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Effect of Withholding Irrigation at Different Growth Stages on Yield and Yield Components of Mungbean (*Vigna radiata* L. Wilczek) Varieties

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Abstract: In order to study the response of Mungbean varieties to withholding irrigation at various phenological stages, an experiment was conducted at farm of the Islamic Azad University of Shahre-rey, in Tehran, Iran, during summer 2008. Varying timing of irrigation had significant effect on yield and yield components. No irrigation at the flowering stage, reduced number of pods plant^{-1}, number of seeds pod^{-1} and seed yield, while, withholding irrigation at the pod filling stage, decreased 1000-seed weight. Among three varieties of Mungbean, variety Partow, gave significantly higher number of pods plant^{-1}, number of seeds pod^{-1} and seed yield, than variety Barymung 2 and vc 6368, against, variety vc 6368 had higher 1000-seed weight. The highest seed yield (243.39 g m^{-2}) was recorded in irrigation throughout the growing period by variety Partow and the lowest seed yield (32.77 g m^{-2}) was obtained in stop irrigation at the flowering stage by vc 6368.

Key words: Irrigation · Mungbean · Yield and yield components · Growth stages

INTRODUCTION

Mungbean (*Vigna radiate* L. Wilczek) is an important legume crop of Asia and a major component of many cropping systems. Mungbean seeds are rich in protein and amino acids, thus serve as a valuable protein source for human consumption. Pods and sprouts of Mungbean are also eaten as a vegetable and are a source of vitamins and minerals [1]. Moreover, this crop is nitrogen fixing, has a short life cycle and therefore, is widely grown as mixed, inter crop or in rotation to improve nitrogen status of soil or to break the disease/pest cycles [2].

Irrigation is, nowadays, the largest freshwater consumer in the world. The scarcity of water supplies and increasing demand of the water use sectors suppose an urgent need to improve irrigation management [3]. Therefore, innovations are needed to increase the efficiency of use of the water that is available. One approach is the development of new irrigation scheduling techniques such as deficit irrigation, which are not necessarily based on full crop water requirement. Deficit (or regulated deficit) irrigation is one way of maximizing water use efficiency (WUE) for higher yields per unit of irrigation water applied [4]. In this method, the crop is exposed to a certain level of water stress either during a particular period or throughout the whole growing season [5]. The expectation is that any yield reduction will be insignificant compared with the benefits gained through diverting the saved water to irrigate other crops [6]. However the grower must have prior knowledge of crop yield responses to deficit irrigation [4]. Irrigation scheduling is the farmer's decision process related to 'when' to irrigate and 'how' much water to apply to a crop. Irrigation scheduling requires knowledge on crop water requirements and yield responses to water, the constraints specific to each irrigation method and irrigation equipment, the limitations relative to the water supply system and the financial and economic implications of the irrigation practice [7]. Accurate water application prevents over or under irrigation. Over-irrigation wastes water, energy and labour, leaches nutrients below the root zone and leads to waterlogging which reduces crop yields. Under-irrigation stresses the plant resulting in yield reductions and decreased returns [8]. Irrigation water can be conserved and yields maintained by using appropriate irrigation timing to avoid plant water deficit stress at critical growth stages [9]. Water stress during certain growth stages may have more effect on grain yield than similar stress at other growth stages [10].

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Water stress affects almost all aspects of Mungbean growth and development [11]. This crop suffering water stress resulted in decreased seed yield, pod number, number of seeds pod^{-1} and 1000-seed weight [12]. Supplemental irrigation, particularly at the pod filling stage to improve plant water status gives economic increase in yields in areas of super optimal temperature during the reproductive growth [13]. The late flowering and pod setting stages appear to be the most sensitive stages to soil moisture stress [14]. Mungbean yield was depressed when the irrigation treatments were given at flowering, with or without pre flowering irrigation [15].

Adequate amount of water must be applied at the right time in order to get higher crop yield in irrigated lands. Therefore it is vital to determine the water consumption of plants and periods that plants are susceptible for water beside the irrigation intervals in order to increase crop yield in a limited area. Water requirement of plants from seed sowing to the harvest varies depending on plant species and plant growth stages [16]. Thus, the objective of this study was to determine the effect of different times of irrigation on the yield and yield components of Mungbean varieties.

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. The field 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 varieties in sub plots. Eight irrigation levels viz. I_0= irrigation throughout the growing period (control), I_1= no irrigation at the 2 leafy stage, I_2= no irrigation at the 4 leafy stage, I_3= no irrigation at the 2 and 4 leafy stage, I_4= no irrigation at the pre flowering (budding) stage, I_5= no irrigation at the flowering stage, I_6= no irrigation at the pod formation stage, I_7= no irrigation at the pod filling stage and three varieties viz. Partow, Barymung 2 and vc 6368 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 before sowing to control the seed borne disease. Row to row and plant to plant distance was 50 cm and 10 cm,respectively. Size of each plot was 15 m^2 (5 m × 3 m). Crop management practices such as weeding, thinning and plant protection measures were done as per requirement. Irrigation was done as per treatments. At physiological maturity ten plants plot^{-1} were selected randomly, sun dried and were recorded number of pods plant^{-1}, number of seeds pod^{-1} and 1000-seed weight. To determine seed yield, plants were harvested by hand from pre demarcated two rows of each plot that were sun dried properly. Collected data were analyzed statistically using MSTAT-C program and the means were compared by Duncan's Multiple Range Test at 5% probability level [17].

RESULTS AND DISCUSSION

Number of Pods Plant^{-1}: Data indicated that number of pods plant^{-1} varied significantly ($p \leq 0.01$) in different varieties. The maximum number of pods plant^{-1} (20.83) were observed in the variety Partow and the minimum number of pods plant^{-1} (8.92) were obtained in case of variety vc 6368 (Table 1). Variation in number of pods plant^{-1} in Mungbean genotypes was also reported by Bismillah khan *et al.* [18] and Ahmad *et al.* [19].

Statistical analysis showed that different irrigation levels had a significant effect ($p \leq 0.01$) on number of pods plant^{-1}. Mean value of the data indicated that the maximum number of pods plant^{-1} (17.22) was recorded in those plots which were treated with irrigation throughout the growing period while the minimum number of pods plant^{-1} (9.33) was obtained in those plots which were treated with no irrigation at the flowering stage (Table 1). Withholding irrigation at the flowering stage caused increase flowers abortion [20]. Irrigation during flowering stage helps for retention of flowers and pod development [21]. Irrigation during flowering and pod filling stages, increased pod initiation and pod growth rates. The greatest pod growth rates were probably due to the greatest availability of reproductive sinks and the greater radiation use efficiency during these periods [22]. Similar results were observed by Chapman *et al.* [23] and Jamieson *et al.* [24].

Table 1: Mean comparison of yield and yield components of Mungbean as affected by irrigation levels and variety

Treatments	Pods/plant	Seeds/pod	1000-seed weight (g)	Seed yield (g m^{-2})
Irrigation levels				
I_0	17.22 a	8.32 a	49.02 a	142.50 a
I_1	16.08 b	8.08 a	47.82 b	126.41 b
I_2	15.38 c	7.78 b	45.82 c	108.00 c
I_3	14.06 d	7.61 b	44.46 d	93.81 d
I_4	9.77 f	7.16 c	43.24 e	60.24 e
I_5	9.33 f	6.85 d	42.21 f	53.27 f
I_6	10.53 e	7.20 c	39.22 g	58.19 ef
I_7	16.81 a	7.52 b	36.35 h	88.71 d
Varieties				
Partow	20.83 a	9.05 a	39.44 b	151.92 a
Barymung 2	11.20 b	8.07 b	35.37 c	65.39 b
Vc 6368	8.92 c	5.57 c	55.75 a	56.86 c

Means with the same letter 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= no irrigation at the 2 leafy stage
I_2= no irrigation at the 4 leafy stage
I_3= no irrigation at the 2 and 4 leafy stage
I_4= no irrigation at the pre flowering (budding) stage
I_5= no irrigation at the flowering stage
I_6= no irrigation at the pod formation stage
I_7= no irrigation at the pod filling stage

Table 2: Interaction effects of irrigation levels and variety on yield and yield components of Mungbean

Treatments combination	Pods/plant	Seeds/pod	1000-seed weight (g)	Seed yield (g m^{-2})
I_0 × Partow	25.17 a	9.61 a	48.44 g	234.39 a
I_0 × Barymung 2	15.40 f	8.73 c-g	39.40 j	105.92 e
I_0 × vc 6368	11.10 j	6.63 j	59.21 a	87.23 fgh
I_1 × Partow	24.40 b	9.50 ab	46.07 h	213.79 b
I_1 × Barymung 2	13.50 h	8.34 e-h	39.36 j	88.80 fg
I_1 × vc 6368	10.33 k	6.40 jk	58.04 b	76.71 hi
I_2 × Partow	23.77 c	9.15 abc	40.43 i	175.78 c
I_2 × Barymung 2	12.77 i	8.23 fgh	39.01 jk	81.97 gh
I_2 × vc 6368	9.60 l	5.94 kl	58.01 b	66.10 ij
I_3 × Partow	21.67 d	9.04 a-d	38.94 jkl	152.61 d
I_3 × Barymung 2	11.10 j	8.13 gh	38.32 kl	69.23 ij
I_3 × vc 6368	9.40 l	5.65 l	56.12 c	59.57 j
I_4 × Partow	15.40 f	8.90 b-f	38.13 l	104.68 e
I_4 × Barymung 2	7.30 n	7.73 hi	35.55 n	40.17 k
I_4 × vc 6368	6.60 op	4.86 mn	56.06 c	35.90 k
I_5 × Partow	15.10 fg	8.41 d-h	37.34 m	93.63 f
I_5 × Barymung 2	6.60 op	7.42 i	34.13 o	33.40 k
I_5 × vc 6368	6.30 p	4.72 n	55.15 d	32.77 k
I_6 × Partow	16.10 e	8.81 c-f	34.46 o	97.80 ef
I_6 × Barymung 2	8.40 m	7.89 hi	30.05 q	39.83 k
I_6 × vc 6368	7.10 no	4.90 mn	53.15 e	36.93 k
I_7 × Partow	25.00 ab	9.00 a-e	31.67 p	142.70 d
I_7 × Barymung 2	14.53 g	8.09 gh	27.11 r	63.78 j
I_7 × vc 6368	10.90 jk	5.45 lm	50.27 f	59.69 j

Means with the same letter in each column are not significantly different at probability level of 5% using DMRT.
I_0= irrigation throughout the growing period (control)
I_1= no irrigation at the 2 leafy stage
I_2= no irrigation at the 4 leafy stage
I_3= no irrigation at the 2 and 4 leafy stage
I_4= no irrigation at the pre flowering (budding) stage
I_5= no irrigation at the flowering stage
I_6= no irrigation at the pod formation stage
I_7= no irrigation at the pod filling stage

Interaction effect between irrigation regimes and varieties was significant ($p \le 0.01$) in case of number of pods plant^{-1}. The highest number of pods plant^{-1} (25.17) was observed in irrigation throughout the growing period by variety Partow and the lowest number of pods plant^{-1} (6.30) was achieved in no irrigation at the flowering stage by variety vc 6368 (Table 2).

Number of Seeds Pod^{-1}: Different varieties varied significantly ($p \le 0.01$) with regard to number of seeds pod^{-1}. The maximum number of seeds pod^{-1} (9.05) was produced by the variety Partow while, the minimum number of seeds pod^{-1} (5.57) was observed by the variety vc 6368 (Table 1). Variability in number of seeds pod^{-1} between genotypes might be due to their different genetic makeup [25-27].

Variation of number of seeds pod^{-1} was significant ($p \le 0.01$) for different irrigation levels. The highest number of seeds pod^{-1} (8.32) was obtained in irrigation throughout the growing period, against, the lowest number of seeds pod^{-1} (6.85) was produced in no irrigation at the flowering stage (Table 1). No irrigation at the flowering stage caused decrease in the fertilization values and so decrease number of seeds pod^{-1}. Nielsen and Nelson [28] also reported that number of seeds pod^{-1} was reduced, when water stress occurred during reproductive stage.

Interaction effect between irrigation regimes and varieties was non significant in case of number of seeds pod^{-1}. Nonetheless, the highest number of seeds pod^{-1} (9.61) was recorded in irrigation throughout the growing period by variety Partow and the lowest number of seeds pod^{-1} (4.72) was achieved in no irrigation at the flowering stage by variety vc 6368 (Table 2).

1000-Seed Weight: Analysis of the data revealed that different varieties had a significant effect ($p \le 0.01$) on 1000-seed weight. The heaviest seeds (55.75 g) was produced in plots seeded with vc 6368 while, the lightest seeds (35.37 g) was obtained from plots planted with Barymung 2 (Table 1). The variation in 1000-seed weight among different Mungbean genotypes occurred due to varying genetic potential for this parameter [19]. These results are in conformity with those reported by Maqsood *et al.* [29] and Siddique *et al.* [30] who stated that different 1000-seed weight in Mungbean genotypes.

Significant variation at $p \le 0.01$ was observed for 1000-seed weight among different irrigation levels. The highest 1000-seed weight (49.02 g) was observed in irrigation throughout the growing period, against, the lowest 1000-seeds weight (36.35 g) was recorded in no irrigation at the pod filling stage (Table 1). Stop irrigation at the pod filling stage caused decrease in the photosynthate mobilization to seeds and seed filling period and thus, decrease seed weight. In agreement with the present experiment, Maqsood *et al.* [25] also observed that irrigation at the flowering and pod formation stages, increased 1000-seed weight of Mungbean.

Interaction effect between irrigation regimes and varieties was significant ($p \leq 0.01$) in case of 1000-seed weight. The highest 1000-seed weight (59.21 g) was observed in irrigation throughout the growing period by variety vc 6368, while, the lowest 1000-seed weight (27.11 g) was produced in no irrigation at the pod filling stage by variety Barymung 2 (Table 2).

Seed Yield: The varieties showed significant differences ($p \leq 0.01$) in their seed yield. The highest seed yield (151.92 g m^{-2}) was produced by the Partow, against, the lowest seed yield (56.86 g m^{-2}) was recorded by the variety vc 6368 (Table 1). The maximum seed yield of variety Partow was due to higher number of pods $plant^{-1}$ and number of seeds pod^{-1}. Significant effect of Mungbean genotypes on seed yield had been reported by Ahmad *et al.* [19], Bismillah khan *et al.* [18], Maqsood *et al.* [25], Siddique *et al.* [20] and Singh *et al.* [27].

Variation of seed yield was significant ($p \leq 0.01$) for different irrigation levels. The highest seed yield (142.50 g m^{-2}) was achieved in irrigation throughout the growing period, while, the lowest seed yield (53.27 g m^{-2}) was produced in no irrigation at the flowering stage (Table 1). Withholding irrigation at the flowering stage caused decrease in number of pods $plant^{-1}$ and number of seeds pod^{-1} and therefore, decrease seed yield. These findings are quite in agreement with those of Nielsen and Nelson [28] and Kokubun *et al.* [20]. Thomas *et al.* [31] also reported that seed yield of Mungbean was reduced by 59% when water stress was imposed at early flowering. Irrigation is critical during flowering and pod filling stages mainly, because of the highest LAI during this periods and consequently the greatest demand for water. Moreover, water stress during flowering and pod filling stages, significantly reduced pod initiation and pod growth rates and thereby reduced harvest index [22].

Interaction effect between irrigation regimes and varieties was significant ($p \leq 0.01$) in case of seed yield. The maximum seed yield (234.39 g m^{-2}) was observed in irrigation throughout the growing period by variety Partow, while, the minimum seed yield (32.77 g m^{-2}) was produced in no irrigation at the flowering stage by variety vc 6368 (Table 2).

CONCLUSION

Water stress reduced Mungbean yield and yield components regardless of whether the stress was imposed when the plants were in the vegetative or reproductive stage of development. However, water stress that occurred at the reproductive stages specially flowering and pod formation, affected seed yield more severely than its occurrence at other stages. As results of this study, irrigation is critical during flowering and pod formation stages and to maximize Mungbean yields in the dry season of the dry zone of Iran, irrigation should extend across all phenological stages, specially the flowering and pod formation.

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