DETERMINATION OF THE FREQUENCY OF IRRIGATION ON THE YIELD OF SELECTED MUNGBEAN VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled, ***"INFLUENCE OF WATER DEFICIT ON THE MORPHOPHYSIOLOGY AND YIELD ATTRIBUTES OF MUNGBEAN"*** *submitted to the Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE in AGRICULTURAL BOTANY****, embodies the result of a piece of bona fide research work carried out by* ***SOHANA SHARMIN*** *Registration No. 05-01541 under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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september, 2011 **The Author**

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ABSTRACT

The experiment was conducted at the Agricultural Botany, field of Sher-e-Bangla Agricultural University, Dhaka during the Rabi season from October, 2011 to February, 2012 to study the influence of water deficit on the morphophysiology and yield attributes of mungbean. In the experiment the consisted of five mungbean varieties viz. BARI mung 2, BARI mung 3, BARI mung 4, BARI mung 5, BARI mung 6 and four different number of irrigation, I_1 = three irrigations, I_2 = two irrigations, I_3 = One irrigation, I_4 = no irrigation. The experiment was laid out in a two factors randomized complete block design (RCBD) with three replications. The days to emergence was not significantly affected due to the variety of mungbean. The maximum days to emergence was obtained from days to emergence BARI mung 4. Results showed that a significant variation was observed among the treatments in respect of majority of the observed parameters. The tallest plant was obtained from BARI mung 2. Treatment BARI mung 3 produced maximum number of leaves and branches. The earliest of days to first flowering, the longest time of days to last flowering, the earliest of days to first pod setting and days to first maturity were found in BARI mung 2. The highest numbers of flower per plant, pod length and number of seeds per plant (5.04) was recorded in BARI mung 2. The highest yield (1.39 t/ha) was recorded in BARI mung 2. The tallest plant was obtained from three irrigation levels. Treatment three irrigations produced maximum number of leaves and branches. The earliest of days to first flowering, the longest time of days to last flowering, the earliest of days to first pod setting and days to first maturity were found in three irrigations. The highest number of flowers per plant and pod length was produced in three irrigations. The highest number of seeds per plant (6.92) was recorded in three irrigations. The maximum yield (1.31 t/ha) was obtained from three irrigations. Interaction effect of variety and number of irrigation had a significant variation on all parameter. The tallest plant and highest number of leaves were obtained from BARI mung 2 with three irrigation treatment. The earliest of days to first flowering, the longest time of days to last flowering, the earliest of days to first pod setting and the earliest of days to first maturity were found in BARI mung 2 with three irrigations. The highest number of flower per plant, pod length was produced in BARI mung 2 with three irrigations. The highest seeds weight per plant (10.63g) was obtained from BARI mung 2 with three irrigations. The highest yield (1.62 t/ha) was obtained from BARI mung 2 with three irrigations.

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LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
HRC	=	Horticulture Research Centre
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
et al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Muriate of Potash
RCBD	=	Randomized Complete Block Design
DAT	=	Days after Transplanting
ha^{-1}	=	Per hectare
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance

CHAPTER 1

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is one of the leading pulse crop of Bangladesh. This commonly grown pulse crop belongs to the family leguminosae. It holds the 3rd in protein content and 4th in both acreage and production in Bangladesh (Sarkar *et al.*, 1982). The agro-ecological condition of Bangladesh is favourable for growing this crop. Pulses constitute the main source of protein for the people, particularly the poor sections of Bangladesh. These are also the best source of protein for domestic animals. Besides, the crops have the capability to enrich soils through nitrogen fixation. Mungbean contains 51% carbohydrates, 26% protein, 4% mineral and 3% vitamin. On the nutritional point of view, mungbean is one of the best among pulses (Khan, 1985). It is widely used as "Dal" in the country like other pulses.

Bangladesh is a developing country. The land of our country is limited. But the population is very high. More people need more food. We have to produce more food in our limited land. To meet up the increased demand of food, farmers are growing more cereal crops. Due to the high population pressure, the total cultivable land is decreasing day by day along with the pulse cultivable land. So, at present the cultivation of pulse has gone to marginal land because farmers do not want to use their fertile land in pulse cultivation. Pulse cultivation is also decreasing because of its low yield & production. The long term cereal crop cultivation also affects soil fertility and productivity.

Mungbean covers an area of 23077 hectare and production was about 20000 metric tons. The average production of mungbean in the country is about 867 kg ha^{-1}(BBS, 2010). About 3 t ha^{-1} of seed yield have been reported in a trial in Taiwan (Lawn, 1978) but in Bangladesh the average yield is very low. The yield difference indicates the wide scope for increasing yield of mungbean. The climatic conditions of Bangladesh favour mungbean production almost throughout the year.

The farmers of Bangladesh generally grow mungbean by one ploughing and hardly use any fertilizer and irrigation due to its lower productivity and also to their poor socio-economic condition and lack of proper knowledge. As a result the yield becomes low. There is an ample scope for increasing the yield of mungbean with improved management practices.

The agro-ecological condition of Bangladesh is favourable for munbean cultivation almost throughout the year. The crop is usually cultivated during rabi season. But because of poor yield and marginal profit as compared to cereal crops, farmers prefer growing boro, maize and wheat than mungbean during rabi season. Besides, the release of high yielding cultivars of cereals have pushed this crop to marginal and sub-marginal lands of less productivity and made its cultivation less remunerative. Recently, Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) has developed six and seven photo-sensitive high yielding cultivars respectively which are getting attention to the farmers. During kharif season the crop fits well into the existing cropping system of many areas in Bangladesh.

Mungbean has special importance in intensive crop production system of the country for its short growing period. It is drought tolerant and can be cultivated in low rainfall areas, but faces well in areas with 750 - 900 mm rainfall (Kay, 1979). The crop is grown with residual moisture under rained conditions. It is cultivated both in summer and winter season in many countries of the world (Bose, 1982; Singh and Bhardwaj, 1975). It is traditionally grown throughout the country during the month of September to December in Rabi season but across these days, this crop has been growing throughout the country in the month of March to June in summer.

The proper sowing time again depends on the varieties and prevailing environment. Selection of right varieties for sowing at optimum time is the key factor for successful mungbean production. Growers tend to manipulate sowing time in order to obtain better growth and higher quality yield. The time of sowing is also adjusted so as to synchronize the time of harvest with market demand.

The frequency of irrigation and the amount of water required depend on such factors as cultivar, soil type, season, amount of rainfall and diseases; therefore, it is difficult to give definite recommendation. Over irrigation, as well as under irrigation may lower yields (Jones and Mann, 1963). Efficient water management thus plays a vital role in mungbean production. This can be achieved by adopting improved irrigation practices. Although both timing and the amount of water applied affect irrigation efficiency, timing has greater effect on the yield and quality of a crop. Therefore, a judicious irrigation schedule is needed to avoid over or under irrigation and for profitable mungbean cultivation.

The deficit situation of mungbean production in our country can be overcome either by bringing more area under mungbean cultivation or by increasing the yield through improvement of production technology, such as optimizing the dose of N, P and K fertilizers.

The experimental evidences on the influence of water deficit on the morpho physiology and yield attributes of mungbean are limited under Bangladesh condition. The present study was therefore, undertaken with the following objectives.

1. To find out the influence of water deficit on the growth, development and yield attributes of mungbean varieties.
2. To determine the effect of different irrigation levels (frequency of irrigation) on the morphophysiological characters of selected mungbean varieties.

CHAPTER II

REVIEW OF LITERATURE

The growth and yield of mungbean are influenced by variety and different sowing time. Following review of literature includes reports as studied by several investigators who were engaged in understanding the problems that may help in the explanation and interpretation of results of the present investigation. In this chapter, an attempt has been made to review the available information in home and abroad regarding the effect different agronomic management along with different irrigation levels on the growth, morphology and yield of mungbean.

2.1 Effect of variety on the performance of mungbean

Mungbean cultivars Pusa 105 and Pusa Vishal were sown at 22.5 and 30 cm spacing and supplied with 36-46 and 58-46 kg NP/ha in field experiment which was conducted, in Delhi, India during the kharif season of 2000. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t/ha, respectively) compared to cv. Pusa 105. Row spacing at 22.5 cm resulted in higher grain yields in both crops (Tickoo et al. 2006).

Ali *et al.* (2004) carried out an experiment at BARI, Joydebpur, Gazipur to find out the response of inoculation with different plant genotypes of mungbean. Three varieties of mungbean viz. BARI mung 1, BARI mung 2, BARI mung 3 and Rhizobial inoculums (BARI Rvr 405) were use in this experiment. Each variety was tested with and without inoculation. Inoculated plants gave significantly higher number of nodules.

Solaiman *et al.* (2003) studied on the response of mungbean cultivars BARI mung 2, BARI mung 3, BARI mung 4, BARI mung 5, BINA moog-2 and BU mung-1 to *Rhizobium sp.* Strains TAL 169 and TAL441. It was observed that inoculation of the seeds increased nodulation.

Bhuiyan *et al.* (2003) conducted a field Experiment at Regional Agricultural Research Station (RARS), Rahmatpur, Barisal, to study the response of inoculation with different plant genotypes. Four varieties of mungbean viz. BARI mung 2, BARI mung 3, BARI mung 4, BARI mung 5, and Rhizobial inoculum (Bradyrhizobium strain RVr-441) were used in this experiment. Each variety was tasted with/without inoculation. Inoculated plants gave significantly higher nodule number.

Ali *et al.* (2004) carried out an experiment at BARI, Joydebpur, Gazipur to find out the response of inoculation with different plant genotypes of mungbean. Inoculated plants gaves significantly higher nodule weight.

Bhuiyan *et al.* (2003) carried out a field experiment at Regional Agricultural Research Station (RARS), Rahmatpur, Barisal and found that inoculated plants gave significantly higher nodule weight.

From an experiment at BARI, Joydebpur, Gazipur. Ali *et al.* (2004) showed that inoculated plants gave significantly higher root weight, shoot weight.

Solaiman, *et al.* (2003) reported that inocultation of the seeds increased dry matter production.

Bhuiyan *et al.* (2003) conducted a field experiment at Regional Agricultural Research Station (RARS), Rahmatpur, Barisal. Each variety was tested with/without inoculation. Inoculated plants gave significantly higher root weight and shoot weight.

Ali *et al.* (2004) conducted an experiment with mungbean varieties at BARI, Joydebpur, Gazipur. Each variety was tested with and without inoculation. Inoculated plants gave significantly higher stover yield and seed yield compared to non inoculated plants. Among 3 varieties, BARI mung-1 produced the highest yield (1.35 t ha^{-1}).

Bhuiyan *et al.* (2003) conducted a field experiment at Regional Agricultural Research Station (RARS), Rahmatpur, Barisal. Inoculated plants gave significantly higher stover yield and seed yield copared to non-inoculated plants. Among 4 varieties, BARI mung2 produced higher yield. The variety BARI mung 2 gave the highest seed yield (1.38 t/ha) with inoculation.

2.2 Effect of irrigation on the performance of mungbean

Bakhsh *et al.* (2007) conducted a field study was undertaken to evaluate newly developed chickpea genotypes under water application and rain-fed management system. Highly significant differences were observed between genotypes and between two management practices for all the traits except primary branches per plant, which were non-significantly different between two managements. The interaction between genotypes and managements (G x M) was non-significant for number of primary branches and number of secondary branches. The yield and most of the yield components were improved with the application of irrigation. On average basis 48% increase in number of pods per plant, 36% in total dry weight and 17% in grain yield was recorded due to irrigation. On the contrary, the grain size was reduced by 16% and the number of primary and secondary branches remained un-affected due to irrigation. The genotype 93A086 with grain yield of 14.37 g per plant was better under irrigation while 92A207 with grain yield of 12.60 g per plant performed better under rain-fed planting. It may be inferred from the present study that any genotype that responds positively to irrigation with respect to seed size coupled with increase in number of pods per plant will be most suitable for irrigated areas.

Under rain fed condition the chickpea crop usually faces moisture stress due to low rainfall and responds favorably to supplemental irrigation (Singh, 1980; Raghu & Choubey, 1983).

The study of genetic parameters of chickpea under irrigated and rain-fed management conditions revealed significantly positive effect of irrigation on all the parameters including yield (Nawaz *et al.*, 1994; Shinde *et al.*, 1996; Jagganath *et al.*, 1999; Anwer *et al.*, 2003). Several research workers have reported positive response of chickpea to irrigation (Agarwal *et al.*,1997). Several studies have also shown that optimum yield can be obtained with irrigation at branching, flowering and pod formation stages (Prihar and Sandhu, 1968).

A field experiment was conducted at College of Agriculture, Dharwad during rabi season of 1997-98 and 1998-99 to study dray matter production, growth and yield in *kabuli* chickpea (ICCV-2) as influenced by dates of sowing and irrigation levels. Significantly higher dry matter production (10.81 g/plant) and seed yield (16.18 g/plant) recorded at higher IW/CPE ratio of 0.8 over 0.4 IW/CPE ratio and control, but was at par with 0.6 IW/CPE ratio. While sowing at IIFN of October recorded significantly higher seed yield (1802 kg/ha) compared to I FN of October and II FN of November which was mainly due to more pods/plant (55.6) and 100-seed weight (26.65 g). The non significant effect due to phosphorus levels was observed on growth, yield components, seed and bhusa yield except branches/plant. The effect of irrigation levels and interaction effects were no significant on harvest index, seed yield canopy width and pods/plant (Munsur *et al.* 2006).

Mehar Singh *et al.* (2000) opined that method of sowing plays a great role in influencing the seed germination and thereby affecting plant population and yield. They conducted a study on the method of sowing soybean, and obtained maximum seed yield under ridges and furrow sowing (2103 kgha-1) and on average this method gave 36.1 per cent more grain yield over the flat beds.

Pawar (2000) reported that pod yields of groundnut obtained with ridges and furrows were significantly higher over yields under flat beds. The effect of field layouts on growth and yield of groundnut was studied by Pawar. (2000) and they reported pod yield increase of 7.5 per cent under broad bed and furrow method than that of flat beds. They found that the environmental conditions in respect of soil and water plant relationship largely influenced the pod formation and development in broad bed furrow, which also provided loose soil mass, adequate soil moisture and air.

Griason *et al.* (1955) calculated the water use rates at 6.4, 7.0 and 6.03 inches for june, July, and August for optimum soybean growth. The total water use was 25 inches. Whit and Van Bavel (1955) estimated the water requirement in the range of 13 to 23 inches. The average rate was 0.3 inches/day, during July and August at Missouri. According to their opinion the daily water use was higher because they measured irrigation water on small plots. Somerhalder and Schieusener (1960) found that 18 to 25 inches of water was required by soybean for optimum growth at Nebraska, USA. They obtained highly significant increase in soybean grain yield by supplying 25 acre inches of water in a season. While Cartter and Hartwig (1962) stated that a good crop of soybean required about 20 to 30 acre inches of irrigation water per season. Herpich (1963) recommended that 20 to 24 acre inches was the water requirement of the crop in Kansas USA. Pendelton and Hartwig (1973) stated that soybean used on an average 0.5 cm/day over the antire season and about 0.8 cm/day during the reproduction stage in July-September. This corresponded to a need of about 51 cm of usable water per hectare to produce a 2699 kg/ha soybean yield. Doss et al. (1974) found that sragg variety of soybean used 52.7 cm of water per season. Doss and Thurlow (1974) stated that the daily water use rates varied greatly on numerous factors including calendar date, leaf area, available soil water, radiant energy, temperature and wind speed.

The soybean germination occurs between 5 to 8 days under favourable soil temperature and moisture conditions. Hunter and Erickson (1952), in their experiment on the moisture requirement of various crops for seed germination found that soybean required 50% available soil moisture. They further stated that higher moisture content in soil would result in an invasion of pathogens. But even under lower soil moisture content, the seed swelled and it got infected with fungal growth. Whereas, Hillel (1972) stated that a good contact between seed and firm soil would increase the capillary conductivity of the soil and improve water transport to the seed. Heatherly and Russell (1979) pointed out that much lower soil water potential (>-1.0bar) was required for seedling emergence than reported previously for seed germination. On the other hand excessive soil moisture impeded soybean seedling emergence primarily through restriction to Oxygen supply or enhanced invasion of Pathogen organisms. Grable and Danielson (1965) found that a soil water potential of 0.3 bar resulted in the development of profuse fungal infection on germinating soybean seed, which almost completely stopped root growth.

Soybean root and shoot relationships were investigated by Hoogenboom *et al.* (1983). They reported that water stressed plants had larger root system with more roots extending into the deeper, water soil profile. The difference between shoot, root ratios of the stressed and non-stressed plants was greater during the very dry summer of 1981 than relatively wet summer of 1982. These results suggest that water stressed plants partition more dry matter into their root system during vegetative growth, thus reducing shoot growth. Huck *et al.* (1984) from a partitioning of dry matter in water stressed soybeans, observed that water stressed plants had more roots than non-stressed plants and were more evenly distributed throughout the soil profile. They further stated that when water stress occurred during pod fill stage. However, additional root growth occurred at the expense of seed growth.

Huck *et al.* (1984) by partitioning of dry matter in water stressed soybean, observed that water stress during pod fill resulted into additional growth of root at the expense of seed growth, both the total number of seed per plant and the weight of individual seeds, were significantly reduced due to water stress during pod fill stage.

Huck *et al.* (1986) concluded that water stress significantly reduced total shoot weight and seed weight. Both total seed weight and individual seed weight per treatment were significantly reduced by water stress. Apparent harvest index varied between 0.36 and 0.56. The above ground dry matter production and seed yield were directly dependent upon availability of water during critical productive states.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agricultural Botany field of Sher-e-Bangla Agricultural University, Dhaka during the *Rabi* season from October, 2011 to February, 2012 to study the influence of water deficit on the morphophysiology and yield attributes of mungbean. Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Description of the experimental site

3.1.1 Site and soil

Geographically the experimental field was located at $23^0 77'$ latitude and $88^0 33'$ E longitudes at an altitude of 9 m above the mean sea level. The soil is belonged to the Agro-ecological Zone – Modhupur Tract (AEZ 28). The land topography was medium high and soil texture was silt clay with pH 8.0. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-1.

3.1.2 Climate and weather

The climate of the locality is subtropical which is characterized by high temperature and heavy rainfall during *Kharif* season (April-September) and scanty rainfall during *Rabi* season (October-March) associated with moderately low temperature. The prevailing weather conditions during the study period have been presented in Appendix-II.

3.2 Plant materials

BARI mung-2:

BARI mung-2 was used as planting material. BARI mung-2 was released and developed by BARI in 1987. Plant height of the cultivar ranges from 55 to 60 cm. It is resistant to cercospora leaf spot and tolerant to yellow mosaic virus. Its life cycle is about 60 to 65 days after emergence. One of the main characteristics of this cultivar is synchronization of pod ripening. Average yield of this cultivar is about 1500 kg ha^{-1}. The seeds of BARI mung-2 for the experiment were collected from BARI, Joydepur Gazipur. The seeds were drum-shaped, dull and greenish and free from mixture of other seeds, weed seeds and extraneous materials.

BARI mung-3:

BARI mung-3 was used as planting material. BARI mung-3 was released and developed by BARI in 1996. Plant height of the cultivar ranges from 50 to 55 cm. It is resistant to cercospora leaf spot and tolerant to yellow mosaic virus. Its life cycle is about 50 to 55 days after emergence. One of the main characteristics of this cultivar is synchronization of pod ripening. Average yield of this cultivar is about 1300 kg ha^{-1}. The seeds of BARI mung-3 for the experiment were collected from BARI, Joydepur Gazipur. The seeds were drum-shaped, dull and greenish and free from mixture of other seeds, weed seeds and extraneous materials.

BARI mung-4:

BARI mung-4 was used as planting material. BARI mung-4 was released and developed by BARI in 1996. Plant height of the cultivar ranges from 52 to 57 cm. It is resistant to cercospora leaf spot and tolerant to yellow mosaic virus. Its life cycle is about 60 to 65 days after emergence. One of the main characteristics of this cultivar is synchronization of pod ripening. Average yield of this cultivar is about 1400 kg ha^{-1}. The seeds of BARI mung-4 for the experiment were collected from BARI, Joydepur Gazipur. The seeds were drum-shaped, dull and greenish and free from mixture of other seeds, weed seeds and extraneous materials.

BARI mung-5:

BARI mung-5 was used as planting material. BARI mung-5 was released and developed by BARI in 1997. Plant height of the cultivar ranges from 40 to 45 cm. It is resistant to cercospora leaf spot and tolerant to yellow mosaic virus. Its life cycle is about 55 to 60 days after emergence. One of the main characteristics of this cultivar is synchronization of pod ripening. Average yield of this cultivar is about 1700 kg ha^{-1}. The seeds of BARI mung-5 for the experiment were collected from BARI, Joydepur Gazipur. The seeds were large shaped, deep green and free from mixture of other seeds, weed seeds and extraneous materials

BARI mung-6:

BARI mung-6 was used as planting material. BARI mung-6 was released and developed by BARI in 2003. Plant height of the cultivar ranges from 40 to 45 cm. It is resistant to cercospora leaf spot and tolerant to yellow mosaic virus. Its life cycle is about 55 to 58 days after emergence. One of the main characteristics of this cultivar is synchronization of pod ripening. Average yield of this cultivar is about 1800 kg ha^{-1}. The seeds of BARI mung-6 for the experiment were collected from BARI, Joydepur Gazipur. The seeds were large shaped, deep green and free from mixture of other seeds, weed seeds and extraneous materials. The seeds had a 30% yield advantage over BARI mung-6).

3.3 Treatments under investigation

There were two factors in the experiment namely variety and irrigation levels as mentioned below:

Factor-A: Variety-5

V_1 = BARI mung 2

V_2 = BARI mung 3

V_3 = BARI mung 4

V_4 = BARI mung 5

V_5 = BARI mung 6

Factor-B: irrigation levels

1. I_1 : three irrigations were provided during the whole life cycle of the plant.
2. I_2: two irrigations were provided during the whole life cycle of the plant.
3. I_3: One irrigation was provided during the whole life cycle of the plant.
4. I_4: No irrigation was provided during the whole life cycle of the plant.

Thus the Treatment combinations were as Follows:

I_1V_1, I_2V_1, I_3V_1, I_4V_1, I_1V_2, I_2V_2, I_3V_2, I_4V_2, I_1V_3, I_2V_3, I_3V_3, I_4V_3, I_1V_4, I_2V_4, I_3V_4, I_4V_4, I_1V_5, I_2V_5, I_3V_5 and I_4V_5

3.4 Experimental design and layout

The experiment was laid out in a two factors with randomized complete block design (RCBD) having three replications. Each replication had 20 unit plots to which the treatment combinations were assigned randomly. The unit plot size was 3 m^2 (1m ×3m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing respectively. Lay out of the experiment was done on 12 October, 2011. The lay out of the experiment is presented in Appendix III.

3.5 Land preparation

The experimental land was opened with a power tiller on 14^{th} October, 2011. Ploughing and cross ploughing were done with country plough followed by laddering. Land preparation was completed on 19th October, 2011 and was ready for sowing of seeds.

3.6 Fertilizer application

The fertilizers were applied as basal dose at final land preparation where N, K_2O, P_2O_5 Ca and S were applied @ 20.27 kg ha^{-1}, 33 kg ha^{-1}, 48 kg ha^{-1}, 3.3 kg ha^{-1} and 1.8 kg ha^{-1} respectively in all plots. All fertilizers were applied by broadcasting and mixed thoroughly with soil (Afzal *et al.* 2003).

3.7 Sowing of seeds

Seeds were sown at the rate of 45 kg ha^{-1} in the furrow on April 05, 2011 and the furrows were covered with the soils soon after seeding. The line to line (furrow to furrow) distance was maintained in treatment arrangements with continuous sowing of seeds in the line.

3.8 Emergence of seeds

Seed emergence occurred from 3rd day of sowing. On the 4th day the percentage of emergence was more than 85% and on the 5th day nearly all baby plants (seedlings) came out of the soil.

3.9 Intercultural operations

3.9.1 Weed control

Weeding was done once in all the unit plots with care so as to maintain a uniform plat population as per treatment in each plot at 15 DAS.

3.9.2 Thinning

Thinning was done at 20 days after sowing (DAS) and 35 DAS. Plant to plant distance was maintained at 10 cm.

3.9.3 Irrigation and drainage

Irrigation was provided as per treatment.

3.9.4 Insect and pest control

Hairy caterpillar was successfully controlled by the application of Malathion 57 EC @ 1.5 L ha^{-1} on the time of 50% pod formation stage (55 DAS).

3.10 Determination of maturity

At the time when 80% of the pods turned brown colour, the crop was considered to attain maturity.

3.11 Harvesting and sampling

The crop was harvested at 70 DAS from prefixed 1.0 m^2 areas. Before harvesting ten plants were selected randomly from each plot and were uprooted for data recording. The rest of the plants of prefixed 1 m^2 area were harvested plot wise and were bundled separately, tagged and brought to the threshing floor.

3.12 Threshing

The crop was sun dried for three days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks.

3.13 Drying, cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level. The dried seeds and straw were cleaned and weighed.

3.14 Recording of characters

i. Days to first emergence

Dates of first emergence were recorded treatment wise and the period of time for first emergence in days was calculated from the date of sowing.

ii. Plant height (cm)

The height of the selected plant was measured from the ground level to the tip of the plant at 15, 25, 35, 45 and 55 days after sowing (DAS).

iii. Number of leaves per plant

Number of leaves per plant was counted from each selected plant sample and then averaged at 15, 25, 35, 45 and 55 days after sowing.

iv. Number of branch per plant

Number of branch per plant was counted from each selected plant sample and then averaged at 15, 25, 35, 45 and 55 days after sowing.

v. Days to first flowering

Dates of first flowering were recorded treatment wise and the period of time for first flowering in days was calculated from the date of sowing.

vi. Days to last flowering

Dates of last flowering were recorded treatment wise and the period of time for last flowering in days was calculated from the date of sowing.

vii. Days to first fruit set

Dates of first fruit set were recorded treatment wise and the period of time for first fruit set in days was calculated from the date of sowing.

viii. Days to first maturity

Dates of first maturity were recorded treatment wise and the period of time for first maturity in days was calculated from the date of sowing.

ix. Number of flower per plant

Number of flower plant^{1} was counted from the 10 selected plant samples and then the average flower number was calculated.

x. Pod length (cm)

Pod length was measured in centimeter (cm) scale from randomly selected ten pods. Mean value of them was recorded as treatment wise.

xi. Seed yield per plant (g)

Seed yield was recorded on the basis of total harvested seeds plant^{1} and was expressed in terms of yield (g). Seed yield was adjusted to 12% moisture content.

xii. Seed yield (t ha^{-1})

Seed yield was recorded on the basis of total harvested seeds plot^{-1} and was expressed in terms of yield (t ha^{-1}). Seed yield was adjusted to 12% moisture content.

3.15 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and the mean differences were adjusted by Least Significance Difference (LSD) test (Gomez & Gomez, 1986).

CHAPTER IV

RESULTS AND DISCUSSION

Result obtained from the present study have been presented and discussed in this chapter. The data have been presented in different tables and figures. The results have been presented and discussed and possible interpretations are given under the following headings.

4.1 Days to emergence of seedlings

The days to emergence of seedlings was not significantly affected due to the varieties of mungbean. The maximum days to emergence of seedlings average of (3.75) was obtained from days to emergence of seedlings V_3 (BARI mung 4) and V_4 (BARI mung 6) and the minimum days to emergence of seedlings average of (3.33) was obtained in V_1 (BARI mung 2), V_2 (BARI mung 3) and V_5(BARI mung 6) (Fig. 1).

Days to emergence of seedlings was influenced by irrigation. The maximum days to emergence of seedlings average of (3.53) was obtained from I_1 (three irrigations), I_2 (two irrigations) and I_3 (One irrigation) treatment and the minimum (3.40) from I_4 (no irrigation) (Fig. 2).

Interaction effect of varieties and number of irrigation had a significant variation on days to emergence of seedlings. The maximum days to emergence of seedlings (4.00) was obtained from V_3I_4 and V_4I_4 treatment while the shortest (3.00) with V_5I_3 and V_5I_4 (Table 1) was obtained from.

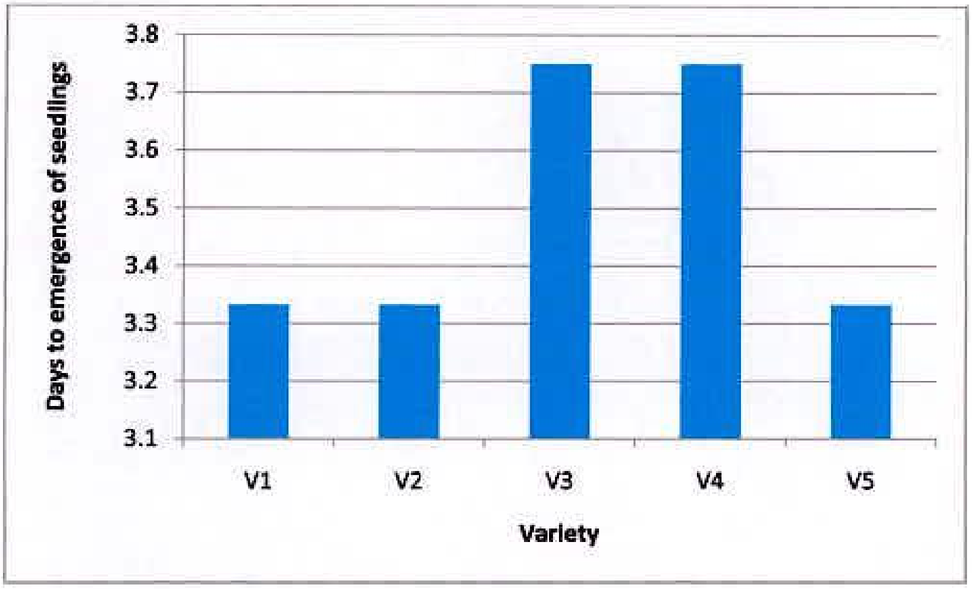

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Fig.1 Effect of varieties of mungbean on days to emergence of seedlings of seed

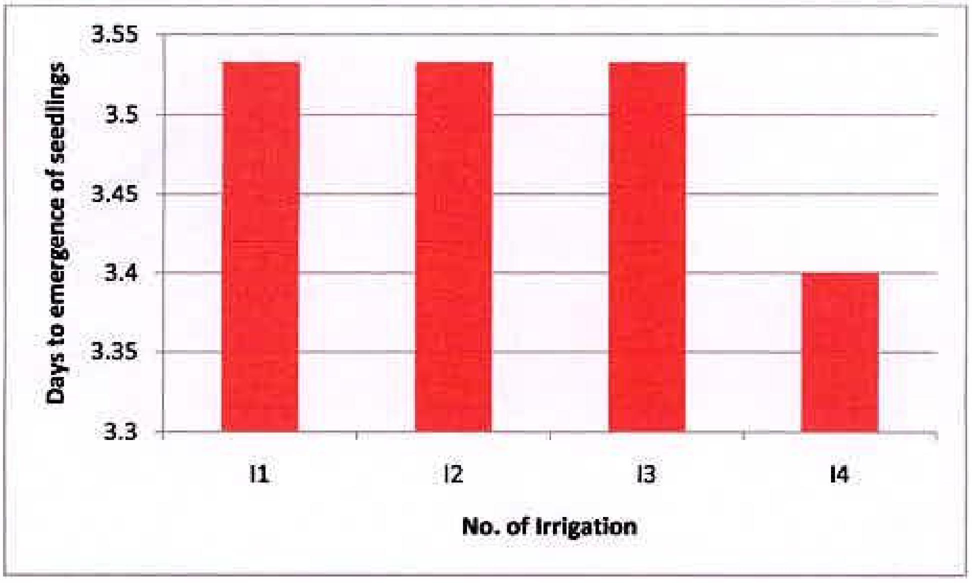

Fig.2 Effect of no. of irrigation of mungbean on days to emergence of seedlings of seed

Table 1. Effect of varieties and no. of irrigation interaction on the days to emergence of seedlings of mungbean

Treatment	Days to emergence of seedlings
V_1I_1	3.33 ab
V_1I_2	3.33 ab
V_1I_3	3.33 ab
V_1I_4	3.33 ab
V_2I_1	3.33 ab
V_2I_2	3.33 ab
V_2I_3	3.33 ab
V_2I_4	3.33 ab
V_3I_1	3.66 ab
V_3I_2	3.66 ab
V_3I_3	3.66 ab
V_3I_4	4.00 a
V_4I_1	3.66 ab
V_4I_2	3.66 ab
V_4I_3	3.66 ab
V_4I_4	4.00 a
V_5I_1	3.66 ab
V_5I_2	3.66 ab
V_5I_3	3.00 b
V_5I_4	3.00 b
LSD $_{(0.05)}$	0.768
CV (%)	13.17

In a column same letter(s) do not significantly differ at 0.05 level of probability.

4.2 Plant height

Data on plant height were recorded periodically at 15, 25, 35, 45, and 55 days after sowing (DAS). The plant height was significantly affected due to the different varieties at different days after sowing. The tallest plant height (16.67, 32.92, 40.59, 43.57 and 44.99 cm at 15, 25, 35, 45, and 55 DAS, respectively) was obtained from V_1 (BARI mung 2) and the shortest plant height (9.18, 27.21, 34.90, 36.75 and 38.58 cm at 15, 25, 35, 45, and 55 days DAS, respectively) was obtained in V_5 (BARI mung6) (Fig. 3). This variation in plant height might be attributed to the genetic characters. Similar findings of plant heights were obtained by Farghali and Hossein (1995).

Plant height was influenced by number of irrigation. The tallest plant (15.13, 32.57, 39.92, 42.19 and 43.70 cm at 15, 25, 35, 45, and 55 days DAS, respectively) was obtained from I_2 treatment and the shortest (12.17, 29.03, 36.48, 39.17 and 40.86 cm at 15, 25, 35, 45, and 55 days DAS, respectively) from I_4 (Fig. 4).

Interaction effect of different varieties and irrigation had a significant variation on plant height. The tallest plant (18.07, 34.18, 41.65, 44.62 and 46.31 cm at 15, 25, 35, 45, and 55 days DAS, respectively) was obtained from V_1I_2 (BARI mung 2 with two irrigation) treatment while the shortest (8.37, 24.03, 32.25, 34.48 and 37.08 cm at 15, 25, 35, 45, and 55 days DAS, respectively) with V_5I_4 (BARI mung 6 with no irrigation) (Table 2).

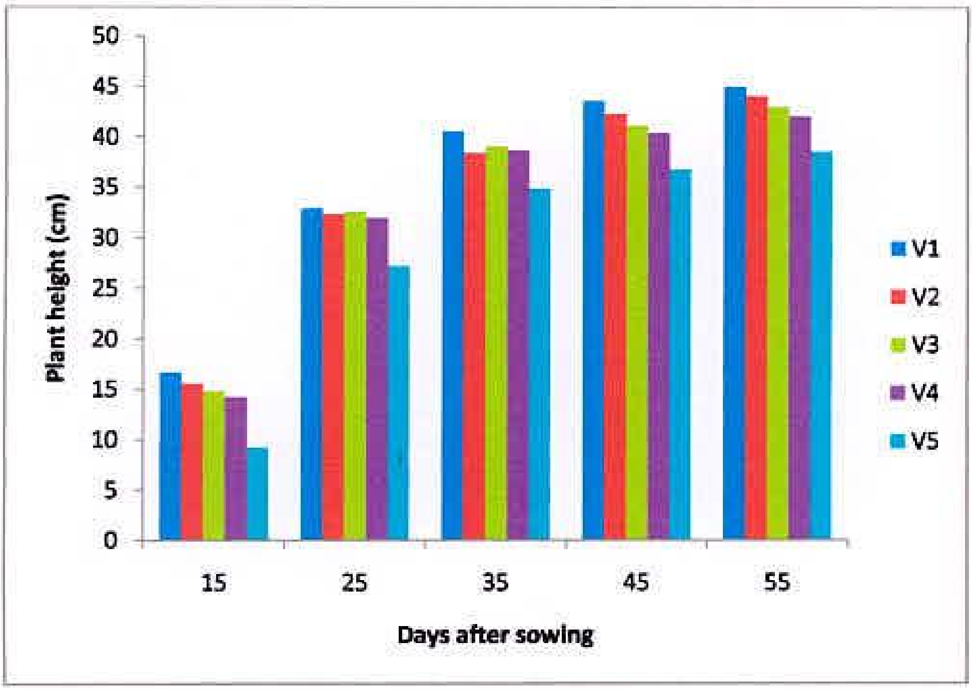

Figure 3. Effect of varieties on the plant height of mungbean at different days after sowing

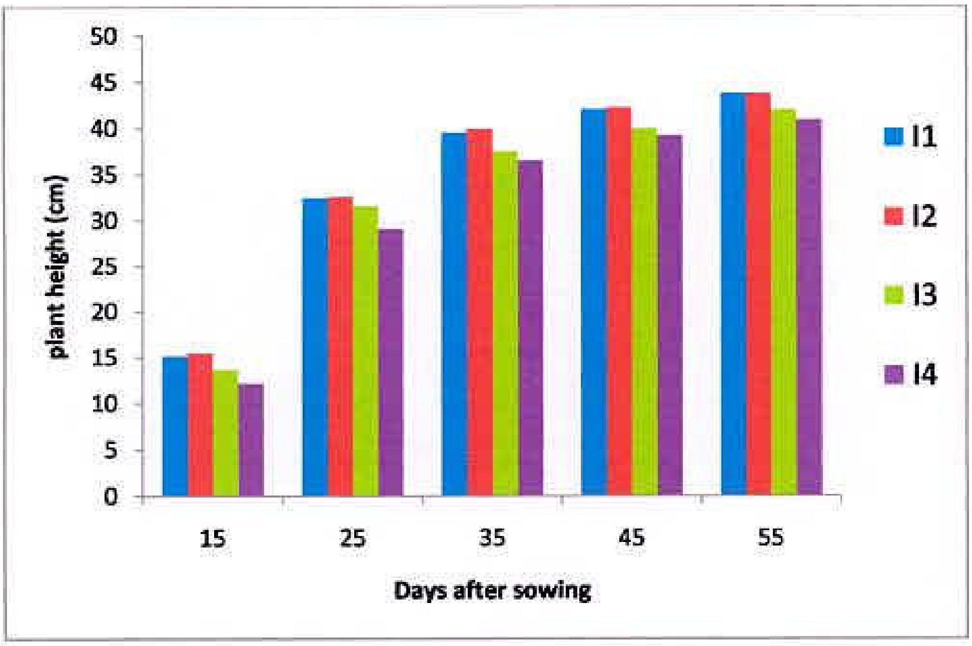

Figure 4. Effect of irrigation on the plant height of mungbean at different days after sowing

Table 2. Effect of varieties and irrigation interaction on the plant height of mungbean plant at different days

Treatment	Plant height (cm)									
	15 DAS		25 DAS		35 DAS		45 DAS		55 DAS	
V_1I_1	17.00	ab	33.45	abc	41.57	a	44.53	a	45.46	ab
V_1I_2	18.07	a	34.18	a	41.65	a	44.62	a	46.31	a
V_1I_3	16.27	abcd	32.40	abcd	39.71	abc	42.69	abc	44.70	abcd
V_1I_4	15.33	abcd	30.43	bcdef	39.42	abc	42.43	abc	43.49	abcde
V_2I_1	16.73	abc	33.55	abc	40.46	ab	42.32	abc	44.46	abcd
V_2I_2	16.87	ab	33.03	abc	38.14	abc	43.82	ab	45.28	abc
V_2I_3	15.53	abcd	32.82	abc	38.89	abc	42.64	abc	44.76	abcd
V_2I_4	13.20	de	30.03	cdef	36.18	cd	40.37	abcd	41.92	abcdefg
V_3I_1	16.49	abcd	33.71	ab	41.59	a	43.69	ab	45.53	ab
V_3I_2	15.38	abcd	33.33	abc	40.32	ab	42.13	abc	43.91	abcde
V_3I_3	14.00	bcd	33.23	abc	38.30	abc	40.44	abcd	42.90	abcdef
V_3I_4	13.47	cd	31.41	abcde	36.13	cd	38.25	bcde	39.73	defg
V_4I_1	16.71	abc	33.31	abc	39.84	abc	41.72	abc	43.90	abcde
V_4I_2	16.05	abcd	33.08	abc	39.55	abc	41.41	abc	42.90	abcdef
V_4I_3	13.79	bcd	32.22	abcd	36.90	bcd	38.14	bcde	40.34	cdefg
V_4I_4	10.47	ef	29.26	def	38.41	abc	40.34	abcd	41.11	bcdefg
V_5I_1	10.27	ef	28.40	ef	36.11	cd	37.85	cde	39.13	efg
V_5I_2	9.30	f	29.21	def	37.66	abc	38.96	abcde	40.10	defg
V_5I_3	8.79	f	27.21	f	33.59	de	35.72	de	38.02	fg
V_5I_4	8.37	f	24.03	g	32.25	e	34.48	e	37.08	g
LSD $_{(0.05)}$	2.81		3.02		3.36		4.86		4.27	
CV (%)	12.05		5.85		5.31		7.20		6.07	

In a column same letter(s) do not significantly differ at 0.05 level of probability.

4.3 Number of leaves per plant

The number of leaves per plant counted at different days was significantly influenced by varieties. Treatment V_2 produced maximum number of leaves (3.00, 5.3, 7.62, 8.97 and 9.88 at 15, 25, 35, 45, and 55 days DAS, respectively) and the minimum (3.00, 3.92, 5.05, 6.05 and 7.40 at 15, 25, 35, 45, and 55 days DAS, respectively) number of leaves were recorded in V_5 treatment (Fig. 5).

Significant difference was observed due to various number of irrigation in respect of number of leaf per plant. The highest number of leaves (3.00, 5.11, 7.11, 8.76 and 9.45 at 15, 25, 35, 45, and 55 days DAS, respectively) was obtained from I_1 and the lowest (3.0, 3.96, 5.39, 6.65 and 7.83 at 15, 25, 35, 45, and 55 days DAS, respectively) from in I_4 (Fig. 6).

Interaction effect of different varieties and different number of irrigation had a significant variation on number of leaves. The highest number of leaves (3.00, 5.60, 9.00, 9.60 and 10.37 at 15, 25, 35, 45, and 55 days DAS, respectively) was obtained from V_2I_2 treatment while the lowest (3.0, 3.33, 4.13, 4.13 and 6.07 at 15, 25, 35, 45, and 55 days DAS, respectively) with V_5I_4 combination (Table 3).

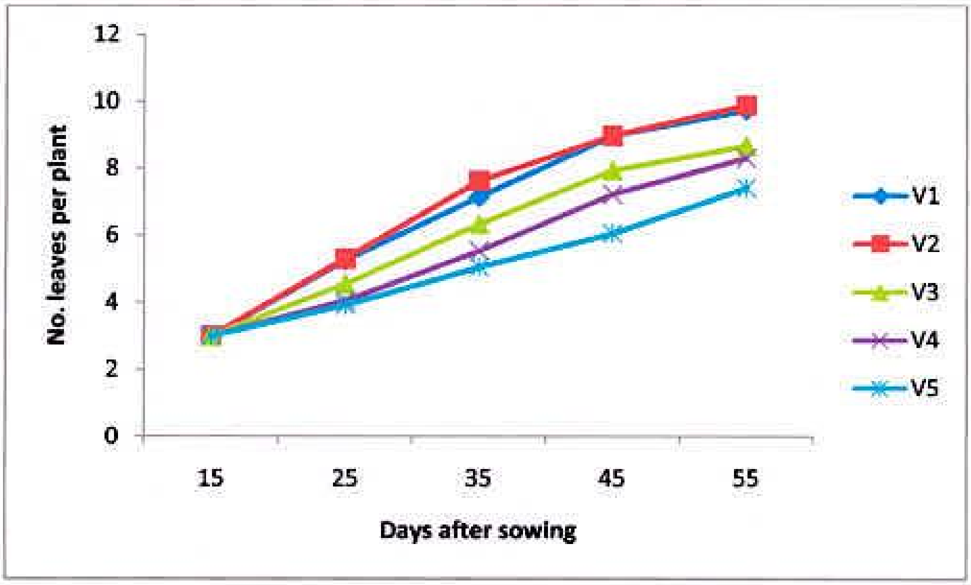

Figure 5. Effect of varieties on the number of leaves of mungbean at different days after sowing

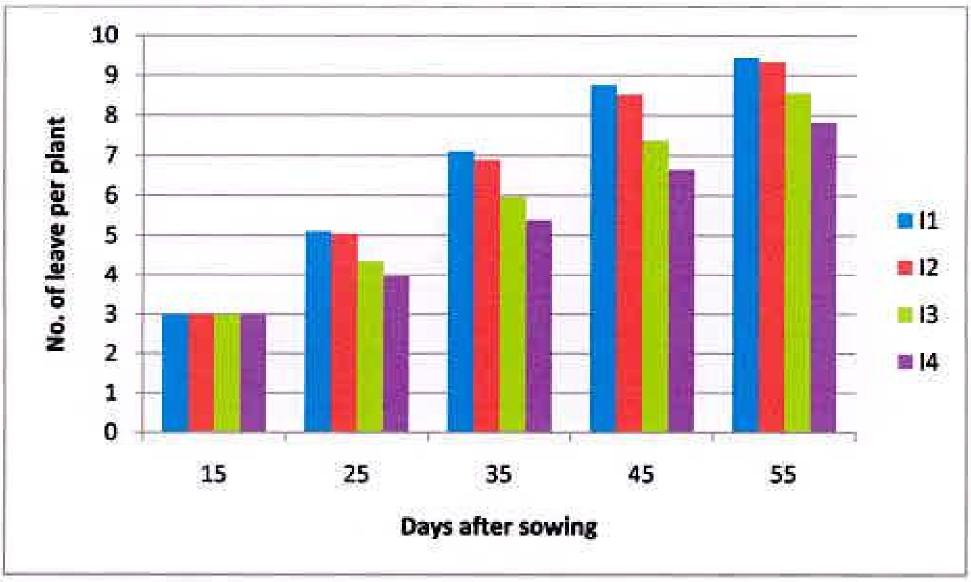

Figure 6. Effect of irrigation on the number of leaves of mungbean at different days after sowing

Table 3. Effect of varieties and irrigation interaction on the number of leaves of mungbean plant at different days after sowing

	Number of leaves per plant									
Treatment	15 DAS		25 DAS		35 DAS		45 DAS		55 DAS	
V_1I_1	3	a	5.60	a	7.40	bc	9.53	a	10.00	a
V_1I_2	3	a	5.60	a	7.47	bc	9.27	ab	9.93	a
V_1I_3	3	a	5.13	abc	7.07	bcd	8.60	abc	9.93	a
V_1I_4	3	a	4.67	abcd	6.60	cd	8.40	abc	9.67	ab
V_2I_1	3	a	5.53	ab	7.60	b	9.53	a	10.07	a
V_2I_2	3	a	5.60	a	9.00	a	9.60	a	10.37	a
V_2I_3	3	a	5.27	abc	7.07	bcd	8.60	abc	9.27	abcd
V_2I_4	3	a	4.80	abcd	6.80	bcd	8.20	abcd	9.20	abcd
V_3I_1	3	a	5.47	ab	7.40	bc	9.00	ab	9.60	abc
V_3I_2	3	a	5.33	ab	7.20	bcd	9.07	ab	9.60	abc
V_3I_3	3	a	3.93	def	5.73	ef	7.13	cdef	8.13	cde
V_3I_4	3	a	3.47	ef	5.00	fg	6.53	ef	7.33	ef
V_4I_1	3	a	4.60	bcd	6.33	de	8.33	abc	9.33	abcd
V_4I_2	3	a	4.60	bcd	6.40	de	7.93	bcde	8.93	abcd
V_4I_3	3	a	3.47	ef	5.00	fg	6.60	ef	8.07	de
V_4I_4	3	a	3.53	ef	4.40	gh	6.00	f	6.87	ef
V_5I_1	3	a	4.33	cde	5.67	ef	7.33	cdef	8.27	bcde
V_5I_2	3	a	4.07	def	5.47	f	6.80	def	7.87	de
V_5I_3	3	a	3.93	def	4.93	fgh	5.93	f	7.40	ef
V_5I_4	3	a	3.33	f	4.13	h	4.13	g	6.07	f
$LSD_{(0.05)}$	0.8081		0.83		0.77		1.32		1.30	
CV (%)	16.03		10.87		7.39		10.19		8.95	

In a column same letter(s) do not significantly differ at 0.05 level of probability.

4.4 Number of branches per plant

The number of branches per plant counted at different days was significantly influenced by varieties. Treatment V_2 produced maximum number of branches (2.48, 3.48, 4.36, and 4.72 at, 25, 35, 45, and 55 days DAS, respectively) and the minimum (1.73, 2.37, 2.92, and 3.53 at 25, 35, 45, and 55 days DAS, respectively) number of branches were recorded in V_5 treatment (Fig. 7). This variation in number of branches per plant might be attributed to the genetic character.

Significant difference was observed due to various number of irrigation in respect of number of branches per plant. The highest number of branches (2.36, 3.23, 4.19 and 4.55 at, 25, 35, 45, and 55 days DAS, respectively) was obtained from I_1 and the lowest (1.80, 2.46, 3.13 and 3.67 at 25, 35, 45, and 55 days DAS, respectively) from in I_4 (Fig. 8).

Interaction effect of different varieties and different number of irrigation had a significant variation on number of branches. The highest number of branches (2.6, 3.6, 5.1, and 4.9 at 25, 35, 45, and 55 days DAS, respectively) was obtained from V_2I_1 treatment while the lowest (1.4, 1.73, 2.53 and 2.90 at 25, 35, 45, and 55 days DAS, respectively) with V_5I_4 combination (Table 4).

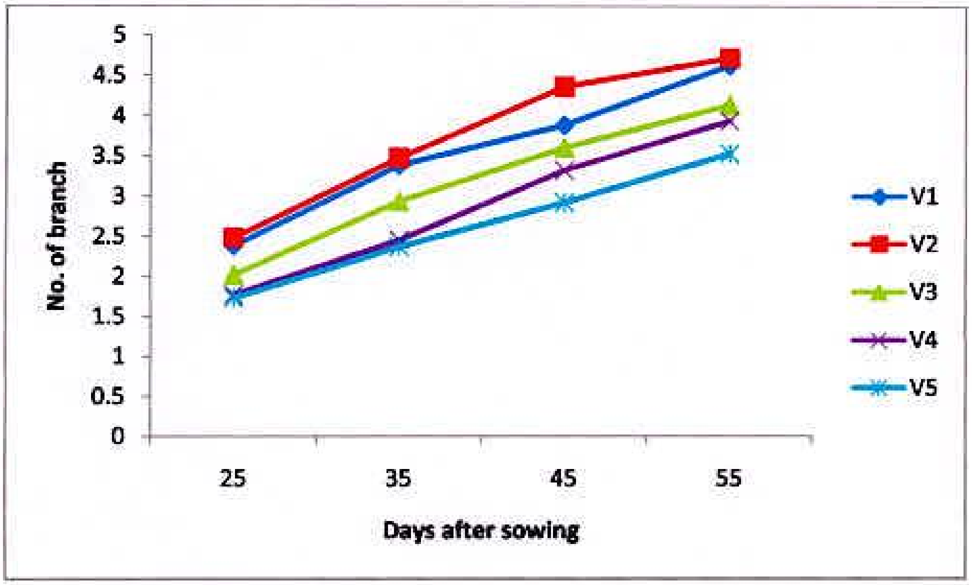

Figure 7. Effect of varieties on the number of branches of mungbean at different days after sowing

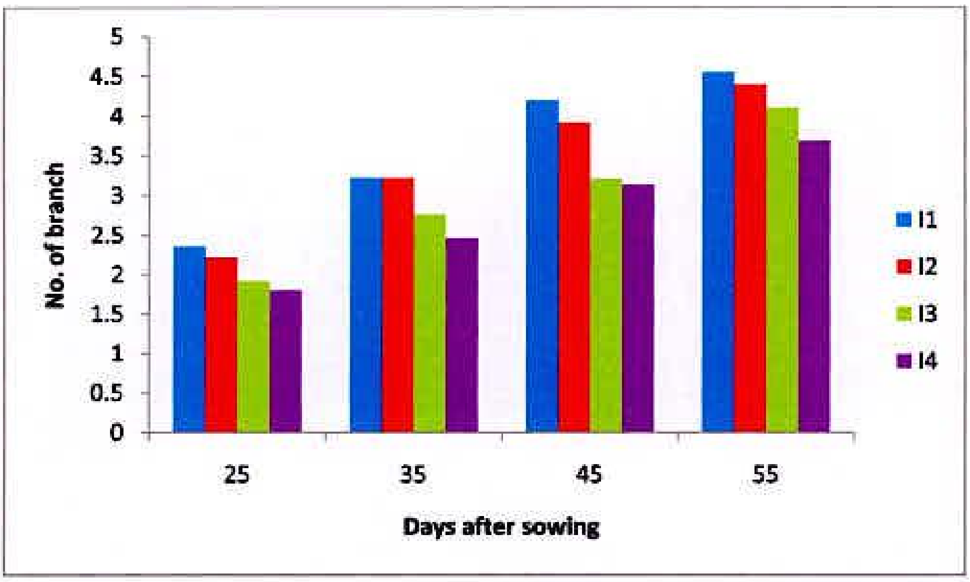

Figure 8. Effect of irrigation on the number of branches of mungbean at different days after sowing

Table 4. Effect of varieties and irrigations interaction on the number of branches of mungbean plant at different days after sowing

Treatment	Number of branches			
	25 DAS	35 DAS	45 DAS	55 DAS
V_1I_1	2.60 a	3.53 ab	4.53 ab	4.80 ab
V_1I_2	2.40 abc	3.53 ab	4.33 abc	4.73 ab
V_1I_3	2.40 abc	3.33 abc	2.73 fgh	4.73 ab
V_1I_4	2.13 bcd	3.13 cd	3.93 bcde	4.60 abc
V_2I_1	2.60 a	3.60 a	5.10 a	4.90 a
V_2I_2	2.40 abc	3.60 a	4.53 ab	4.73 ab
V_2I_3	2.47 ab	3.43 ab	3.87 bcde	4.47 bc
V_2I_4	2.47 ab	3.27 bc	3.93 bcde	4.40 bc
V_3I_1	2.53 a	3.47 ab	4.00 bcde	4.60 abc
V_3I_2	2.47 ab	3.47 ab	4.13 abcd	4.53 abc
V_3I_3	1.60 fg	2.53 ef	3.33 cdefgh	4.00 de
V_3I_4	1.47 fg	2.27 fg	2.93 efgh	3.40 gh
V_4I_1	2.07 cde	2.93 d	3.80 bcdef	4.53 abc
V_4I_2	2.07 cde	2.93 d	3.67 bcdefg	4.27 cd
V_4I_3	1.40 g	2.20 g	3.07 defgh	3.80 ef
V_4I_4	1.53 fg	1.93 h	2.73 fgh	3.13 hi
V_5I_1	2.00 de	2.60 e	3.53 bcdefgh	3.93 de
V_5I_2	1.80 def	2.60 e	2.93 efgh	3.73 efg
V_5I_3	1.73 efg	2.33 efg	2.67 gh	3.53 fg
V_5I_4	1.40 g	1.73 h	2.53 h	2.90 i
$LSD_{(0.05)}$	0.31	0.27	0.96	0.37
CV (%)	9.09	5.52	16.01	5.27

In a column same letter(s) do not significantly differ at 0.05 level of probability.

4.5 Days to first flowering

There was a marked difference among the varieties in the days to first flowering. The earliest of days to first flowering (32 DAS) was found in V_1 and the longest time were recorded in V_5 treatment (35 DAS) (table 5).

Significant difference was observed due to various number of irrigation in respect of days to first flowering. Delayed first flowering (35.6 days) was found in I_4 and first flowering (31.6 DAS) was earlier then other treatment from I_1 (table 6).

Interaction effect of different varieties and different number of irrigation had a significant variation on days to first flowering. The minimum days to first flowering (30) was obtained from V_1I_1 treatment while the maximum (36 days) with V_3I_4 combination which was statistically similar in V_4I_4, V_5I_3 and V_5I_4 (Table 7)

4.6 Days to last flowering

There was a significant difference among the varieties in the days to last flowering. The longest time of days to last flowering (49.08 DAS) was found in V_1 and the earliest of days to last flowering were recorded in V_5 treatment (35 DAS) (table 5).

Significant difference was observed due to various number of irrigation in respect of days to last flowering. Delayed first flowering (47.33 days) was found in I_4 and last flowering (41.8 DAS) was earliest from I_1 (table 6).

Interaction effect of different varieties and different number of irrigation had a significant variation on days to last flowering. The maximum days to last flowering (53.33) was obtained from V_1I_1 treatment while the minimum (36 days) with V_5I_4 combination which was statistically similar result in V_5I_3. (Table 7)

Table 5. Effect of varieties on the days to first, last flowering, first fruit setting and first maturity of pod of mungbean plant

Treatment	Days to first flowering		Days to last flowering		Days to first fruit set		Days to first Maturity	
V_1	32	b	49.08	a	38.83	a	61.17	b
V_2	32.75	ab	46.5	ab	39.92	a	61.67	b
V_3	34	ab	44.08	b	41.5	a	68.67	a
V_4	34	ab	45.67	ab	41.5	a	68.25	a
V_5	35	a	35	c	43.33	a	73	a
$LSD_{(0.05)}$	2.21		4.64		4.4		6.222	
CV(%)	4.65		4.75		4.12		14.98	

In a column same letter(s) do not significantly differ at 0.05 level of probability.

Table 6. Effect of irrigation on the days to first, last flowering, first fruit setting and first maturity of pod of mungbean plant

Treatment	Days to first flowering		Days to last flowering		Days to first fruit set		Days to first Maturity	
I_1	31.6	c	41.8	b	38.07	b	62.27	b
I_2	32.8	bc	42.73	ab	40.4	ab	65.27	ab
I_3	34.2	ab	44.4	ab	41.27	ab	67.33	ab
I_4	35.6	a	47.33	a	44.33	a	71.33	a
$LSD_{(0.05)}$	1.606		5.318		5.044		7.132	
CV(%)	4.65		4.75		4.12		14.98	

In a column same letter(s) do not significantly differ at 0.05 level of probability.

Table 7. Effect of varieties and irrigation interaction on the days to first, last flowering, first fruit setting and first maturity of pod of mungbean plant

Treatment	Days to first flowering (DAS)		Days to last flowering (DAS)		Days to first fruit set (DAS)		Days to first Maturity (DAS)	
V_1I_1	30	b	53.33	a	35	e	56.33	h
V_1I_2	31	ab	43.67	fg	38.33	de	60.33	gh
V_1I_3	32	ab	45.67	defg	39.33	cd	61.33	gh
V_1I_4	35	ab	43.33	fg	42.67	abc	66.67	ef
V_2I_1	31	ab	46.67	cdef	37.67	de	57.67	h
V_2I_2	32	ab	47.67	cde	38.67	d	58.33	h
V_2I_3	33	ab	50	abc	40.67	bcd	64	fg
V_2I_4	35	ab	52	ab	42.67	abc	66.67	ef
V_3I_1	32	ab	42.33	g	38.33	de	64	fg
V_3I_2	33	ab	42.67	g	41	bcd	68	def
V_3I_3	35	ab	44.67	efg	41.33	bcd	69.33	bcde
V_3I_4	36	a	46.67	cdef	45.33	a	73.33	abc
V_4I_1	32	ab	43.67	fg	38	de	64	fg
V_4I_2	33	ab	44.67	efg	41.33	bcd	67.33	def
V_4I_3	35	ab	45.67	defg	41.33	bcd	68.33	cdef
V_4I_4	36	a	48.67	bcd	45.33	a	73.33	abc
V_5I_1	33	ab	33	h	41.33	bcd	69.33	bcde
V_5I_2	35	ab	35	h	42.67	abc	72.33	abcd
V_5I_3	36	a	36	h	43.67	ab	73.67	ab
V_5I_4	36	a	36	h	45.67	a	76.67	a
LSD $_{(0.05)}$	4.176		3.383		3.209		4.537	
CV(%)	4.65		4.75		4.12		14.98	

In a column same letter(s) do not significantly differ at 0.05 level of probability.

4.7 Days to first pod set

There was a marked difference among the varieties in the days to first pod setting. The earliest of days to first pod setting (38.83 DAS) was found in V_1 and the longest time (43.33 DAS) were recorded in V_5 treatment (table 5).

Significant difference was observed due to various number of irrigation in respect of days to first pod setting. Delayed first pod setting (44.33 days) was found in I_4 and first pod setting (38.07 DAS) was earliest from I_1 (table 6).

Interaction effect of different varieties and different number of irrigation had a significant variation on days to first pod setting. The minimum days to first pod setting (35 days) was obtained from V_1I_1 treatment while the maximum (45.67 days) with V_5I_4 combination which was statistically similar in V_3I_4 and V_4I_4 (Table 7)

4.8 Days to first maturity

There was a significant difference among the varieties in the days to first maturity. The earliest of days to first maturity (61.17 DAS) was found in V_1 and the longest time (73.00 DAS) were recorded in V_5 treatment (table 5).

Significant difference was observed due to various number of irrigation in respect of days to first maturity. Delayed first maturity (71.33 days) was found in I_4 and first pod setting (62.27 DAS) was earliest from I_1 (table 6).

Interaction effect of different varieties and different number of irrigation had a significant variation on days to first maturity. The minimum days to first maturity (56.33 days) was obtained from V_1I_1 treatment while the maximum (76.67 days) with V_5I_4 combination (Table 7).

4.9 Number of flower per plant

The number of flower per plant was significantly affected by varieties. The highest number of flower per plant (11.25) was recorded in V_1 and the minimum (4) in V_5 (Table 8).

There was significant variation in the number of flower per plant due to the different irrigation. The maximum number of flower per plant (11.00) was obtained from I_1 treatment and the minimum (5.53) was from I_4 treatment (Table 9).

Interaction effect of different varieties and irrigation had a significant effect on number of flower per plant. The highest number of flower per plant (13.67) was obtained from V_1I_1 treatment which was statistically similar in V_1I_2 and V_2I_1 while the lowest (2.67) from V_5I_4 (Table 10).

4.10 Pod Length

Pod length is one of the most important yield contributing characters in mungbean. Varieties showed significant difference in pod length (Table 8). The longest pod length (8.11 cm) was recorded in V_1 and the shortest (6.64 cm) in V_5. This result is agreement with the result of Sarkar *et al.* (2004) who reported that pod length differed from varieties to varieties. The probable reason of this difference could be the genetic make-up of the varieties.

However, there was significant variation in the pod length due to the sowing time. Numerically the longest pod length (7.8 cm) was obtained from I_1 treatment and the minimum (6.96 cm) was obtained in I_4 treatment (Table 9).

Table 8. Effect of varieties on the yield contributing characters of mungbean plant

Treatment	No. of flower per plant	Pod length (cm)	Seed weight per plant (gm)	Yield (t/ha)
V_1	11.25 a	8.11 a	5.041 a	1.39 a
V_2	10.5 ab	7.74 ab	4.932 a	1.32 b
V_3	8.5 ab	7.48 bc	3.822 b	1.15 c
V_4	8.25 b	7.01 cd	3.593 b	1.02 d
V_5	4 c	6.64 d	2.138 c	0.85 e
$LSD_{(0.05)}$	2.886	0.56	0.7381	0.07
CV(%)	12.3	5.36	8.35	6.58

In a column same letter(s) do not significantly differ at 0.05 level of probability.

Table 9. Effect of irrigation on the yield contributing characters of mungbean plant

Treatment	No. of flower per plant	Pod length (cm)	Seed weight per plant (gm)	Yield (t/ha)
I_1	11.00 a	7.80 a	6.923 a	1.308 a
I_2	9.67 a	7.61 a	4.465 b	1.186 b
I_3	7.80 ab	7.22 ab	2.534 c	1.097 c
I_4	5.53 b	6.96 b	1.699 c	0.996 d
$LSD_{(0.05)}$	3.308	0.65	0.846	0.082
CV(%)	12.3	5.36	8.35	6.58

In a column same letter(s) do not significantly differ at 0.05 level of probability.

Table 10. Effect of varieties and irrigation interaction on the yield contributing character of mungbean plant

Treatment	No. of flower per plant	Pod length (cm)	Seed weight per plant (gm)	Yield (t/ha)
V_1I_1	13.67 a	8.59 a	10.63 a	1.62 a
V_1I_2	13.33 a	8.44 ab	7.1 c	1.39 c
V_1I_3	10.67 bc	8.04 bc	2.4 j	1.30 de
V_1I_4	7.333 de	7.36 ef	1.893 jkl	1.24 fg
V_2I_1	13.67 a	8.24 abc	8.333 b	1.49 b
V_2I_2	12.00 ab	8.03 bc	4.673 de	1.34 d
V_2I_3	10.00 bc	7.40 ef	2.943 i	1.25 ef
V_2I_4	6.33 e	7.27 efg	1.92 jkl	1.17 hi
V_3I_1	10.67 bc	7.87 cd	7.053 c	1.29 def
V_3I_2	10.00 bc	7.57 de	4.367 ef	1.19 gh
V_3I_3	7.33 de	7.34 ef	2.26 j	1.12 ij
V_3I_4	6.00 ef	7.14 efg	1.607 kl	0.99 k
V_4I_1	11.00 bc	7.29 efg	5.173 d	1.16 hi
V_4I_2	9.00 cd	7.15 efg	4.033 fg	1.09 j
V_4I_3	7.67 de	6.93 fgh	3.6 gh	0.96 k
V_4I_4	5.33 efg	6.66 hi	1.567 kl	0.85 lm
V_5I_1	6.00 ef	6.99 fgh	3.427 hi	0.95 k
V_5I_2	4.00 fgh	6.85 gh	2.153 jk	0.89 l
V_5I_3	3.33 gh	6.36 i	1.507 l	0.82 m
V_5I_4	2.67 h	6.35 i	1.467 l	0.70 n
$LSD_{(0.05)}$	2.104	0.41	0.5381	0.05
CV(%)	12.3	5.36	8.35	6.58

In a column same letter(s) do not significantly differ at 0.05 level of probability.

Interaction effect of different varieties and irrigation had a significant variation on pod length. The longest pod length (8.59 cm) was obtained from V_1I_1 treatment while the shortest (6.35 cm) from V_5I_4 combination (Table 10).

4.11 Number of seeds per plant

The number of seeds per plant was significantly affected by varieties. The highest number of seeds per plant (5.04) was recorded in V_1 and the minimum (2.14) in V_5 (Table 8). A result was found by Infante *et al.* (2003) which was not similar with this study. They found significant difference on number of seeds per pod among the varieties.

There was significant variation in the number of seeds per plant due to the irrigation. The maximum number of seeds per plant (6.92) was obtained from I_1 treatment and the minimum (1.69) was from I_4 treatment (Table 9).

Interaction effect of different varieties and irrigation had a significant effect on number of seeds per plant. The highest number of seeds per pod (10.63) was obtained from V_1I_1treatment while the lowest (1.47) from V_5I_4(Table 10).

4.12 Yield (t/ha)

The yield was significantly affected by varieties. The highest yield (1.39 t/ha) was recorded in V_1 and the minimum (0.85) in V_5 (Table 8). The probable reason of this difference might be due to higher number of pod length, seeds per pod. The performance of other varieties was as intermediate yielder.

There was significant variation in the yield due to the irrigations. The maximum yield (1.31 t/ha) was obtained from I_1 treatment and the minimum (1.00) was from I_4 treatment (Table 9).

Interaction effect of different varieties and irrigations had a significant effect on yield. The highest yield (1.62 t/ha) was obtained from V_1I_1 (BARI mung 2 with three irrigation) treatment while the lowest (0.71) from V_5I_4 (BARI mung 6 with no irrigation) (Table 10).

CHAPTER IV

SUMMARY AND CONCLUSION

The experiment was conducted at the Agricultural Botany field of Sher-e-Bangla Agricultural University, Dhaka during the *Rabi* season from October, 2011 to February, 2012 to study the influence of water deficit on the morphophysiology and yield attributes of mungbean. In experiment, the treatment consisted of five mungbean varieties viz. V_1 = BARI mung 2, V_2 = BARI mung 3, V_3 = BARI mung 4, V_4 = BARI mung 5, V_5 = BARI mung 6 and four different number of irrigation, I_1 = three irrigations, I_2 = two irrigations, I_3 = One irrigation, I_4 = no irrigation. The experiment was laid out in a two factors randomized complete block design (RCBD) with three replications. The fertilizers were applied as basal dose at final land preparation where N, K_2O, P_2O_5 Ca and S were applied @ 20.27 kg ha^{-1}, 33 kg ha^{-1}, 48 kg ha^{-1}, 3.3 kg ha^{-1} and 1.8 kg ha^{-1} respectively in all plots. Necessary intercultural operations were done as and when necessary.

Results showed that a significant variation was observed among the treatments in respect majority of the observed parameters. The collected data were statistically analyzed for evaluation of the treatment effect.

The days to emergence was not significantly affected due to the variety of mungbean. The maximum days to emergence (3.75) was obtained from days to emergence V_3 (BARI mung 4). The plant height was significantly affected due to the different variety at different days after sowing. The tallest plant height (16.67, 32.92, 40.59, 43.57 and 44.99 cm at 15, 25, 35, 45, and 55 DAS, respectively) was obtained from V_1 (BARI mung 2). The number of leaves per plant counted at different days was significantly influenced by variety. Treatment V_2 produced maximum number of leaves (3.00, 5.3, 7.62, 8.97 and 9.88 at 15, 25, 35, 45, and 55 days DAS, respectively). The number of branch per plant counted at different days was significantly influenced by variety. Treatment V_2 produced maximum number of branch (2.48, 3.48, 4.36, and 4.72 at, 25, 35, 45, and 55 days DAS, respectively). The earliest of days to first flowering (32 DAS) was found in V_1.

The longest time of days to last flowering (49.08 DAS) was found in V_1. The earliest of days to first pod setting (38.83 DAS) was found in V_1. The earliest of days to first maturity (61.17 DAS) was found in V_1. The highest number of flower per plant (11.25) was recorded in V_1. The longest pod length (8.11 cm) was recorded in V_1. The number of seeds per plant was significantly affected by variety. The highest seeds weight per plant (5.04g) was recorded in V_1 and the minimum (2.14) in V_5 (BARI mung 6). The highest yield (1.39 t/ha) was recorded in BRRI mung 2.

The maximum days to emergence (3.53) was obtained from I_1 (three irrigations), I_2 (two irrigations) and I_3 (One irrigation) treatment. The tallest plant (15.13, 32.57, 39.92, 42.19 and 43.70 cm at 15, 25, 35, 45, and 55 days DAS, respectively) was obtained from I_2 treatment. The highest number of leaves (3.00, 5.11, 7.11, 8.76 and 9.45 at 15, 25, 35, 45, and 55 days DAS, respectively) was obtained from I_{1} (. The highest number of branch (2.36, 3.23, 4.19 and 4.55 at, 25, 35, 45, and 55 days DAS, respectively) was obtained from I_1. Significant difference was observed due to various number of irrigation in respect of days to first flowering. First flowering (31.6 DAS) was earliest from I_1. Last flowering (41.8 DAS) was earliest from I_1. First pod setting (38.07 DAS) was earliest from I_1. First pod setting (62.27 DAS) was earliest from I_1. There was significant variation in the number of flower per plant due to the different irrigation. The maximum number of flower per plant (11.00) was obtained from I_1 treatment. Numerically the longest pod length (7.8 cm) was obtained from I_1 treatment. There was significant variation in the number of seeds per plant due to the irrigation. The maximum seed weight per plant (6.92g) was obtained from I_1 treatment and the minimum (1.69) was from I_4 treatment. The maximum yield (1.31 t/ha) was obtained from I_1treatment.

Interaction effect of variety and number of irrigation had a significant variation on all parameter. The maximum days to emergence (4.00) was obtained from V_3I_4 and V_4I_4. The tallest plant (18.07, 34.18, 41.65, 4.62 and 46.31 cm at 15, 25, 35, 45, and 55 days DAS, respectively) was obtained from V_1I_2 (BARI mung 2 with two irrigation) treatment. The highest number of leaves (3.00, 5.60, 9.00, 9.60 and 10.3 at 15, 25, 35, 45, and 55 days DAS, respectively) was obtained from V_2I_2 treatment. The highest number of branch (2.6, 3.6, 5.1, and 4.9 at 25, 35, 45, and 55 days DAS, respectively) was obtained from V_2I_1 treatment. Interaction effect of different variety and different number of irrigation had a significant variation on days to first flowering. The minimum days to first flowering (30) was obtained from V_1I_1 treatment. The maximum days to last flowering (53.33) was obtained from V_1I_1 treatment. The minimum days to first pod setting (35 days) was obtained from V_1I_1 treatment. The minimum days to first maturity (56.33 days) was obtained from V_1I_1 treatment. Interaction effect of different variety and irrigation had a significant effect on number of flower per plant. The highest number of flower per plant (13.67) was obtained from V_1I_1 treatment. The longest pod length (8.59 cm) was obtained from V_1I_1 treatment. Interaction effect of different variety and irrigation had a significant effect on seeds weight per plant. The highest seeds weight per plant (10.63g) was obtained from V_1I_1treatment while the lowest (1.47 g) from V_5I_4. The highest yield (1.62 t/ha) was obtained from V_1I_1 (BARI mung 2 with three irrigation) treatment while the lowest (0.71) from V_5I_4 (BARI mung 6 with no irrigation)

From the results of the study, it may be concluded that the performance of mungbean cv. BARI mung-2 was better in respect of growth, yield and yield components when sown with three irrigations were provided during the whole life cycle of the plant. However, such result has made basis for further study that should be conducted in different seasons involving different factors of production of mungbean. Further research is, therefore, necessary to achieve at a definite conclusion.

However, in this experiment performance of only five BARI released mungbean varieties were observed only at four irrigation levels. So, the response of other varieties to different irrigation level should be studied in order to make a clear recommendation on the subject.

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APPENDICES

Appendix I: Soil characteristics of Agricultural Botany farm of Sher-e-Bangla Agricultural University are analyzed by soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agricultural Botany farm, SAU, Dhaka
AEZ	Modhupur tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	**N/A**

Source: SRDI

B. Physical and chemical properties of the initial soil

Characteristics	Value
Practical size analysis	
Sand (%)	16
Silt (%)	56
Clay (%)	28
Silt + Clay (%)	84
Textural class	Silty clay loam
pH	5.56
Organic matter (%)	0.25
Total N (%)	0.02
Available P (µgm/gm soil)	53.64
Available K (me/100g soil)	0.13
Available S (µgm/gm soil)	9.40
Available B (µgm/gm soil)	0.13
Available Zn (µgm/gm soil)	0.94
Available Cu (µgm/gm soil)	1.93
Available Fe (µgm/gm soil)	240.9
Available Mn (µgm/gm soil)	50.6

Source: SRDI

Appendix II. Monthly air temperature, Rainfall and Relative humidity of the experimental site during the study period (October, 2010 to January, 2011)

Year	Month	Air temperature (^{0}C)			Rainfall** (mm)	* Relative humidity (%)
		Max.	Min.	Mean		
2011	October	36.6	18.5	27.455	320	64.5
	November	30.8	15.8	24.3	14	67.0
	December	27.2	11.3	19.75	0.00	63.0
2012	January	28.0	10.5	19.75	23	61.5
	February	26.5	10.1	18.3	0	62.3

* Monthly average

** Monthly total

Source: The Meteorological Department (Weather division) of Bangladesh, Agargoan, Dhaka

Appendix III. Layout and design of the experimental plot

N

W E

S

Plot size = 3 m × 1 m
Plot to plot distance = 0.5 m
Replication to replication distance = 1m

18 m

10 m

Replication I		Replication II		Replication III	
V_1I_1	V_5I_1	V_5I_1	V_2I_3	V_3I_3	V_2I_1
V_2I_2	V_1I_3	V_4I_4	V_1I_3	V_5I_1	V_3I_1
V_3I_4	V_2I_1	V_2I_1	V_5I_1	V_2I_3	V_1I_1
V_4I_1	V_3I_2	V_1I_1	V_4I_2	V_1I_3	V_5I_4
V_5I_4	V_5I_2	V_3I_1	V_5I_4	V_4I_1	V_3I_4
V_1I_2	V_4I_4	V_4I_1	V_4I_3	V_5I_2	V_1I_4
V_1I_4	V_2I_3	V_1I_4	V_3I_4	V_2I_4	V_2I_2
V_4I_2	V_3I_3	V_5I_3	V_2I_2	V_1I_2	V_3I_4
V_3I_1	V_5I_3	V_3I_3	V_1I_2	V_1I_3	V_4I_3
V_4I_3	V_2I_4	V_2I_4	V_3I_2	V_3I_1	V_5I_3