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The Influence of Water Stress on Biomass and Harvest Index in Three Mung Bean (*Vigna radiata* (L.) R. Wilczek) Cultivars

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Abstract: The effect of water stress at the vegetative and reproductive growth stages and also no stress conditions on Biomass (B), Harvest Index (HI), Plant Height (PH) and Seed Protein Content (SP) of three mung bean cultivars (Partow, Barymung-2 and vc6368) were investigated. Experiment was conducted at the experimental farm of the Islamic Azad University of Shahre-rey, in Tehran, Iran, during summer 2008. The experiment was set up in a split plot on the basis of complete block design with four replications that placed water stress levels in the main plots and cultivars in sub plots. Correlation coefficients between some traits showed that, Seed Yield (SY) correlated positively with HI (r = 0.829**), B (r = 0.918**) and PH (r = 0.516**). HI correlated positively with B (r = 0.595**). Also, results indicated that the water stress decreased the B, HI and PH, while increased SP in three cultivars. Water stress at the flowering stage was more effective than vegetative stage on B, HI and SP, but less effective on PH. Cultivar partow was less affected, which showed its adaptability to the water stress conditions. Thus, mung bean is most sensitive to the water stress imposes at the flowering stage and in dry regions of Iran can be cultivated the Partow, in addition, for improvement in yield of mung bean, major emphasis should be placed on the B, HI and PH.

Key words: Mung bean (*Vigna radiata*), water stress, biomass, harvest index

INTRODUCTION

Mung bean (*Vigna radiata* L.) is an important short-duration grain legume crop with wide adaptability, low input requirements and the ability to improve the soil by fixing atmospheric nitrogen. Mung bean is well suited to a large number of cropping systems and constitutes an important source of high quality protein in the cereal-based diets of many people in Asia (Khattak *et al*., 2001). Drought is a worldwide problem, constraining global crop production and quality seriously and recent global climate change has made this situation more serious. Water is vital factor for plant growth and development. Water deficit, permanent or temporary, limits the growth and distribution of natural vegetation and the performance of cultivated plants more than any other environmental factors. Water stress is the major problem in agriculture and the ability to withstand such stress is of immense economic importance (Shao *et al*., 2008). Water deficit decreases PH and B (Mahieu *et al*., 2009; Shao *et al*., 2008). HI is the ratio of total seed dry weight to total B, thus, indicating the fraction of total B partitioned to seeds. A positive relationship exists between HI and dry matter (Zhang *et al*., 2008). Drought during the reproductive stage reduces the HI (Shao *et al*., 2008). Shoot B accumulation is considered an important trait to attain high seed yield in grain legumes (Rosales-Sernaa *et al*., 2004). Pulses productivity is relatively low for their poor dry matter partitioning in to grains as compared with vegetative matter. To improve yield potential of mung bean varieties capable of high B production and having ability to convert maximum of the dry matter in to grains are required (Ur-Rehman *et al*., 2005). High HI trait is very important for increasing yield potential in crops, but it is very complex character in legumes, because it is sensitive to environmental variations (Ghafoor *et al*., 2000). Water stress reduces plant growth and yield. However, if that occurs at the reproductive stage affects mung bean cultivars growth more severely than its occurrence at other stages (Tomas Robertson *et al*., 2004). In any given environment, grain yield in any crop is a function of B and the HI. Hence, the grain yield can be increased either by increasing the B or the HI or both. On the other hand, for maximum yields to be attained a pulse crop should have a high B with a high HI (Hegde *et al*., 2007). Optimization of inputs at the farm level would maximize B production as well as increasing the HI (Pandey *et al*., 2000). Singh *et al*. (2006) and Amanullah and Hatam (2000) reported significant differences for the yield in the mung bean which were mainly because of differences in the HI values. Under the drought stress, differential effects have been observed among mung bean cultivars for B and its translocation to seeds (Maqsood *et al*., 2000). Due to the cultivar differences to the water stress, the objective of the study is to find out and compare the effects of water stress at the vegetative and reproductive growth stages, on the HI, B, SP and PH of mung bean cultivars. Also, the relationship between traits were evaluated.

MATERIALS AND METHODS

The experiment was conducted at the experimental farm of the Islamic Azad University of Shahre-rey, in Tehran, Iran, during summer 2008. The research field is located in an arid climate where the summer is hot and dry and the winter is cool and dry. The altitude of the research field is 1000 m. Experimental area is located at 35°-35' N and 51°-28' E. The mean annual precipitation and temperature are 201.7 mm and 20.4°C, respectively. The experiment was laid out in a split plot on the basis of complete block design with four replications that placed different times of withholding irrigation in the main plots and cultivars in sub plots. Three irrigation levels viz., I_0: irrigation throughout the growing period (control), I_1: no irrigation at the four leaved stage (vegetative) and I_2: no irrigation at the flowering stage (reproductive) and three mung bean cultivars viz., Partow, Barymung-2 and vc6368 were used. The soil of experimental field was clay loam with pH 7.8 and contains organic matter 1.3%, total nitrogen 0.077%, available phosphorus 15 ppm, exchangeable potassium 265 ppm and EC of 2.7 mmohs cm^{-1}. Experimental plots were uniformly fertilized with 60-60-20 kg ha^{-1} NPK in the form of urea, triple superphosphate and muriate of potash at the time of final land preparation. The sowing was done with the help of a single row hand drill in rows on June 27, 2008. Seeds were treated with Bavistin (fungicide) before the sowing to control the seed borne disease. Distances on and between rows were 10 and 50 cm, respectively. Size of each plot was 15 m^2 (5×3 m). Crop management practices such as weeding, thinning and plant protection measures were done as required. Irrigation was done as per treatments.

At physiological maturity, 10 plants per plot were selected randomly from second and fifth rows to determine PH and SP. The SP, was estimated by the Kjeldahl (6.25×N) method (Anonymous, 1984). To determine SY, B and HI plants were harvested by hand from three m^2 in two middle rows of each plot. Dry matter was determined after drying at 75°C for 48 h. HI was calculated by dividing SY with total dry matter. All obtained data were analyzed by MSTAT-C statistical software and the means were compared by Duncan's Multiple Range test at the 5% probability level (Steel and Torrie, 1980).

RESULTS

PH (cm): The cultivars showed significant variation ($p \leq 0.01$) in PH. The cultivar of Partow produced maximum PH (37.83 cm), while vc6368 cultivar produced minimum PH (24.34 cm) (Table 1). Withholding irrigation at any growth stage significantly ($p \leq 0.01$) reduced PH. On the other hand, water stress at the vegetative stage caused the highest reduction in PH. The highest PH (34.69 cm) was observed in irrigation throughout the growing period against the lowest PH (28.75 cm) was produced in the water stress at the vegetative stage (Table 1). Interaction effect between the water stress levels and cultivars was found statistically significant ($p \leq 0.01$) for the PH. The highest PH (39.40 cm) was observed under the irrigation conditions throughout the growing period by Partow and the lowest PH (21.09 cm) was achieved under the water stress conditions at the vegetative stage by vc6368 (Table 2).

B (g m^{-2}): All the cultivars varied significantly ($p \leq 0.01$) with regard to total B. Partow cultivar produced highest biological yield (672.0 g m^{-2}) against, vc6368 cultivar produced lowest biological yield (301.19 g m^{-2}) (Table 1). Water stress conditions at the vegetative and flowering stages decreased significantly ($p \leq 0.01$) the total B over

Table 1: Mean comparisons of examined traits in mung bean as affected by water stress and cultivar

Treatments	Plant height (cm)	Biomass (g m^{-2})	Harvest index (%)	Seed protein content (%)
Water stress				
I_0	34.69^a	574.59^a	24.70^a	20.73^c
I_1	28.75^c	473.62^b	22.25^b	21.41^b
I_2	33.62^b	362.60^c	13.88^c	22.29^a
Cultivars				
Partow	37.83^a	672.00^a	24.23^a	22.20^b
Barymung-2	34.89^b	437.51^b	16.43^c	22.40^a
Vc6368	24.34^c	301.19^c	20.17^b	19.83^c

Mean values with the same letter(s) in each column and treatment are not significantly different at probability level of 5% using DMRT. I_0: Irrigation throughout the growing period (control). I_1: Water stress at the vegetative stage, I_2: Water stress at the flowering stage

Table 2: Interaction effects of water stress and cultivar on examined traits of mung bean

Treatments combination	Plant height (cm)	Biomass (g m^{-2})	Harvest index (%)	Seed protein content (%)
I_0×Partow	39.40^a	767.21^a	30.59^a	21.13^e
I_0×Barymung-2	37.96^b	611.60^c	17.65^e	21.88^d
I_0×vc6368	26.73^f	345.00^f	25.85^b	19.20^h
I_1×Partow	35.55^d	701.49^b	25.09^b	22.35^b
I_1×Barymung-2	29.61^e	414.52^e	19.83^d	22.15^c
I_1×vc6368	21.09^h	304.91^g	21.84^c	19.72^g
I_2×Partow	38.54^b	547.50^d	17.02^e	23.11^a
I_2×Barymung-2	37.11^c	286.61^h	11.79^f	23.19^a
I_2×vc6368	25.21^g	253.59^i	12.84^f	20.56^f

Mean values with the same letter(s) in each column are not significantly different at probability level of 5% using DMRT. I_0: Irrigation throughout the growing period (control), I_1: Water stress at the vegetative stage, I_2: Water stress at the flowering stage

Table 3: Correlation coefficients between examined traits in mung bean cultivars

Traits	Harvest index (%)	Biomass (g m^{-2})	Seed protein content (%)	1000-kernel weight (g)	Plant height (cm)
Seed yield (g m^{-2})	0.829**	0.918**	0.041^{ns}	-0.065^{ns}	0.516**
Harvest index (%)		0.595**	-0.406*	0.354*	0.054^{ns}
Biomass (g m^{-2})			0.320^{ns}	-0.349*	0.716**
Seed protein content (%)				-0.972**	0.749**
1000-kernel weight (g)					-0.768**

ns, * and **: Non significant , significant at the 5 and 1% probability levels, respectively

the control. The maximum B (574.59 g m^{-2}) was recorded in control treatment, while the minimum B (362.60 g m^{-2}) was observed in water stress at the flowering stage (Table 1). Interaction effect between water stress levels and used cultivars was found as statistically significant ($p \le 0.01$) for the B. The highest B (767.21 g m^{-2}) was observed in irrigation throughout the growing period by cultivar Partow and the lowest B (253.59 g m^{-2}) was produced in water stress at the flowering stage by cultivar vc6368 (Table 2).

HI (%): The mean HI varied statistically significantly ($p \le 0.01$) among different cultivars. The maximum HI (24.23%) was recorded in Partow cultivar but the minimum HI (16.43%) was taken from Barymung-2 (Table 1). In addition, HI values showed that it decreased significantly ($p \le 0.01$) due to water stress at the vegetative and flowering stages. Water stress at the flowering stage, produced lowest HI (13.88%) while, control treatment, produced highest HI (24.70%) (Table 1). Interaction effect between water stress levels and cultivars was found statistically significant ($p \le 0.01$) for HI. The maximum HI (30.59%) was recorded in irrigation throughout the growing period by Partow and the minimum HI (11.79%) was achieved in water stress at the flowering stage by Barymung-2 (Table 2).

SP (%): Used cultivars were statistically significant influenced ($p \le 0.01$) for the SP. The maximum SP (22.20%) was recorded in Partow, while the minimum SP (19.83%) was recorded in vc6368 (Table 1). SP was significantly ($p \le 0.01$) increased due to water stress at the vegetative and flowering stages. The highest SP (22.29%) was obtained in water stress at the flowering stage, against, the lowest SP (20.73%) was observed in control treatment (Table 1). Interaction effect between water stress levels and cultivars was found statistically significant ($p \le 0.01$) for this trait. The maximum SP (23.19%) was observed in water stress at the flowering stage by Barymung-2, while the minimum SP (19.20%) was produced in irrigation throughout the growing period by vc6368 (Table 2).

Correlation coefficients among some traits in mung bean: Six quantitative characters were evaluated for the correlation among the investigated traits (Table 3). SY correlated positively with HI (r = 0.829**) and B (r = 0.918**) and PH (r = 0.516**). HI showed positive correlation with B (r = 595**) and Kernel Weight (KW) (r = 0.354*) but negative correlation with SP (r = -0.406*). B correlated positively with PH (r = 0.716**) and negatively with KW (r = -0.349*). SP showed negative correlation with KW (r = -0.972**) and positive correlation with PH (r = 0.749**). KW correlated negatively with PH (r = -0.768**) (Table 3).

DISCUSSION

All the cultivars varied significantly with regard to PH. Thus, the PH being a genetically controlled character. These results are comparable to the findings of Malik *et al.* (2008), Ajman and Ul-Hassan (2002) and Amanullah and Hatam (2000) who reported, significant differences among the mung bean cultivars for the PH. Likewise, water stress at any growth stage reduced PH, but this stress at the vegetative stage caused the highest reduction. Nielson and Nelson (1998) are being verified this finding. The cultivars showed significant variation for the B. These results are in line with those of Mensah and Tope (2007) and Bismillah Khan *et al.* (2003), who observed that mung bean cultivars differed significantly in the B. Water stress at the vegetative and flowering stages decreased the total B over the control. Moreover, the B was more affected by the water stress at the flowering stage. Similar results were observed by Asaduzzaman *et al.* (2008) and De Costa *et al.* (1999). In terms of HI, used cultivars were significantly influenced. Singh *et al.* (2006) and Maqsood *et al.* (2000) also found a significant difference in partitioning of photosynthates towards seeds of mung bean genotypes. HI was significantly decreased due to the water stress at the vegetative and flowering stages, but this stress at the flowering stage, was given the lowest HI. De Costa *et al.* (1999) also observed that, water stress during the reproductive growth stage, reduced HI. In addition, Maqsood *et al.* (2000) reported that water stress, reduced HI in mung bean genotypes. Similarly, Pandey *et al.* (1984) showed that HI decreased linearly with increasing levels of drought for legumes among mung bean. The mean SP varied significantly among the used cultivars. Similar results have been reported by Makeen *et al.* (2007), Ahmad *et al.* (2003) and Afzal *et al.* (2003), who reported that SP of mung bean was affected significantly by cultivars. SP showed that it increased significantly due to water stress at the vegetative and flowering stages. Water stress at the flowering stage, produced highest SP. Tawfik (2008) and Soni and Gupta (1999) also observed that, SP decreased with the increasing number of irrigations. SY correlated positively with the HI, B and PH. Amanullah and Hatam (2000), Ghafoor *et al*. (2000) and Ajman and Ul-Hassan (2002) reported positive correlation between SY and HI. Malik *et al*. (2008) and Ghafoor *et al*. (2000) also showed positive correlation between SY and B. Makeen *et al*. (2007) and Hakim (2008) found positive correlation between SY and PH. The HI showed positive correlation with B and KW, but negative correlation with SP. De Costa *et al*. (1999) showed positive correlation between HI and B. Amanullah and Hatam (2000) and Ghafoor *et al*. (2000) reported positive correlation between HI and KW. B correlated positively with PH and negatively with KW. Salehi *et al*. (2008) and Ajman and Ul-Hassan (2002) also found positive correlation between B and PH. SP showed negative correlation with KW and positive correlation with PH. The highly significant negative correlation between seed size and SP in mung bean indicated that when carbon accumulation is more, then reduce nitrogen content (Afzal *et al*., 2003). KW correlated negatively with PH. Similar result was reported by Motiar Rohman *et al*. (2003). These results clearly indicated that, the HI, B and PH were the important traits in relation to the SY of mung bean.

CONCLUSION

Results of the present experiment indicated that, mung bean is the most sensitive to water stress imposed at the flowering stage, because at this stage, the HI, B and SY were adversely affected which ultimately reduced. Cultivar Partow showed that, it is adaptability more than other cultivars under the water stress conditions. Thus, in dry regions of Iran can be cultivated Partow. In addition, for improvement in the yield of mung bean, major emphasis should be placed on the B, HI and PH.

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