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The interactive effect of different levels of nitrogen and drought stress on yield and yield components of the mung bean

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Abstract

In order to investigate the interactive effect of different levels of nitrogen and drought stress on yield and yield components of the Mung Bean, field experiment was carried out in the city of Ahwaz field healthy martyr in a split plot randomized complete block design with four replications in crop year of 2011-2012. In this experiment three levels of drought stress (50, 75, 100 mm evaporation from class A evaporation pan) as the main factor and three levels of nitrogen (50, 100, 150 kg/ha) as the sub factor were examined. The results of the research showed that the effect of different levels of drought stress on the grain yield, number of grains per pod, 100-grain weight, and number of pods per plant was significant, so that the highest rate of grain yield, number of grains per pod, 100-grain weight, and number of pods per plant belonged to the treatment with 50 mm evaporation. Furthermore, the results showed that the effect of different level of nitrogen on abovementioned traits was significant except the number of pods per plant and 100-grain weight. The results also showed that drought stress had a negative effect on most agronomic and physiological traits associated with the yield, but nitrogen fertilizer had a positive effect on them.

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Introduction

Legumes grains by having 18-32% protein have an important role in supplying the required protein for human diet (Mazaheri, 2008). One of the main factors reducing the crop yield throughout the world is water constraints and lack of proper distribution of it during the growth season. In other words, for optimal allocation of water to crops production there should be a proper relationship between the amount of consumed water and the produced crop. In general, drought stress at different growth stages decreases the rate of photosynthesis, stomatal conduction, and relative water content (Gharineh *et al.*, 2008). Nitrogen is an element which often restricts the yield of crops. Nitrogen deficiency greatly reduces plant growth and providing sufficient nitrogen is tangible in apparent reactions and growth of plant such as re-growth of leaves or tillering (Moursi, 1984). Considering the fact that 90% of the country's lands are in arid and semiarid areas the lack of nitrogen and drought stress particularly in Khuzestan with high temperature is more pronounced. Therefore, with regard to water constraint, the efficient use of water in producing more and more mung bean is necessary and saving water and applying proper rate of nitrogen. Pannu *et al.*,(2004) reported that the maximum efficiency of water use was achieved in the most severe drought stress treatment, but the biomass, grain yield, and harvest index decreased as the drought stress increased. Santos *et al.,* (2006) reported that the Grain yield in legumes is affected by three main factors of number of pods per plant, number of grains per pod, and 100-grain weight. Yield components of the mung bean are less affected by climatic factors and are more affected by optimal farming factors (Verma *et al.,* 1999). Investigating the effects of drought stress on grain yield as the final result of growth and development may reflect the general response of plants to drought stress (Bayat *et al.,* 2010). Mung bean suffers from water stress as the decrease of grain yield, number of pods, number of grains per pod, and 100-grain weight (Haqqani and Pandey, 2003). Evaluating promising varieties of the mung bean under drought stress conditions, Nishi *et al.,* (2007) stated that there was a significant difference between the cultivars in terms of number of pods per plant, number of grains per pod, 100-grain weight, grain and straw yield. In more serious drought stress, the weight of grain and harvest index got minimized. Generally, it has been reported that drought stress reduces the yield of mung bean by decreasing total dry weight of plant and harvest index (Thomas *et al.,* 2009). Pannu *et al.,* (2004) that as the drought stress increased, the harvest index decreased in the mung bean. Lazcano *et al.,* (2004) By the increase of nitrogen fertilizer under drought stress condition, the site water drainage inhibited plant growth and reduced the number of pods per plant particularly during the reproductive growth stage. Thomas *et al.,* (2009) reported that Lack of adequate moisture and the presence of high levels of nitrogen caused the reduction of growth and production of photosynthetic materials, and the reduction of produced assimilates particularly during the grain filling stage decreased the weight of grains. With regard to biological nitrogen fixation by the mung bean, appropriate levels of nitrogen can increase its yield and high levels of nitrogen can sometimes decrease its yield.

The aim of this study was to evaluate the the interactive effect of different levels of nitrogen and drought stress on yield and yield components of the Mung Bean and develop a best levels of nitrogen and drought stress in the Ahwaz region.

Materials and methods

Field experiment

This research was conducted in crop year of 2011-2012 in the farm of martyr healthy located in the city of Ahwaz latitude 31° 36´ north and longitude 48° 53´ east and 51 m above the sea level.

Experiment Soil : The soil of experiment site has clay-loamy texture with 7.7 pH and electrical conductivity of 4.6.

The experiment was conducted as split plots in the form of randomized complete block design with four replications. In this experiment three levels of drought stress (50, 75, 100 mm evaporation from class A evaporation pan) as the main factor and three levels of nitrogen (50, 100, 150 kg/ha) as the sub factor were examined. The distance between the main plots was considered to be 2.25 m and the distance between the sub plots was 1.5 m.

Land preparation operation:

In order to carry out the experiment the land preparation operation was done including plowing to the depth of 30 cm, making holes to the depth of 15 cm and flatting. After preparation, the farming land was plotted according to the plan. Every plot contained 5 lines each 5 meters long and 10 cm apart from each other. The distance between the main plots was considered to be 2.25 m and the distance between the sub plots was 1.5 m.

Sowing operation:

Sowing operation was done manually. The land was irrigated immediately after sowing. The weeding was done manually after the seeds germinated and the stems got strong. Drought stress was applied in four-leaf stage about 15 days after planting.

Measured Traits and their Measurement Method:

The final samples were taken from the middle lines of plots with eliminating the marginal effect (2 m^2) and the samples after separation and necessary measurements were dried and weighed. The measured traits included 100-grain weight, number of pods per plant, number of grains per pod, biological yield, grain yield, and harvest index. The harvest index (HI) was calculated by the ratio of grain dry weight to biological yield as the following.

Harvest index was calculated by equation:

HI= Harvest index

Ye= Economical yield HI= Ye / Yb

Yb= Biological yield

Statistical analysis

Data variance analysis was done by means of SAS software the means were compared by Duncan's multi range tests at 5% and 1% probability levels.

Results and discussion

100-grain Weight

The results of the experiment showed that drought stress had a significant effect on 100-grain weight at 5% level (Table 1). Among the stress treatments, the one with 50 mm evaporation produced the highest weight of 100-grain by 5.05 g and the treatment with 100 mm evaporation produced the lowest weight of 100-grain by 3.18 g (Table 2). it seems that one of the factors decreasing 100-grain weight is the decrease of growth period due to drought (Brevedan *et al.,* 1992). Especially, if the drought stress occurs during the grain feeling stage the weight of grains will be affected more (Lazkano *et al.,* 2004). The mean of grain weight is determined by the rate of available assimilates transferred to the pods between flowering stage and grain maturity stage. This, in turn, depends on the leaf area duration and the relation between the source and target (Moursi, 1984). The effect of drought stress on 100-grain weight at vegetative and reproductive stages was not significant (Bayat *et al.,* 2010). The effect of drought stress on 100-grain weight was significant at 1% level. Zabet, (2013) in his study, tried to determine the best drought resistant indices in the mung bean and stated that the negative effect of drought stress caused the lowest damage to the weight of 100-grain, the harvest index, and the pod length. He also stated that the highest damage was related to the plant height and biological yield and the lowest yield was related to economic yield and the number of grains per pod which are nearly stable traits in the environment. The results were consistent with the findings of Haqqani and Pandey, (2003).

Drought stress leads to the decrease of endosperm size and stored starchy materials and thus the weight of 100-grain decreases due to the decrease of source which is followed by the decrease of the reservoir, drought stress also reduces the number of grains per pod and the number of pods. Consequently, 100-grain weight might increase (Hura *et al.,* 2010). The number of pods has decreased due to drought stress and also the number of grains per pod has decreased; therefore, as the source has been less damaged particularly in the mild stress the weight of 100-grain has increased compared to the severe stress, but in the severe stress the weight of 100-grain had decreased too because the stress has greater effect on the source and consequently has greater effect on the reservoir. However, the effect of drought stress on the weight of grain is generally less than its effect on the number of pods per plant and the number of grains per pod (Zabet, 2013). At the grain filling stage, due to the active relationship between the source and the reservoir some assimilated are reduced from the stem leaf and are transferred to the grains for further support of grain growth and development. This might explain why the grain weight remains the same of course for a short time when the soybean faces lack of water during the grain filling stage (Brevedan *et al.,* 1992).

Table 1. Analysis of variance of some recorded traits under the effect of Stress and Nitrojen.

Source of variation	dF	100 Grain Weight(gr)	Number of grain per pod	Number of pods per plant	Grian yield(gr/m^2)
Replication	3	2.19	2.87	7.52	2281.86
Stress(S)	2	10.57*	26.81**	516.57**	131293.23**
Ea	6	1.45	0.777	8.44	7178.14
Nitrojen(N)	2	1.39 n.s	14.21*	20.94 n.s	15935.13*
S*N	4	0.158 n.s	6.56 n.s	20.71 n.s	20936.66**
Eb	18	0.755	3.42	15.57	355.52
C.V(%)		21.09	17.65	12.55	30.89

**And* ns respectively significant at the one percent and five percent level, and no significant difference.

Number of Pods per Plant

In this study, the effect of drought stress on the number of pods per plant was significant at 1% level (Table 1). Comparison of the means showed that the treatment with 50 mm evaporation had the highest number of pods per plant by 37.50 pods and the treatment with 100 mm evaporation had the lowest number of pods per plant by 24.47 pods (Table 2). Shortage of water decreased the number of pods per plant in the mung bean because it caused pre-maturity and decreased the length of podding stage (Naresh *et al.,* 2013). Moreover, due to the decrease of number of sub branches as the result of water deficit, the number of pods per plant decreased (Tatti, 1985). In the stress treatment with 50 mm evaporation the water is available for synthesizing and mobilizing assimilates into reproductive parts and also radiation use efficiency for plant is more in irrigation with less drought stress (De Costa *et al.,* 1999). In general, lack of water in the mung bean affects the yield components. The findings are consistent with the results of other researches (Rahman *et al.,* 1999). Bayat *et al.,* (2010) reported that the One of the causes of the reduction of number of pods per plant under water deficit conditions might be the decrease of plant growth period which results in reduction of assimilates production. Pannu *et al.,*(2004) reported that the decrease of assimilates production and consequently the increase of competition within the plant along with the loss of flowers due to water deficit stress led to the decrease of number of pods per plant. Panwar *et al.,* (1995) severe stress in the vegetative growth stage has possibly decreased the source capacity and in the plant has decreased the number of its produced flowers and pods in order to make a balance between source and sink. It was observed that mild and severe water stress treatments at the reproductive stage produced pods respectively 22% and 58% lower than the control treatment. With regard to the fact that at the beginning of reproductive stage there is a serious competition between the forming reservoirs (growing flowers and pods) for the available assimilates, it seems that lack of moisture at the reproductive stage has led to some events such as photosynthesis reduction, increase of abscisic acid and decrease of loading assimilates and ultimately decrease of flowers and pods These results are consistent with the findings of Brevedan *et al.,* (1992).

Number of Grains per Pod

The results showed that drought stress had a significant effect on the number of grains per pod at 1% level (Table 1), so that the highest number of grains per pod belonged to the treatment with 50 mm evaporation by 11.88 and the lowest number belonged to the treatment with 100 mm evaporation by 8.9 (Table 2). Since for production of dry matter there is an urgent need to photosynthetic surface to produce assimilates and as the production of photosynthetic materials for the storage of transferred assimilates occurs in the presence of sufficient moisture, it seems that under drought stress conditions these goals have not been achieved and the number of grains per pod has decreased (Thomas *et al.,* 2009). According to the results, different levels of nitrogen had a significant effect on the number of grains per pod at 5% level (Table 1). Comparison of the means showed that the highest number of grains per pod by 11.70 grains belonged to the treatment with 150 kg nitrogen and the lowest number by 9.64 grains belonged to the treatment with 100 kg nitrogen which was at the same statistical level with the treatment with 50 kg nitrogen by 10.09 grains (Table 2).

Table 2. Mean comparison of some agronomic traits in mung bean.

Treatments	100 Grain Weight(gr)	Number of grain per pod	Number of pods per plant	Grian yield(gr/m2)
Stress				
S1	5.05a	11.88a	37.5a	0.61a
S2	4.28ab	10.65b	32.33b	0.54b
S3	3.18b	8.9c	24.47c	0.53b
Nitrojen				
N1	3.86a	10.09b	30.2a	0.48c
N2	4.54a	9.64b	32.83a	0.49c
N3	4.12a	11.7a	31.27a	0.48c

Means with same letters in each column are not significantly different at 5% probability level.

Grain Yield

Data analysis of the experiment results showed that drought stress had a significant effect on grain yield at 1% level (Table 1). Comparison of the means shows that the treatment with 50 mm evaporation had the highest grain yield by 295.46 g and the treatment with 100 mm evaporation had the lowest grain yield by 89.29 g (Table 2). The decrease of grain yield was due to the decrease of yield components and this treatment had the lowest rate of grain yield reduction. The results were consistent with the other findings (Monti *et al.,* 1992). It seems that the decrease of growth period is one of the main reasons of grain yield reduction in the mung bean (Thomas *et al.,* 2003). Moreover, drought stress, by affecting the plant physiology, reduced stomatal conduction, current photosynthesis, and plant power in using existing inputs and reduced the grain yield. De Costa *et al.,* (1999) did an experiment on the mung bean and concluded that positive response of the grain yield to irrigation was for the maximum increase of dry matter and harvest index. Since the grain yield is a part of the grain yield of total dry matter produced by plant, the decrease of plant dry matter under drought stress condition can justify a part of grain yield reduction. Drought stress decreases the mung bean yield via decreasing the total dry weight of plant and the harvest index (Thomas *et al.,* 2003). Investigating the effects of drought stress on the grain yield as the final result of growth and development can reflect the total reaction of plant to drought stress (Haqqani and Pandey, 2003). The results of the research showed that the effect of nitrogen on the grain yield was significant at 5% level (Table 1), so that the treatment with 150 kg nitrogen had the highest rate of grain yield by 226.38 g and the treatments with 100 and 50 kg nitrogen had the lowest rates of grain yield by 198.09 and 154.07 g, respectively (Table 2). With regard to biological nitrogen fixation by the mung bean, appropriate levels of nitrogen can increase its yield and high levels of nitrogen can sometimes decrease its yield (Balasubramanian *et al.,* 2002).

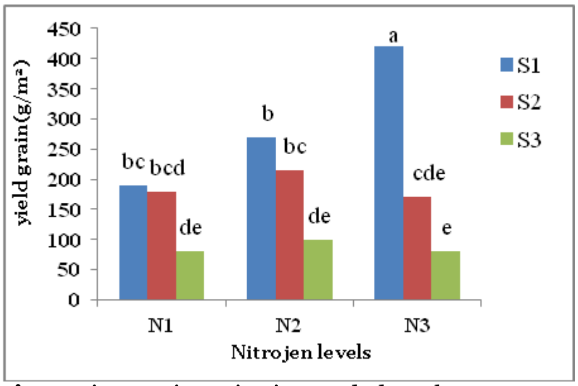

Fig. 1. interaction nitrojen and drought stress on grain yield.

The results of the research showed that the interactive effect of different levels of nitrogen and drought stress on grain yield was significant at 1% level. The highest rate of grain yield belonged to the treatment with 50 mm evaporation and 100 kg nitrogen by 374.88 g and the lowest rate belonged to the treatment with 100 mm evaporation and 150 kg nitrogen (Fig. 1) which indicates the importance of appropriate moisture because the presence of sufficient moisture can lead to the formation of more flowers and consequently the number of pods and finally the grain yield will increase (Zabet, 2013).

Conclusion

The results of the research showed that the effect of different levels of drought stress on the grain yield, number of grains per pod, 100-grain weight, and number of pods per plant was significant, so that the highest rate of grain yield, number of grains per pod, 100-grain weight, and number of pods per plant belonged to the treatment with 50 mm evaporation. Furthermore, the results showed that the effect of different level of nitrogen on abovementioned traits was significant except the number of pods per plant and 100-grain weight. The results also showed that drought stress had a negative effect on most agronomic and physiological traits associated with the yield, but nitrogen fertilizer had a positive effect on them.

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