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Response of some morphophysiological traits of common bean (*Phaseolus vulgaris* L.) cultivars to water deficit

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ABSTRACT: In order to investigate the effects of different irrigation treatments on morphological and physiological traits of different common bean (*Phaseolus vulgaris* L.) cultivars, 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 and I3: irrigation after 60, 90 and 120 mm evaporation from class A pan, respectively) were assigned to main plots and eight common bean cultivars(Sadri, Sayyad, Goli, Akhtar, Pak, Shokofa, Derakhshan and Khomein) were allocated to the sub plots. The results showed that among irrigation treatments, the highest values of plant height, leaf number per plant, stem diameter, chlorophyll content index and grain yield were observed in I1 treatment. Among cultivars, Pak and Khomein had the highest chlorophyll content index, compared to those of other cultivars. Pak and Goli cultivars had the highest grain yield, in comparison with other those of cultivars. In general, we can conclude that Pak and Goli cultivars were the most tolerant to water deficit among the bean cultivars and had the highest grain yield under these conditions.
Keywords: Common bean cultivars, morphological and physiological traits, water deficit

INTRODUCTION

In dry areas, the major factor limiting agricultural production is water. Drought stress is one of the most important environmental stresses affecting agricultural productivity around the world and may result in considerable yield reductions (Ludlow and Muchow, 1990). Decreasing the growth trend of roots and shoots, leaf area, photosynthesis, transpiration, plant height and dry weight are some of the drought-induced losses reported by Jiang and Huang (2000). 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 phenological 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 fruit formation periods (Blum, 2005).

Common bean (*Phaselus vulgaris* L.) is the most important food legume and is an important source of calories, proteins, dietary fiber and minerals (Singh *et al.,* 1999). 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 and physiological traits of eight bean cultivars.

MATERIALS AND METHODS

A. Site description and experimental design

The field experiment was conducted in 2014 at the Research Farm of the University of Tabriz, Iran (latitude 38°05_N, longitude 46°17_E, 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 andI3: irrigation after 60, 90 and 120mm evaporation from class A pan, respectively) were assigned to main plots and eight common bean cultivars(Sadri, Sayyad, Goli, Akhtar, Pak, Shokofa, Derakhshan and Khomein) were allocated to the sub plots.Seeds of common bean were obtained from Agricultural Center of Tabriz, Iran. Seeds were treated with 2 g/kg Benomyl and then were sown with a density of 50 plant/m2. Each plot was included 8 rows of 5 m long, 50 cm apart. 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, leaf number and stem diameter 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 4 m2 was harvested from the middle part of each plot considering marginal effect. At flowering stage, three plants were randomly selected and chlorophyll content index (CCI) of upper, middle and lower leaves was measured by a chlorophyll meter (CCM-200, Opti-Science, USA).

C. Statistical analysis

Statistical analysis of the data was performed with SPSS (Ver.21) software. Duncan multiple range test was applied to compare means of each trait at 5% probability.

RESULTS AND DISCUSSION

Irrigation regime and cultivar had significant effect on plant height of common bean (Table 1). Plant height was reduced as irrigation intervals increased. The highest plant height (39.27 cm) was observed under I1 (60 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. The highest plant height was related to Sadri and Khomein cultivars with significant difference with other cultivars and the lowest of plant height was related to Akhtar, Pak and Derakhshan cultivars (Fig. 2). Malik *et al.* (1993) reported similar results in the effect of drought stress on white bean cultivars in a field study evaluation.

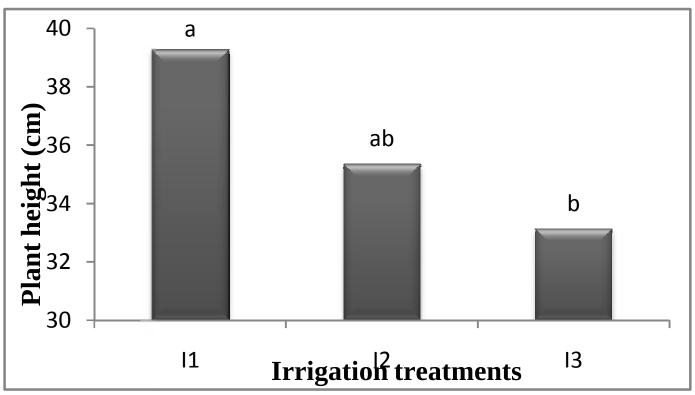

Fig. 1. Effect of different irrigation treatments (I_1, I_2 and I_3: irrigation after 60, 90 and 120 mm evaporation from class A pan, respectively) on plant height of common bean (Different letters indicate significant differences at $p \leq 0.05$).

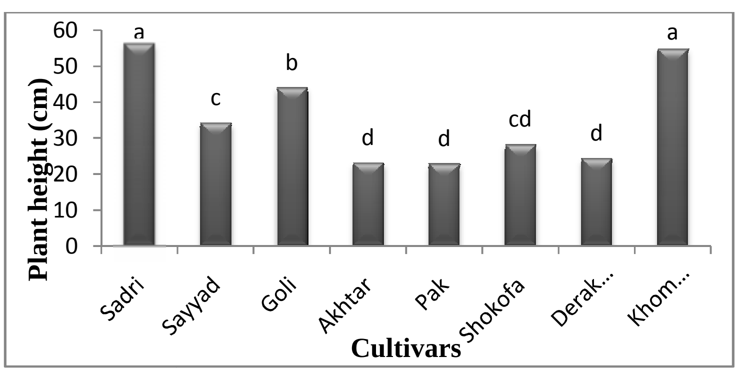

Fig. 2. Effect of different cultivars on plant height of common bean (Different letters indicate significant differences at $p \leq 0.05$).

Irrigation and cultivar treatments had a significant effect on leaf number of common bean, but interaction of irrigation and cultivar was not significance for this trait (Table 1). The maximum leaf number per plant (18.54) was obtained from I1; Irrigation at 60 mm evaporation from class A pan, but difference between I1 and I2 treatments was not significant, and the minimum leaf number (14.75) obtained from irrigation at 120 mm (I3) evaporation from class A pan, respectively (Fig. 3). 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. Goli had the highest leaf number under all irrigation treatments, compared to other cultivars (Fig. 4). 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).

Table 1: Analysis of variance of common bean traits affected by irrigation and cultivar.

S.O.V	df	Plant height	Leaf number	Stem diameter	Chlorophyll content index	Grain yield
Block	2	333.85 **	23.89 *	0.262	51.44 *	4626.05
Irrigation (I)	2	231.46 *	94.95 **	1.457 **	272.72 **	57096.14 **
Error	4	19.64	0.44	0.163	18.51	3735.48
Cultivar (C)	7	1740.809 **	458.16 **	3.69 **	58.19 **	19015.3 **
I × C	14	10.51	2.51	0.086	2.03	489.04
Error	42	55.08	8.95	0.126	11.49	2250.32

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

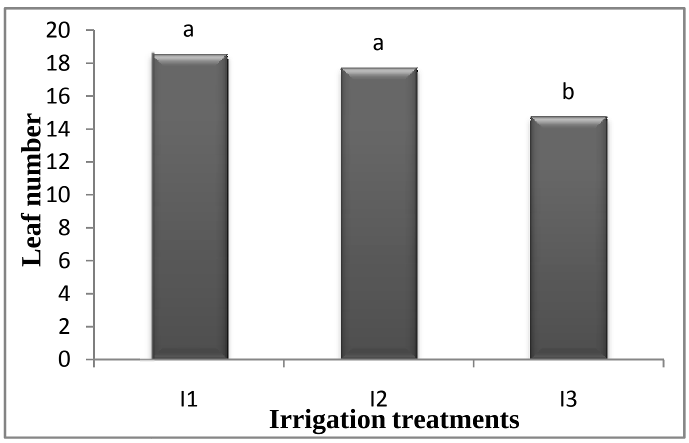

Fig. 3. Effect of different irrigation treatments (I_1, I_2 and I_3: irrigation after 60, 90 and 120 mm evaporation from class A pan, respectively) on leaf number of common bean (Different letters indicate significant differences at $p \leq 0.05$).

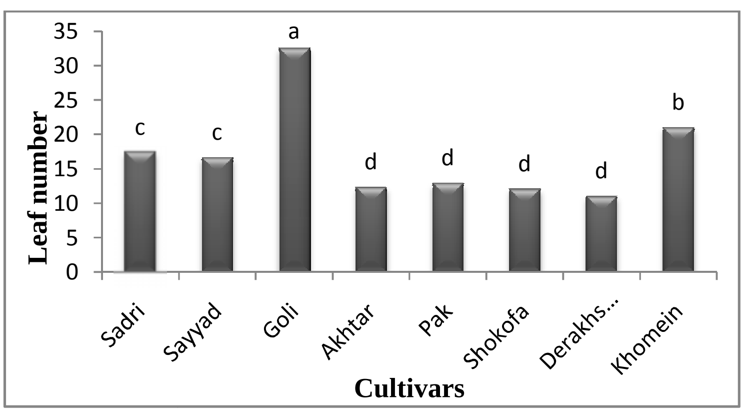

Fig. 4. Effect of different cultivars on leaf number of common bean (Different letters indicate significant differences at $p \leq 0.05$).

Stem diameter was significantly affected by irrigation and cultivar treatments, but interaction between irrigation and cultivar was not significant (Table 1). The highest stem diameter (3.28 mm) was obtained in I1 (60 mm evaporation from class A pan) treatment (Fig. 5) and difference between I1 and I2 treatments was not significant. Derakhshan and Akhtar cultivars had produced morestem diameter than that of other cultivars with significant difference (Fig. 6). Increasing in irrigation period from I1 to I3 (120 mm evaporation from class A pan), resulted in significant reduction of stem diameter. This result was similar to findings of Fredric *et al.* (2001). The reduction of stem diameter 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). Results from this study are similar to those found by Kinark *et al.* (2001) where plant height and stem diameter of water stressed plants were smaller than the equivalent component in the well-watered plants.

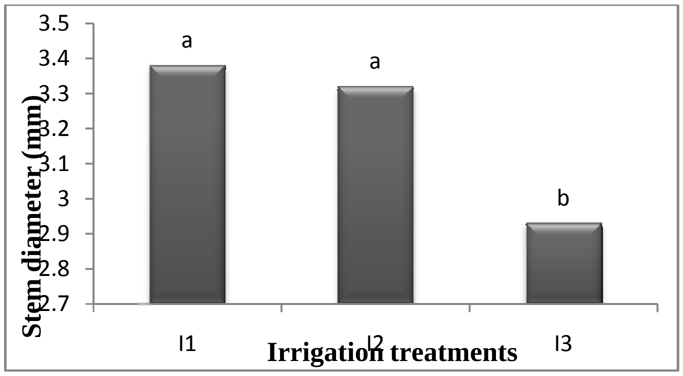

Fig. 5. Effect of different irrigation treatments (I_1, I_2 and I_3: irrigation after 60, 90 and 120 mm evaporation from class A pan, respectively) on stem diameter of common bean (Different letters indicate significant differences at $p\leq 0.05$).

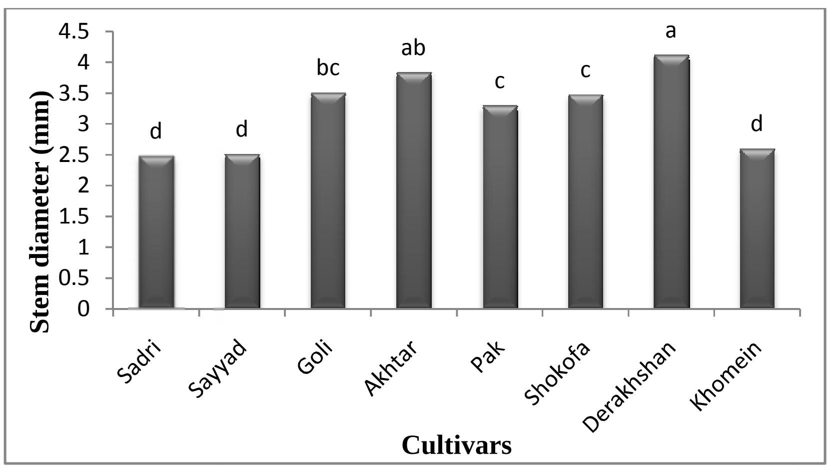

Fig. 6. Effect of different cultivars on stem diameter of common bean (Different letters indicate significant differences at $p\leq 0.05$).

On the basis of our results, irrigation treatments and cultivar had significant effect on leaf chlorophyll content index (CCI) (Table 1). This effect was similar to other traits, as the maximum chlorophyll content index (22.45) was obtained from I1; Irrigation at 60 mm evaporation from class A pan, and the minimum chlorophyll content index was (15.76) served in irrigation at 120 mm (I3) evaporation from class A pan (Fig. 7). The highest (23.66) leaf chlorophyll content index was recorded for Pak cultivar (Fig. 8). Hassanzadeh *et al.* (2009) found a positive relation between chlorophyll content index and grain yield of chickpea, especially under drought stress, and reported that the greater chlorophyll content index resulting in increasing grain yield, which supports the results of our research on common bean. Chlorophyll content of common bean leaves diminished with increasing of drought stress (Fig. 7). Reduction in chlorophyll content under water stress could be related to increasing damage to chloroplasts by active oxygen species, pigment photo-oxidation and chlorophyll degradation (Terzi *et al.*, 2010) and (Makbule *et al.*, 2011).

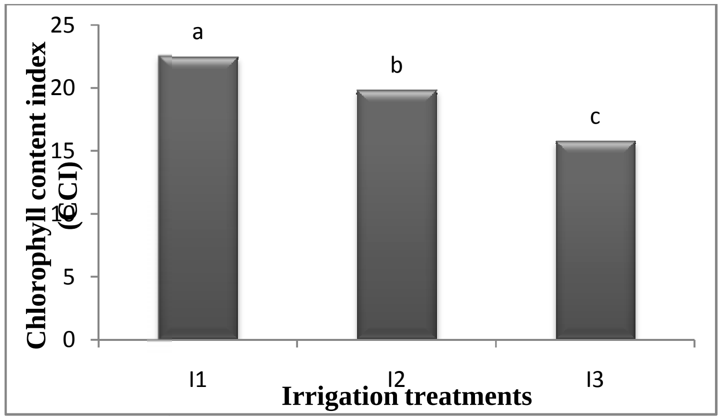

Fig. 7. Effect of different irrigation treatments (I_1, I_2 and I_3: irrigation after 60, 90 and 120 mm evaporation from class A pan, respectively) on chlorophyll content index of common bean (Different letters indicate significant differences at *p*≤ 0.05).

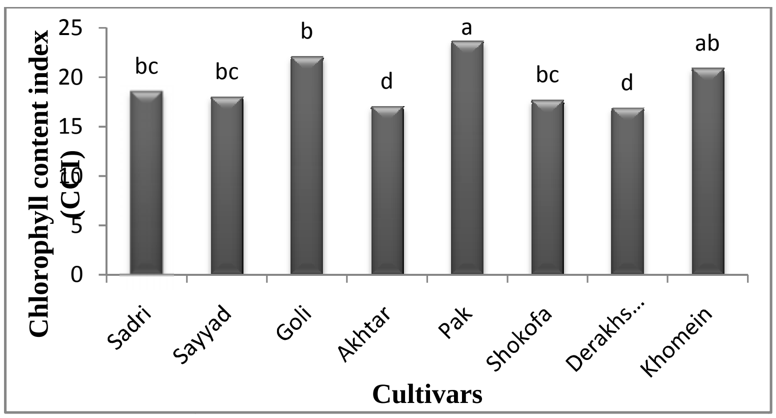

Fig. 8. Effect of different cultivars on chlorophyll content index of bean (Different letters indicate significant differences at *p*≤ 0.05).

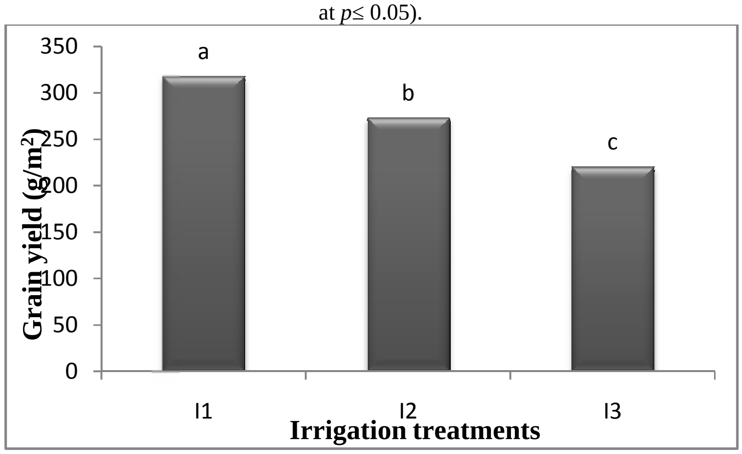

Fig. 9. Effect of different irrigation treatments (I_1, I_2 and I_3: irrigation after 60, 90 and 120 mm evaporation from class A pan, respectively) on grain yield of common bean (Different letters indicate significant differences at *p*≤ 0.05).

Results indicated that, grain yield of common bean cultivars was significantly affected by irrigation treatment (Table 1). Maximum grain yield (317.35 g/m^2) was obtained from I1; Irrigation at 60 mm evaporation from class A pan, and the minimum grain yield (219.92 g/m^2) obtained from irrigation at 120 mm (I3) evaporation from class A pan, respectively (Fig. 9).

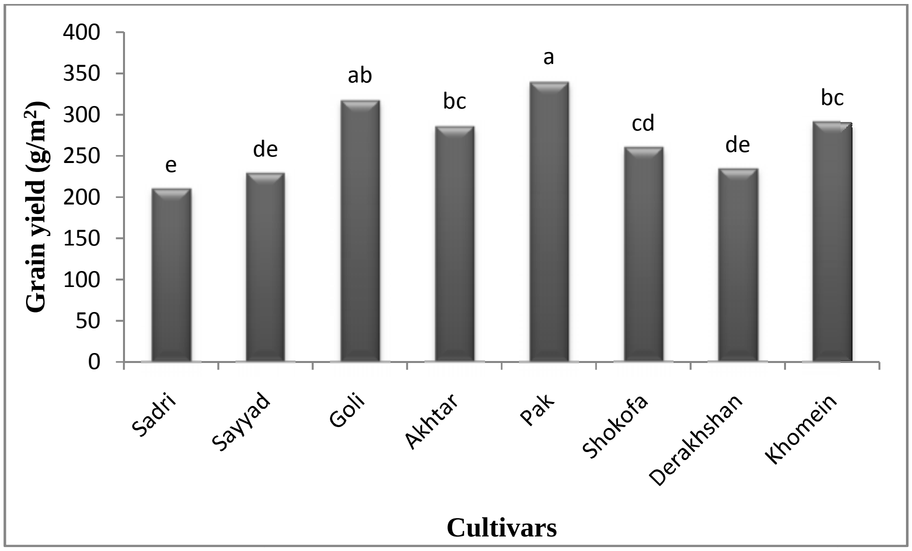

Fig. 10. Effect of different cultivars on grain yield of common bean (Different letters indicate significant differences at $p \leq 0.05$).

Water deficit negatively affected grain yield of all cultivars. In general, grain yield in all cultivars was considerably reduced, as the intensity of water limitation increased. Pak had the highest grain yield under all irrigation treatments, compared to other cultivars and difference between Pak and Goli cultivars was not significant (Fig. 10). 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.

CONCLUSION

In the present study, irrigation treatments had a significant impact on morphological and physiological traits and grain yield of common bean cultivars. The highest plant height, leaf number, stem diameter, chlorophyll content index and grain yield were obtained from I1(irrigation after 60 mm evaporation from class A pan) irrigation treatment. Comparisons among the genotypes revealed that Pak and Goli were more drought-tolerant than that of other cultivars in the studied traits. Thus, irrigation after 60 mm evaporation is recommended as the best irrigation interval for the semi-arid regions such as Azarbayjan. On the other hand, it seems that Pak and Goli were more tolerant to water deficit and had acceptable morphological traits and grain yield under these conditions.

REFERENCES

Blum, A., Shipler, L., Golam G.& Meyer, J. (1999). Yield stability and canopy temperature of wheat genotypes under drought stress. *Field Crop Research.* **22**: 289-296.

Blum, A. (2005). Drought resistance, water use efficiency and yield potential, are they compatible, dissonant, or mutually exclusive? *Australian Journal of Agriculture Research*. **56**: 1159-1168.

Boonjung, H. & Fukai, S. (1996). Effect of soil water deficit at different growth stage on rice growth and yield. *Field Crops Research*. **48**: 37-45.

Chaves, M.M., Pereira, J.S., Maroco, J., Rodrigues, M.L., Ricardo, C.P.P., Osorio, M.L., Carvalho, I., Faria T. & Pineiro, C. (2002). How plants cope with water stress in the eld. Photosynthesis and growth. *Annual Botany.* **89**: 907-916.

Deepak, M. & Wattal, N.P. (1995). Influence of water stress on seed yield of Canadian rape at flowering and role of metabolic factors. *Plant Physiology and Biochemistry of New Delhi*. **22**: 115-118.

Evett, S.R., Howell A.T.& Schneider, A.D. (2000). Energy and water balances for surface and subsurface drip irrigated corn. *International Water and Irrigation*. **20**: 18-22.

Fredric, J.R., Camp C.R.& Bauer, P.J. (2001). Drought stress effects on branch and main stem seed yield and yield components of determinate soybean. *Crop Science.* **41**: 759-763.

Golestani, S.A. & Assad, M.T. (1998). Evaluation of four screening techniques for drought resistance and their relationship to yield reduction ratio in wheat. *Euphytica*. **103**: 293-299.

Hammad, H.M., Ahmad, A., Abbas F. &Farhad, W. (2012). Optimizing water and nitrogen use for maize production under semiarid conditions. *Turkish Journal of Agriculture and Forestry*. **36**: 519-532.

Hassanzadeh, M., Ebadi A. & Panahyan, M. (2009). Evaluation of drought stress on relative water content and chlorophyll content of sesame. *Research Journal of Environment and Science*. **5**: 345-350.

Jiang, Y. & Huang, B. (2000). Effects of drought or heat stress alone and in combination on Kentucky bluegrass. *Crop Science.* **40**: 1358-1362.

Kirnak, H., Kaya, C., Tas I. & Higgs D. (2001). The influence of water deficit on vegetative growth, physiology, fruit yield and quality in eggplants. *Bulgarian Journal of Plant Physiology*. **27**: 34-46.

Lauer, J. (2003). What happens within the corn plant when Drought occurs? *Corn Agronomy*. **10**: 153-155.

Leport, L., Turner, N.C., French, R.J., Tennant, D., Thomson B.D. & Siddique, K.H.M. (1998). Water relation, gas exchange, and growth of cool-season grain legumes in a Mediterranean-type environment. *European Journal of Agronomy*. **9**: 295-303.

Ludlow, M.M. & Muchow, R.C. (1990). A critical evaluation of the traits for improving crop yield in water limited environments. *Advances in Agronomy*. **43**: 107-153.

Makbule, S., Saruhan-Guler, N., Durmus N. & Guven, S. (2011). Changes in anatomical and physiological parameters of soybean under drought stress. *Turkish Journal of Botany*. **35**: 369-377.

Malik, V.S., Swanton C.J. & Michaels, TE. (1993). Interaction of white bean (*Phaseolus vulgaris* L.)cultivars, row spacing and seeding density with annual weeds. *Weed Science*. **41**: 62-68.

Mustapha, Y. (2005). Effects of water stress at different growth stages on growth and yield of soybean genotypes. MSc thesis, University of Ilorin, Nigeria.

Pshibytko, N. (2003). Effects of high temperature and water deficit on photosystem II in barley leaves various ages. *Russian Journal of Plant Physiology*. **50**: 44-51.

Sarker, B.C., Hara M. & Uemura, M. (2005). Proline synthesis, physiological responses and biomass, yield of eggplants during and after repetitive soil moisture stress. *Sciences of Horticultural*. **103**: 387-402.

Singh, P.S., Teran, H., Munoz C.G. & Takegami, J.C. (1999). Two cycles of recurrent selection for seed yield in common bean. Crop Science. **39**: 391-397.

Terzi, R., Saglam, A., Kutlu, N., Nar H. &Kadloglu, A. (2010). Impact of soil drought stress on photochemical efficiency of photosystem II and antioxidant enzyme activities of *Phaseolus vulgaris* cultivars. *Turkish Journal of Botany*. **34**: 1-10.

Thompson, J.A. & Chase, D.L. (1992). Effect of limited irrigation on growth and yield of semi dwarf wheat in Southern New South Wales. *Australian Journal of Experimental Agriculture*. **32**: 725-730.

Tilsner, J.N., Kassner, C., Struck C. & Lohaus, G. (2005). Amino acid contents and transport in maize under different selenium conditions. *Plant Journal*. **484**: 445-470.