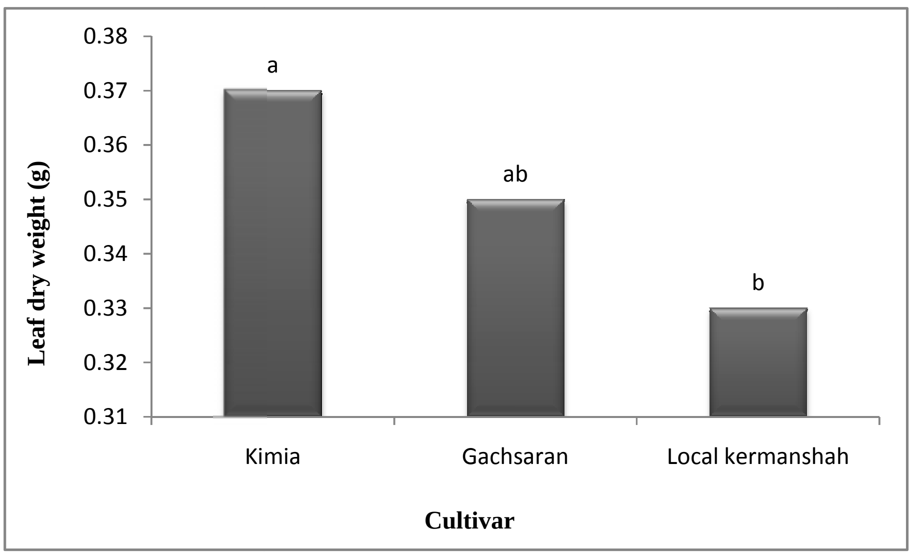

Fig. 7. Effect of different cultivars (Kimia, Gachsaran and Local kermanshah) on leaf dry weight of lentil (Different letters indicate significant differences at $p \leq 0.05$).

Analysis of variance indicated that irrigation and cultivar treatments significantly affected stem dry weight, but interaction had no effect on this trait (Table 1). Stem dry weight was reduced as water limitation increased. Maximum and minimum stem dry weight were achieved in I1 (0.52 mg) and I4 (0.3 mg) respectively (Fig. 8). The highest stem dry weight was related to Gachsaran cultivar with no significant difference with Kimia cultivar and the lowest stem dry weight was observed in Local Kermanshah (Fig. 9).

Water deficit considerably reduced the leaf dry weight of lentil cultivars, due to large reductions in stem dry weight. Our finding in stem dry weight reduction with water stress increasing is confirmed with results of Xia (1997). According to our results, irrigation and cultivar treatments significantly affected pod dry weight but, interaction had no effect on this trait (Table 1). Pod dry weight was reduced as irrigation intervals increased. The highest pod dry weight (1.57 gr) was achieved under without drought stress treatment (Fig. 10).

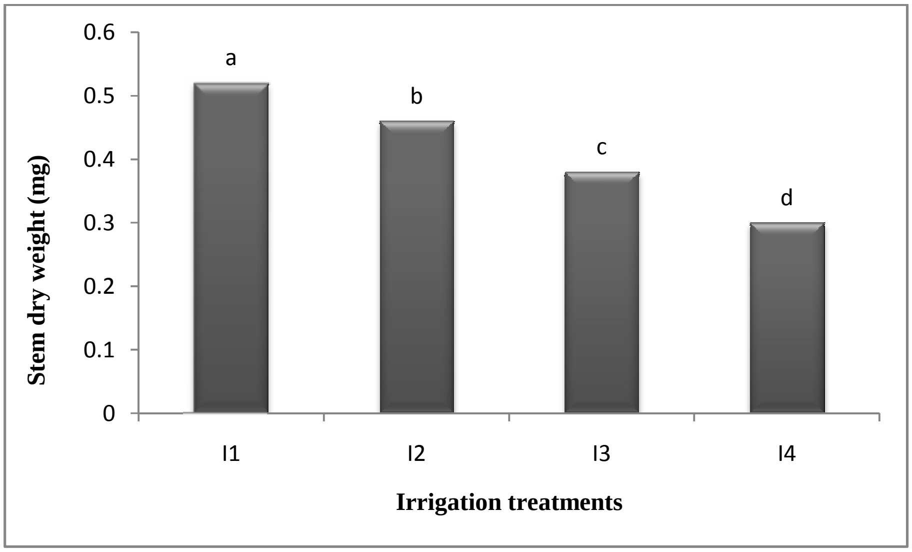

Fig. 8. Effect of different irrigation treatments (I_1, I_2, I_3 and I_4: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively) on stem dry weight of lentil (Different letters indicate significant differences at $p\leq 0.05$).

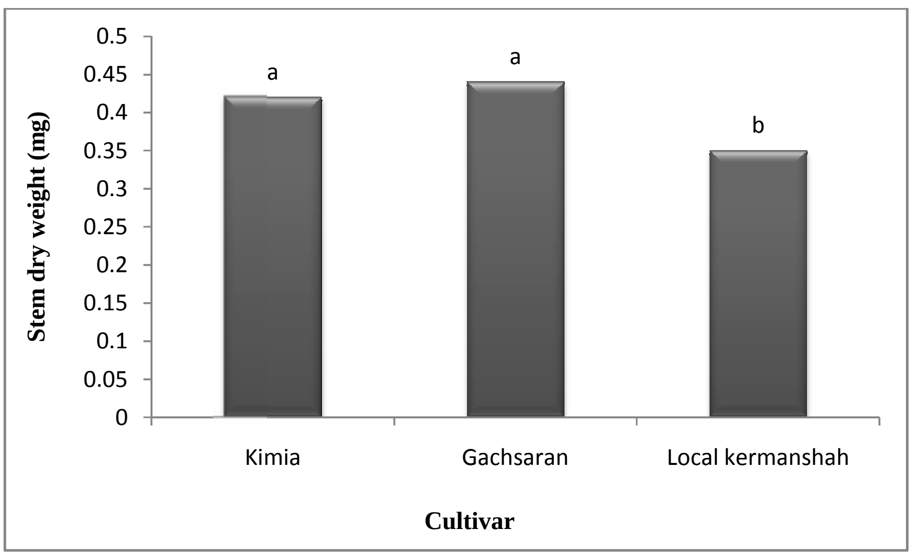

Fig. 9. Effect of different cultivars (Kimia, Gachsaran and Local kermanshah) on stem dry weight of lentil (Different letters indicate significant differences at $p\leq 0.05$).

Gachsaran cultivar had produced maximum pods per plant (1.25 gr), but had no significant difference with Kimia cultivar (Fig. 11). Colom and Vazzana (2002) reported that the difference in the pod dry weight of the studied cultivars can be related to the genetic and environmental factors and their interactions. Mistra and Srivastava (2000) studied the effect of different soil moisture regimes on mint yield and showed that drought stress significantly decreased grain and biological yield, growth and finally total dry matter in mint (*Mentha spicata* L.). Results indicated that, grain yield of lentil was significantly affected by irrigation treatments and cultivar and interaction of these treatments (Table 1). Maximum grain (110 g/m^2) was obtained from I1; Irrigation at 70 mm evaporation from class A pan, and the minimum grain yield (70 g/m^2) obtained from irrigation at 160 mm (I4) evaporation from class A pan, respectively (Fig. 12).

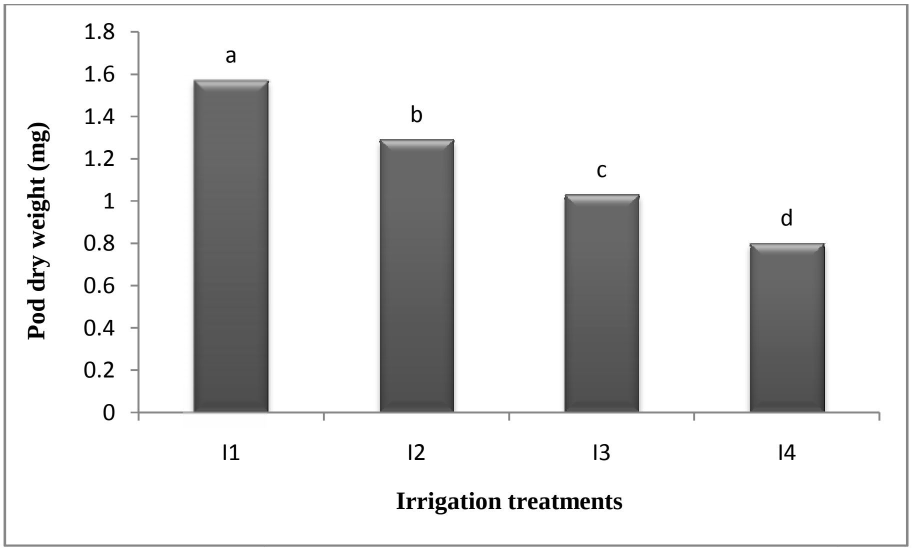

Fig.10. Effect of different irrigation treatments (I_1, I_2, I_3 and I_4: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively) on pod dry weight of lentil (Different letters indicate significant differences at $p \leq 0.05$).

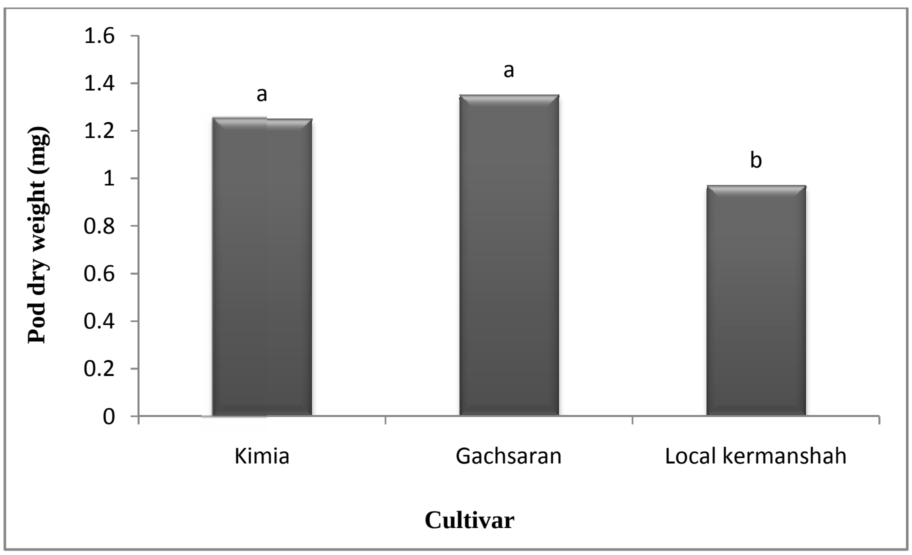

Fig. 11. Effect of different cultivars (Kimia, Gachsaran and Local kermanshah) on pod dry weight of lentil (Different letters indicate significant differences at $p \leq 0.05$).

Water deficit negatively affected grain yield of all cultivars. In general, dry matter production in all cultivars was considerably reduced, as the intensity of water limitation increased. Gachsaran had the highest grain yield under all irrigation treatments, compared to Kimia and Local Kermanshah (Fig. 12). The obtained findings in our research were similar to most of the previous research into determining the effects of different irrigation methods on grain yield in various species such as corn cultivars (Evett *et al.,* 2000; Hammad *et al.,* 2012). Tilsner *et al.* (2005) reported that the difference in the mean of grain yield of the studied cultivars can be related to the genetic and environmental factors and their interactions. Deepak and Wattal (1995) studied the effect of different soil moisture regimes on maize yield and showed that drought stress significantly decreased grain yield, biological yield, grain number per ear, growth and finally total dry matter in corn.

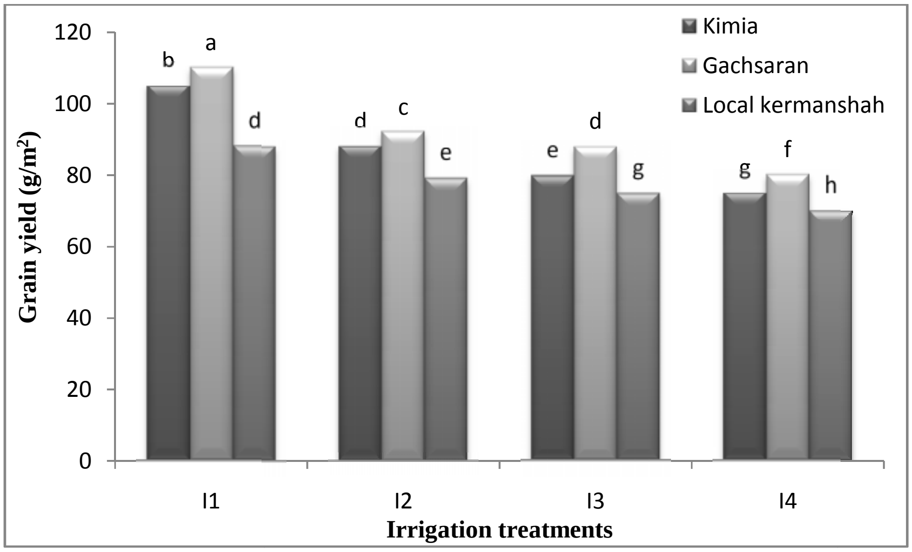

Fig. 12. Effect of different irrigation and treatments (I_1, I_2, I_3 and I_4: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively) and cultivars (Kimia, Gachsaran and Local kermanshah) on grain yield of lentil (Different letters indicate significant differences at $p \leq 0.05$).

CONCLUSION

In the present study, irrigation treatments had a significant impact on morphological traits and grain yield of lentil. The highest plant height, branches per plant, leaf number, leaf dry weight, stem dry weight, pod dry weight and grain yield were obtained from I1(irrigation after 70 mm evaporation from class A pan) irrigation treatment. Comparisons among the genotypes revealed that Kimia and Gachsaran were more drought-tolerant than that of Local Kermanshah in the studied traits. Thus, irrigation after 70 mm evaporation is recommended as the best irrigation interval for the semi-arid regions such as Azarbayjan. On the other hand, it seems that Kimia and Gachsaran were more tolerant to water deficit and had acceptable morphological traits and grain yield under these conditions.

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