WATER RELATIONS AND YIELD OF FOUR MUNGBEAN CULTIVARS UNDER DIFFERENT DATE OF SOWING

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CERTIFICATE

*This is to certify that the thesis entitled "**Water Relations and Yield of Four Mungbean Cultivars under Different Date of Sowing**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **Md. Rezaul Karim, Registration No. 04-01460,** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that any help or sources of information as has been availed of during the course of this work has been duly acknowledged & style of the thesis have been approved and recommended for submission.

Dated:

Dhaka, Bangladesh

Professor Dr. Md. Shahidul Islam
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Supervisor

Dedication

To my elder brother

MD. KHALILUR RAHMAN

Whose efforts and ever willing support have made this dream come true

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The author

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ABSTRACT

The experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka during the *kharif* -1 season from March to June, 2010 to study the water relations and yield of four mungbean cultivars under different date of sowing. The treatment consisted of four mungbean varieties viz., V_1 = BARI mung- 4, V_2 = BARI mung- 5, V_3 = BARI mung- 6, V_4 = BU mung- 4, and three sowing date, viz., S_1 = 9 March, S_2 = 24 March, S_3 = 8 April. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Variety had significant influence on relative water content (RWC), exudation rate (ER); stem, leaf, root and total dry matter; pod length, pods per plant, seeds per pod, 1000-seed weight, seed yield, stover yield, biological yield and harvest index. BARI mung- 4 showed the highest seed yield showing the highest value of yield parameters and harvest index, RWC and ER, whereas, BU mung-4 produced the lowest seed yield. Sowing date also influenced significantly the mentioned parameters. Mungbean sowing on 24 March produced the highest seed yield followed by the sowing on 9 March and 8 April by producing the highest value of yield parameters, biological yield, RWC and ER. Among the interactions, BARI mung-4 sowing on 24 March produced the highest seed yield.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
LAI	=	Leaf area index
ppm	=	Parts per million
et al.	=	And others
N	=	Nitrogen
TSP	=	Triple Super Phosphate
MP	=	Muriate of Potash
RCBD	=	Randomized complete block design
DAS	=	Days after sowing
ha^{-1}	=	Per hectare
g	=	gram (s)
Kg	=	Kilogram
µg	=	Micro gram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
HI	=	Harvest Index
No.	=	Number
WUE	=	Water use efficiency
Wt.	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Not significant
mm	=	millimeter
Max	=	Maximum
Min	=	Minimum
%	=	Percent
cv.	=	Cultivar
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance
Hr	=	Hour
T	=	Ton
viz.	=	Videlicet (namely)

CHAPTER I

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is one of the leading pulse crop of Bangladesh. This commonly grown pulse crop belongs to the family fabaceae. 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 crop has the capability to enrich soils through nitrogen fixation. Mungbean contains 51% carbohydrate, 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 cultivable land of our country is decreasing. But the population is increasing. For increasing population 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. The total pulse cultivation land is decreasing day by day. 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. Mungbean covers an area of 23,077 hectare and production was about 20,000 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 but in Bangladesh the average yield is very low. The yield difference indicates the wide scope for increasing yield of mungbean. The agro 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 local mungbean cultivars are 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) has developed six and Bangladesh Institute of Nuclear Agriculture (BINA) has developed seven photo-sensitive as well as thermo sensitive high yielding mungbean cultivars, 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 got special importance in intensive crop production system of the country for its short growing period. It is drought tolerant, so it 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 soil moisture under rain fed 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 from August to November in *kharif-II* season but across these days, this crop has been growing throughout the country in the month of March to June in *kharif-I* season.

The proper sowing time again depends on the varieties and prevailing environment. Selection of appropriate 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.

For any yield improvement programme selection of superior parents is a prerequisite i.e., possessing better heritability and genetic advance for various traits (Ahmad *et al*., 2008). Sowing time, a non-monetary input, is an important factor to obtain optimum yield from mungbean (Samanta *et al*., 1999). So determination of optimum sowing time for mungbean is inevitable. Optimum time of sowing of mungbean may vary from variety to variety and season to season due to variation in agro ecological conditions. Therefore, there must be a specific sowing dates for specific varieties, especially in the summer season for different varieties to obtain maximum yield. Delayed sowing after March and early sowing before February reduce yield of summer mungbean (Chovatia *et al*., 1993). Mid February may be considered as the optimum time for summer mungbean and late planting after March may subject to rain damage during maturity period (Dharmalingam and Basu, 1993).

The experimental evidences on water relations and yield of four mungbean cultivars studied under different date of sowing are limited under Bangladesh condition. The present study was therefore, undertaken with the following objectives:

1. to identify the suitable mungbean cultivars that give higher yield in *kharif-1* season.
2. to identify the suitable dates of sowing form four mungbean cultivars studied to get higher yield.
3. to identify the optimum combination of mungbean cultivar and date of sowing for higher yield.

CHAPTER II

REVIEW OF LITERATURE

Water relations and yield of four mungbean cultivars were studied under different sowing date. Following review of literature include 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 study. In this chapter, an attempt has been made to review the available information in home and abroad regarding water relations and yield of four mungbean cultivars under different date of sowing.

2.1. Effect of variety

2.1.1. Effect on water relations

Islam *et al.* (2009a) conducted an experiment in a rain-out shelter at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur with four mungbean cultivars under well- watered and water stress condition. They studied some water relation traits (Leaf water potential, Relative water content and Exudation rate) and found variations in all these water relation parameters due to mungbean variety irrespective of water stress treatment.

Genotypic differences in leaf water status were also observed by Omae *et al.* (2005) and Omae *et al.* (2007) in Snap bean; by Morghan (1983) in wheat; by Kumar and Elston (1992) in mustard; by Kumar *et al.* (2005) in snap bean and by Iannucii *et al.* (2000) in soyabean and cotton.

2.1.2. Effect on plant characters

Tickoo *et al.* (2006) studied mungbean cultivars Pusa 105 and Pusa Vishal, which were sown at 22.5 and 30 cm spacing and supplied with 36-46 and 58-46 kg NP ha^{-1} 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 ton ha^{-1} and 1.63 ton ha^{-1}, respectively) compared to cv. Pusa 105 irrespective of NP fertilizers and spacing.

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 used in this experiment. Irrespective of Rhizobial inoculum, BARI mung-1 gave the highest yield as well as dry matter production.

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 TAL 441. Irrespective of *Rhizobium* inoculam, they found significant difference in yield and yield contributing characters and dry matter production due to variety.

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. They also found difference in performance due to variety.

Bhuiyan *et al*. (2003) conducted a field experiment at Regional Agricultural Research Station (RARS), Rahmatpur, Barisal with four mungbean varieties and they found varieties in root and shoot dry matter due to mungbean varieties irrespective of inoculum used.

Ali *et al*. (2004) conducted an experiment with mungbean varieties at BARI, Joydebpur, Gazipur. Each variety was tested with and without inoculation. Among three varieties, BARI mung-1 produced the highest yield (1.35ton ha^{-1}). Bhuiyan *et al.* (2003) conducted a field experiment at Regional Agricultural Research Station (RARS), Rahmatpur, Barisal. Among 4 varieties, BARI mung-2 produced higher yield. The variety BARI mung-2 gave the highest seed yield (1.38 ton ha^{-1}) with inoculation. They also found variations in stover yield due to both inoculation and variety.

2.2. Effect of sowing time

2.2.1. Effect on water relations

Sowing time influences water relation traits as reported by several researchers in different crops.

Anwar *et al.* (2003) conducted an experiment with kabuli chickpea in cool temperature sub-humid climate under different dates of sowing and found that relative water content and exudation rate were significantly influenced by sowing date. Islam (2008) conducted two experiments in *kharif-I* and *kharif-II* seasons of 2006 with BARI mung-2 under well-watered and water-stress conditions with growth regulators. He observed that relative water content and exudation rate varied with the growing season due to different sowing date.

Green gram (*Vigna radiate* L. Wilczek) harvested from early showed best quality than that of late sowing. Late sowing crop was harvested under humidity (>70%) and high air temperature (25-35˚C) conditions, which respond was for poor germination and vigor of the harvested seeds (Yadav and Nagarajan, 1995). Time of sowing had no effect on germination of the pea seeds and there were no differences between in seed quality harvested in either January of February (Castillo *et al.,* 1994; Batra *et al.,* 1992).

Adjustment of sowing date plays an important role in improving the seeds (Srivastava *et al*., 1976). Many efforts are available about the effects of sowing dates on the seeds of different crops. Rahman *et al.* (1989) tested jute seeds of different seasons and found no difference in seed quality. Time of sowing of the pea had no effect on the germination of the seeds produced, but affected seed vigor and electrical conductivity (Castillo *et al.,* 1994).

Sowing times affect not only seed quality but also on the productivity of field crops. Mungbean sown in wet season (early September, mid October and late December) produced greater seed yields than in dry season (late April, mid May and late June) at pasadeniya, Srilanka (Sangakkara, 1998). Crop established in the middle of both seasons produced higher yield with good quality seed. The author explained that, seed quality improved in mid season sowing due to the availability of adequate moisture during the vegetative phase and in dry period at the time of crop maturity. In contrast, late sowing of mungbean was encountered to moisture stress and produced low quality seeds.

Yield potentiality is an inherent character of crop cultivars. The productivity of a crop is governed by such inherent genetic makeup and physiological expression under certain growth environment (Baset *et al*., 1996). In mungbean plant height, number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 1000 seed weight and seed yield were significantly influenced by the dates of sowing (Mian *et al*., 2002).

Seed yield in mungbean is a function of number of pods plant^{-1}, number of seeds pod^{-1} and seed size (Nag *et al.*, 2000). The highest yield was obtained when seeds were sown on 25 January followed by 05 February and 15 January and the lowest in 5 March planting. The lowest yield was obtained from early and delayed planting. The highest plant biomass was produced in 25 January planting followed by 15 January and 5 February whereas lowest in 5 March planting. Seed weight plant^{-1} and seed weight unit^{-1} area were not significantly affected by the date of sowing over the range of sowing date. At the last sowing dates seed weight plant^{-1} and seed weight unit area decreased significantly. There was no significant effect of sowing date on number of pods plant^{-1} and number of pods unit^{-1} area but the effect was significant on number of seeds plant^{-1} and seeds unit^{-1} area. Sowing number 1 to 7 had similar number of seeds plant^{-1}, but sowing 8 had a significantly lower number of seeds plant^{-1}. The lower seed yield plant^{-1} at the last sowing was due to significant decrease in the number of seeds pod^{-1} and thousand seed weight (Siddique *et al.* 2002). Delay in sowing caused a significant reduction in seed yield. The highest seed yield was recorded in 16 November sowing of chickpea (Dixit *et al*., 1993). This may be due to the prevalence of favorable temperature at that sowing time and longer period for crop growth. The late planted crop is subjected to relatively lesser time span available for plant growth and development.

The grain yield of gram was significantly influenced by different date of sowing. Gram sown on 30 October gave highest yield. Daly in sowing beyond 30 October reduced the seed yield (Saxena and Yadav, 1975) these variable results over the years are mainly owing to different weather conditions in different growing years.

In case of groundnut, yield recorded from 5 February and 20 February did not differ markedly, but produced significantly higher yield than that of crop sown earlier on 20 January (Patel *et al.*, 1983).

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field of Sher-e-Bangla Agricultural University, Dhaka during the *kharif* -1 season from March to June, 2010 to study the performance of four mungbean cultivars under different date of sowing. Materials used and methodologies followed in the present investigations 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 $23^0\,77^{\prime}$ latitude and $90^0\,33^{\prime}$ E longitudes at an altitude of 9 m above the mean sea level. The soil 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. Planting materials

BARI mung-4

BARI mung-4 was developed by Bangladesh Agricultural Research Institute (BARI) and released 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 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 developed by BARI and released by National Seed Board (NSB) 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 developed by BARI and released by National Seed Board (NSB) 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.

BU mung-4

BU mung-4 was developed by Bangabandhu Sheikh Mujibur Rahman Agricultural University and released in 2001. 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 BU mung-4 for the experiment were collected from Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur. The seeds were drum-shaped, dull and greenish and free from mixture of other seeds, weed seeds and extraneous materials.

3.3. Treatment

The experiment was consisted with the following two treatment factors:

Factor-A: Cultivar-4

V_1 = BARI mung- 4

V_2 = BARI mung- 5

V_3 = BARI mung- 6

V_4 = BU mung- 4

Factor-B: Date of Sowing-3

S_1 = 9 March

S_2 = 24 March

S_3 = 8 April

3.4. Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) having three replications. Each replication had 12 unit plots to which the treatment combinations were assigned randomly. The unit plot size was 7.5 m^2 (3.0m ×2.5m). The blocks and unit plots were separated by 1.0 m and 0.5 m spacing respectively. Field lay out of the experiment was done on 8 March, 2010.

3.5. Land preparation

The experimental land was opened with a power tiller on 2 March, 2010. Ploughing and cross ploughing were done with country plough followed by laddering. Land preparation was completed on 6 March, 2010 and was ready for sowing 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 continuously sown at the rate of 45 kg ha^{-1} in the 30 cm apart furrow on 9 March, 24 March and 8April, 2010 and the furrows were covered with the soils soon after seeding.

3.8. Germination of seeds

Seed germination occurred from 3^{rd} day of sowing. On the 4^{th} day the percentage of germination was more than 85% and on the 5^{th} day nearly all seedlings came out of the soil.

3.9. Intercultural operations

3.9.1. Weed control

Weeding was done several times in all the unit plots with care so as to keep the crop field weed free.

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

Pre-sowing irrigation was given to ensure the maximum germination percentage. During the whole experimental period, there was a shortage of rainfall in earlier part; however, it was heavier in later one. So, the excess water was essentially removed from the field at the later period.

3.9.4. Pest control

The infestation of 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 black colour, the pod was considered to attain maturity.

3.11. Harvesting and sampling

Mungbean pods were harvested thrice. Ten plants were randomly selected for data recording and $1m^2$ area was remarketed for yield data. Mungbean pods were harvested from pre-selected 10 plants and $1m^2$ area thrice separately. After final harvest, 10 selected plants were uprooted to record stem, leaf and root dry matter, and all the plants collected without root from $1m^2$ area were considered for taking stover yield.

3.12. Threshing

The collected pods were sun-dried and seeds were separated from pods by beating them with bamboo sticks.

3.13. Drying, cleaning and weighing

The seeds collected by threshing were dried in the sun to reduce the seed moisture content. The dried seeds were cleaned and weighed. The stovers were also sun dried and weighed.

3.14. Parameters Studied

A. Water relation traits

- Relative water content
- Exudation rate

B. Plant characters

- Dry weight of leaves
- Dry weight of stem
- Dry weight of root
- Total dry matter weight

C. Yield contributing characters and yields

- No. of pods plant^{-1}
- No. of seeds pod^{-1}
- Pod length
- 1000- seed weight
- Seed yield
- Stover yield
- Biological yield
- Harvest index

Water relation traits

Relative water content: Relative water content (RWC) was measured at first flowering. The leaf samples were cut with a sharp knife with petiole and were put in a polyethylene bag treatment wise. The bags were kept on a tray containing little water and were warp with a moist towel to avoid light and desiccation. Then the samples were brought in the laboratory and their fresh weight was recorded without any delay. The leaf samples were then dipped in water for 24 hours and their turgid weight were recorded after soaking the leaf surface water by paper towel. The samples were then oven-dried to constant weight. The relative water content was measured using the following formula:

Relative water content (RWC%) = [(fresh weight-dry weight)/(turgid weight-dry weight)] × 100.

Exudation rate: Exudation rate was measured from the stem at about 5 cm above from the ground. At first, dry cotton was weighed. A slanting cut on the stem was made with a sharp knife. Then the weighed cotton was placed on the cut surface. The exudation of the sap was collected from the stem for 1 hour at normal temperature. The final weight of the cotton with sap was taken. The exudation rate was calculated by deducting cotton weight from the sap containing cotton weight and was expressed hour^{-1} basis as follows:

Exudation rate= [(weight of cotton+sap)-(weight of cotton)]/time

Dry weight of leaves plant^{-1}

Ten plants were uprooted randomly from each plot at harvest carefully with help of a shovel so that root had minimum damaged. Then the leaves, stems and roots from these plants were separated and were oven dried at 70º C for 72 hours in an oven. Then the dry weights of different plant parts were determined by using the following formula:

Dry weight of leaves plant^{-1} = $\frac{\textbf{Dry weight of leaves of all sample plants}}{\textbf{Number of sample plants}}$

Dry weight of stem plant^{-1} = $\frac{\textbf{Dry weight of stem of all sample plants}}{\textbf{Number of sample plants}}$

Dry weight of root plant^{-1} = $\frac{\textbf{Dry weight of root of all sample plants}}{\textbf{Number of sample plants}}$

Total dry matter

Total dry mater of plant at harvest was calculated by aggregating the dry matter weight of leaves, stems, roots, pod cover and other immature reproductive parts.

Pod length

Pod length was measured in centimeter (cm) scale from randomly selected 10 pods. Mean value of them was recorded as treatment wise.

Pods plant^{-1}

Number of pods plant^{-1} was counted thrice from the 10 randomly selected plant samples thrice as mungbean pods matured asynchronously and then the average pod number plant^{-1} was calculated.

Seeds pod^{-1}

Number of seeds pod^{-1} was counted from 10 randomly selected pods of plants and then the average seed number pod^{-1} was calculated.

1000-seed weight

1000-seed were counted, which were taken from the seed sample of each plot separately, then weighed in an electrical balance and data were recorded.

Seed yield

Pods collected from plants of pre-demarcated central 1 m^2 area, were considered for taking yield data. Pods were collected thrice from that plants and the seeds collected from that pods were adjusted at 12 % moisture content by sun-drying. The weights of that seeds were taken and yield was expressed in ton hectare^{-1}.

Stover yield

Stover yield was determined from the central 1 m^2 area of each plot. After collecting pods, the plant parts were sun-dried weight was taken and finally converted to ton hectare^{-1}.

Biological yield

The biological yield was calculated with the following formula-

Biological yield= Seed yield + Stover yield

Harvest index

Harvest index was calculated on dry basis with the help of following formula.

Harvest index (HI %) = (Seed yield/ Biological yield) × 100

3.15. Data analysis

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, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter using different tables and figures under the following headings:

4.1. Relative water content

4.1.1. Effect of variety

Relative water content (RWC) signifies the water content of plant. The relative water content was significantly influenced by variety. The highest RWC (85.16%) was obtained from V_2 (BARI mung-5) and the lowest RWC (79.83%) was obtained from V_4 (BU mung-4) (Fig. 1). Varietal differences in RWC might be due to the morpho-physiological differences among the varieties. Variations in RWC due to mungbean varieties were also observed by Islam *et. al.* (2009a) and Islam *et. al.* (2009b).

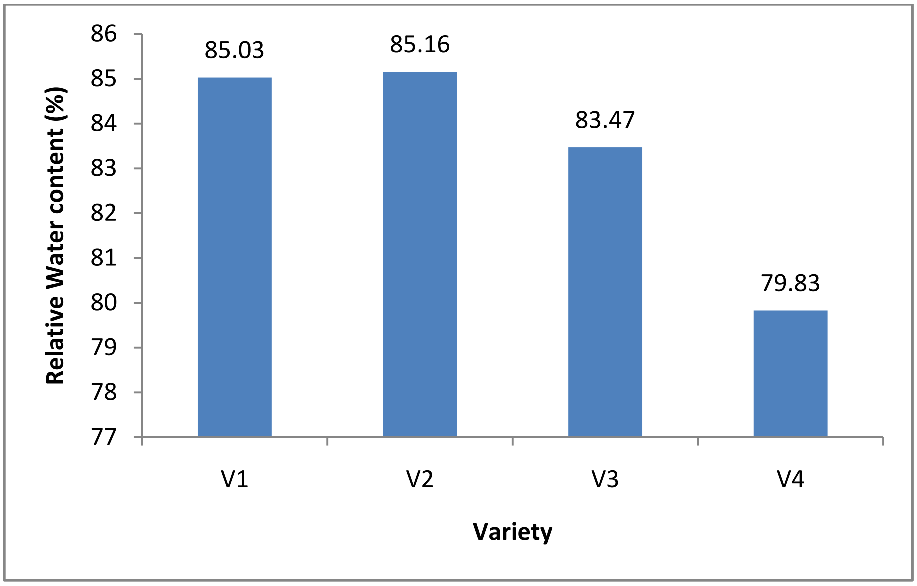
4.1.2. Effect of sowing time

Relative water content was influenced by sowing time. The highest RWC (84.69%) was obtained from S_2 (sowing on 24 March) and the lowest RWC (81.25%) was obtained from S_3 (sowing on 8 April) (Fig. 2). Atmospheric relative humidity and temperature greatly influence the RWC of plant leaves. The highest RWC found sowing on 24 March (S_2) might be attributed to the highest relative humidity existing during RWC determination (at first flowering around 24 April), whereas, the lowest value found sowing on 8 April (S_3)

might be attributed to lower relative humidity and the highest temperature during RWC determination at first flowering (Appendix II), i.e., around at 8 May. Variations in RWC due to temperature and relative humidity, i.e., due to sowing time were also reported by Anwar *et al.* (2003) in chickpea.

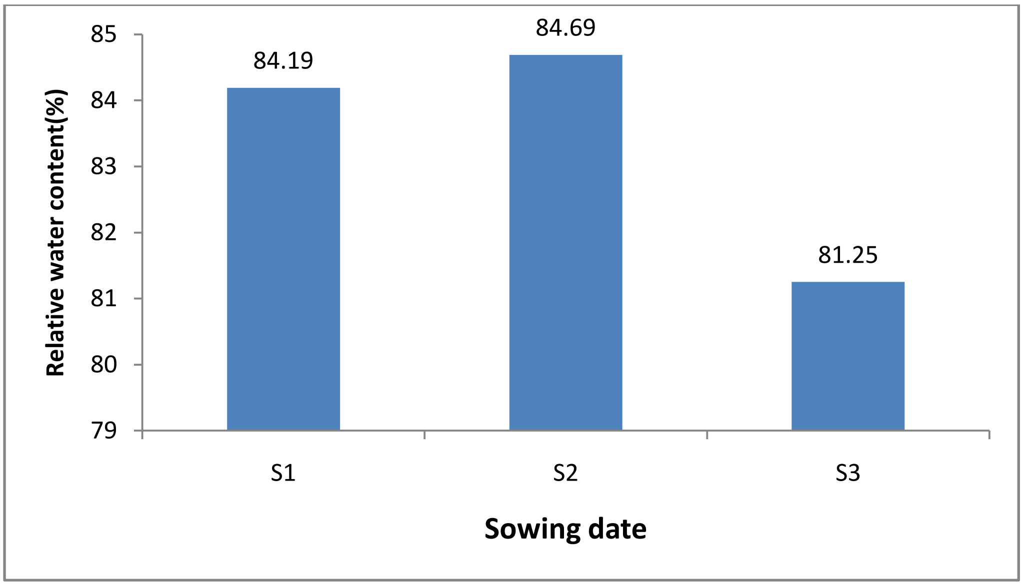
4.1.3. Interaction effect of variety and sowing time

Interaction of variety and sowing time had a significant influence on relative water content of mungbean leaves. The highest RWC (88.54%) was obtained from V_3S_1 (BARI mung-6 sowing on 9 March) while the lowest (74.79%) with V_4S_3 (BU mung-4 sowing on 8 April) (Table 1).



V_1 = BARI mung-4 V_2 = BARI mung-5 V_3 = BARI mung-6 V_4 = BU mung-4

Fig.1. Effect of variety on relative water content of mungbean ($LSD_{(0.05)}$= 2.849)



S_1 = 9 March S_2 = 24 March S_3 = 8 April

Fig.2. Effect of sowing time on the relative water content of mungbean ($LSD_{(0.05)}$=NS)

Table 1. Interaction effect of variety and sowing time on relative water content (RWC) and exudation rate (ER) of mungbean

Treatment	RWC (%)	ER (mg hr^{-1})
V_1S_1	83.31	30.43
V_1S_2	84.35	10.93
V_1S_3	87.44	31.20
V_2S_1	85.85	13.90
V_2S_2	86.22	9.97
V_2S_3	83.43	7.97
V_3S_1	88.54	7.01
V_3S_2	82.53	13.83
V_3S_3	79.33	27.20
V_4S_1	79.05	47.03
V_4S_2	85.66	9.93
V_4S_3	74.79	9.53
LSD $_{(0.05)}$	1.86	6.95
CV (%)	9.83	10.80

V_1 = BARI mung-4 V_2 = BARI mung-5 V_3 = BARI mung-6 V_4 = BU mung-4

S_1 = 9 March S_2 = 24 March S_3 = 8 April

LSD $_{(0.05)}$ = Mean were separated by least significant difference at 5% level of significance.

4.2. Exudation rate

4.2.1. Effect of variety

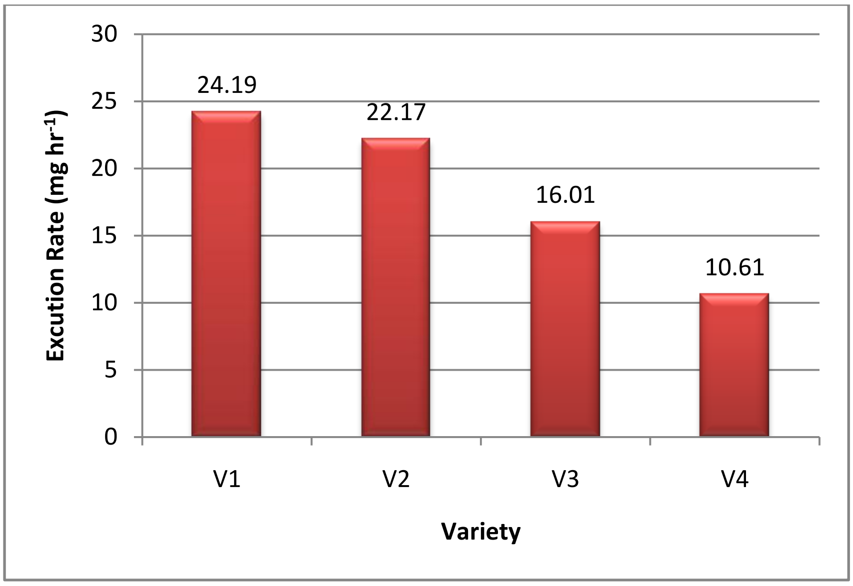
Exudation rate is known as the flow of sap from cut end of stem against the gravitational force. The highest exudation rate (24.19 mg hr^{-1}) was obtained from V_1 (BARI mung-4) and the lowest (10.61 mg hr^{-1}) in V_4 (BU mung-4) (Fig. 3). Morpho-physiological differences in mungbean plants of different varieties might influence the water uptake as well as transpiration stream and thereby influenced exudation rate. Variations in exudation rate due to variety were also observed by Omae *et al.* (2005) in snapbean.

4.2.2. Effect of sowing time

Exudation rate was not significantly influenced by sowing time. However, the highest ER (24.59 mg hr^{-1}) was obtained from S_2 (sowing on 24 March) and the lowest RWC (11.17 mg hr^{-1}) from S_3 (sowing on 8 April)) (Fig. 4).

4.2.3. Interaction effect of variety and sowing time

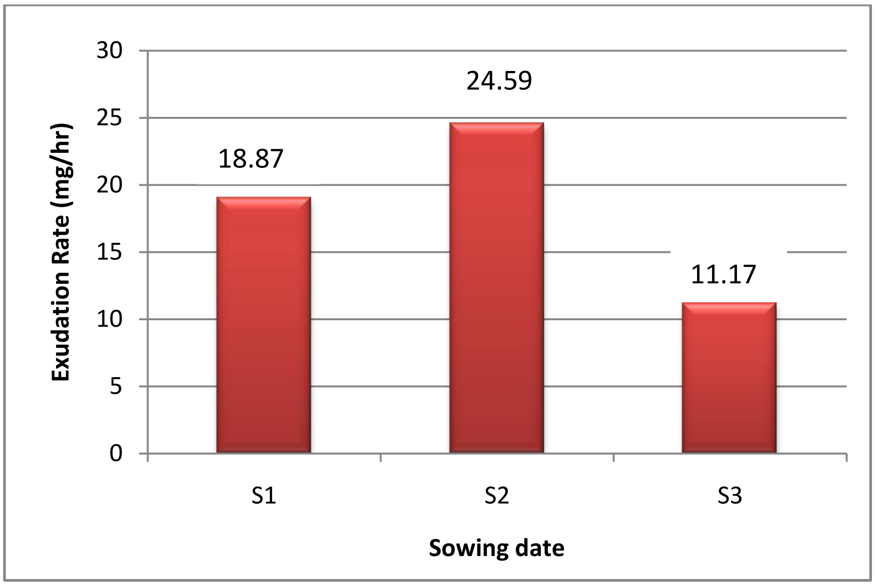
Interaction of variety and sowing time had a significant influence on exudation rate. The highest exudation rate (47.03 mg hr^{-1}) was obtained from V_4S_1 (BU mung-4 sowing on 9 March), while the lowest (7.01mg ha^{-1}) from V_3S_1 (BARI mung-6 sowing on 9 March) (Table 1).



V_1 = BARI mung-4 V_2 = BARI mung-5 V_3 = BARI mung-6 V_4 = BU mung-4

Fig.3. Effect of variety on the exudation rate of mungbean

(LSD $_{0.05}$=10.66)



S_1 = 9 March S_2 = 24 March S_3 = 8 April

Fig.4. Effect of sowing time on the exudation rate of mungbean

(LSD $_{0.05}$=14.42)

4.3. Leaf dry matter

4.3.1. Effect of variety

Variety had a significant influence on the leaf dry matter plant^{-1}. The highest leaf dry matter plant^{-1} (17.96 g) was recorded in V_1 (BARI mung-4),which was statistically identical to that of V_2 (BARI mung-5) and V_4 (BU mung-4) and the lowest (15.83 g) in V_3 (BARI mung-6) (Table 2).

4.3.2. Effect of sowing time

Sowing time had a significant influence on leaf dry matter plant^{-1}. The maximum leaf dry matter plant^{-1} (19.67 g) was obtained from S_2 (sowing on 24 March) and the minimum (15.3g) from S_1 (sowing on 9 March) (Table 3).

4.3.3. Interaction effect of variety and sowing time

Interaction of variety and sowing time had a significant influence on leaf dry matter plant^{-1}. The highest leaf dry matter plant^{-1} (36.58 g) was obtained from V_1S_2 (BARI mung-4 sowing on 24 March), while the lowest (5.48g) from V_3S_1 (BARI mung-6 sowing on 9 March) (Table 4).

4.4. Stem dry matter plant^{-1}

4.4.1. Effect of variety

Variety had a significant influence on the stem dry mater plant^{-1}. The highest stem dry mater plant^{-1} (18.43 g) was recorded in V_4 (BU mung-4), which was statistically identical to that of V_3 (BARI mung-6) and V_2 (BARI mung-5) but significantly different from that of V_1 (BARI mung-4) (Table 2).

4.4.2. Effect of sowing time

There was no significant influence on stem dry mater plant^{-1} due to sowing time. The maximum stem dry mater plant^{-1} (16.48 g) was obtained from S_3 (sowing on 8 April) treatment and the minimum (13.53 g) from S_1 (sowing on 9 March) treatment (Table 3).

4.4.3. Interaction effect of variety and sowing time

Interaction of variety and sowing time had a significant influence on stem dry matter plant^{-1}. The highest stem dry mater plant^{-1} (31.18 g) was obtained from V_3S_3 (BARI mung-6 sowing on 8 April), while the lowest (4.28g) from V_1S_3 (BARI mung-4 sowing on 8 April) (Table 4).

Table2. Effect of variety on dry matter of different plant parts in mungbean

Treatment	Leaf dry matter (g plant^{-1})	Stem dry matter (g plant^{-1})	Root dry matter (g plant^{-1})	Total dry mater (g plant^{-1})
V_1	17.96	11.24	4.82	36.59
V_2	17.25	14.25	5.72	40.47
V_3	15.83	17.55	8.30	47.08
V_4	16.76	18.43	5.64	46.55
LSD $_{(0.05)}$	1.55	5.07	2.91	6.93
CV (%)	13.65	8.96	9.44	7.71

V_1 = BARI mung-4 V_2 = BARI mung-5 V_3 = BARI mung-6 V_4 = BU mung-4

LSD $_{(0.05)}$ = Mean were separated by least significant difference at 5% level of significance.

Table3. Effect of sowing time on dry matter of different plant parts in mungbean

Treatment	Leaf dry matter (g plant^{-1})	Stem dry matter (g plant^{-1})	Root dry matter (g plant^{-1})	Total dry mater (g plant^{-1})
S_1	15.30	13.53	4.91	38.07
S_2	19.67	16.10	7.20	47.86
S_3	15.88	16.48	6.26	42.09
LSD$_{(0.05)}$	2.09	NS	1.77	9.37
CV (%)	13.65	8.96	9.44	7.71

S_1 = 9 March S_2 = 24 March S_3 = 8 April

LSD $_{(0.05)}$ = Mean were separated by least significant difference at 5% level of significance.

NS= Non-significant

Table4. Interaction effect of variety and sowing time on dry matter of different plant parts in mungbean

Treatment	Leaf dry matter (g plant^{-1})	Stem dry matter (g plant^{-1})	Root dry matter (g plant^{-1})	Total dry mater (g plant^{-1})
V_1S_1	11.81	8.79	3.43	25.84
V_1S_2	36.58	20.65	7.76	69.30
V_1S_3	7.51	4.29	3.27	14.63
V_2S_1	11.26	7.09	2.69	22.79
V_2S_2	20.50	16.67	6.70	47.61
V_2S_3	19.98	19.01	7.78	51.00
V_3S_1	5.48	10.24	4.11	23.56
V_3S_2	9.45	11.22	10.55	39.56
V_3S_3	30.53	31.18	10.26	78.11
V_4S_1	30.60	27.98	9.42	80.10
V_4S_2	12.15	15.87	3.81	34.96
V_4S_3	7.53	11.44	3.72	24.60
LSD $_{(0.05)}$	1.01	3.30	1.90	4.52
CV (%)	13.65	8.96	9.44	7.71

V_1 = BARI mung-4 V_2 = BARI mung-5 V_3 = BARI mung-6 V_4 = BU mung-4

S_1 = 9 March S_2 = 24 March S_3 = 8 April

LSD $_{(0.05)}$ = Mean were separated by least significant difference at 5% level of significance.

4.5. Root dry matter plant^{-1}

4.5.1. Effect of variety

Variety had a significant influence on the root dry matter plant^{-1}. The highest root dry matter plant^{-1} (8.31 g) was recorded in V_3 (BARI mung-6) and the lowest (7.82g) in V_1 (BARI mung-4) (Table 2). However, root dry matter recorded in V_3 and V_1 were statistically similar to that in V_2 and V_4 but statistically differed from each other.

4.5.2. Effect of sowing time

Significant variation was found in root dry matter plant^{-1} due to the different sowing time. The maximum root dry matter plant^{-1} (7.20 g) was obtained from S_2 (sowing on 24 March), which was statistically identical to that of S_3 (sowing on 8 April) and significantly different from that of S_1 (sowing on 9 March) (Table 3). However, root dry matter recorded in S_1 and S_3 were also statistically identical.

4.5.3. Interaction effect of variety and sowing time

Interaction of variety and sowing time had a significant influence on root dry matter plant^{-1}. The highest root dry matter plant^{-1} (10.55 g) was obtained from V_3S_2 (BARI mung-6 sowing on 24 March) while the lowest (2.69 g) from V_2S_1 (BARI mung-5 sowing on 9 March) (Table 4).

4.6. Total dry mater plant^{-1}

4.6.1. Effect of variety

Variety had a significant influence on the total dry mater plant^{-1}. The highest total dry mater plant^{-1} (47.08 g) was recorded in V_3 (BARI mung-6), which was statistically identical to that recorded in V_4 (BU mung-4) and V_2 (BARI mung-5) (Table 2). The lowest total dry mater plant^{-1} (36.59g) was recorded in V_1 (BARI mung-4), which was also statistically identical to that recorded in V_4 and V_2 but significantly different from that in V_3. Differences in morpho-physiological behaviors due to variety might influence the photosynthetic characters and hence influenced the total dry matter production. Variations in total dry matter production due mungbean variety were also reported by Islam *et al*. (2009c).

4.6.2. Effect of sowing time

There was a significant variation in total dry mater plant^{-1} due to sowing time. The maximum total dry mater plant^{-1} (47.86g) was obtained from S_2 (sowing on 24 March) and the minimum (38.07 g) from S_1 (sowing on 9 March) (Table 3).

4.6.3. Interaction effect of variety and sowing time

Interaction of variety and sowing time had a significant influence on total dry mater plant^{-1}. The highest total dry mater plant^{-1} (80.10 g) was obtained from V_4S_1 (BU mung-4 sowing on 9 March), while the lowest (14.63 g) from V_1S_3 (BARI mung-4 sowing on 8 April) (Table 4).

4.7. Pod Length

4.7.1. Effect of variety

Pod length is one of the most important yield contributing characters in mungbean. Variety showed significant influence on pod length (Table 5). The longest pod (7.18 cm) was recorded in V_4 (BU mung-4) and the shortest (6.79 cm) in V_2 (BARI mung-5). This result is in agreement with the result of Sarkar *et al.* (2004) who reported that pod length differed from variety to variety. The probable reason of this difference could be the genetic make-up of the variety.

4.7.2. Effect of sowing time

The variation in the pod length due to the sowing time was statistically insignificant. Numerically the longest pod (6.99 cm) was obtained from S_2 (sowing on 24 March) and the shortest (6.92cm) was obtained from S_1 (sowing on 9 March) (Table 6).

4.7.3. Interaction effect of variety and sowing time

Interaction of variety and sowing time had a significant influence on pod length. The longest pod (7.83 cm) was obtained from V_1S_2 (BARI mung-4 sowing on 24 March), while the shortest (5.85 cm) from V_2S_3 (BARI mung-5 sowing on 8 April) (Table 7).

4.8. Number of pods plant^{-1}

4.8.1. Effect of variety

Number of pods plant^{-1} is one of the most important yield contributing characters in mungbean. Variety had a significant influence on the number of pods plant^{-1}. The highest number of pods plant^{-1} (10.25) was recorded in V_1 (BARI mung-4) and the lowest (9.56) in V_4 (BU mung-4) (Table 5). It was remarkable that both the highest and lowest pod bearing varieties were statistically identical to V_2 (BARI mung-5) and V_3 (BARI mung-6) but were significantly different from each other.

4.8.2. Effect of sowing time

There was a significant variation in number of pods plant^{-1} due to the sowing time. The maximum number of pods plant^{-1} (10.73) was obtained from S_2 (sowing on 24 March), which was statistically identical (10.16) to that obtained from S_1 (sowing on 9 March) but significantly different (8.82) from that of S_3 (sowing on 9 March) (Table 6).

4.8.3. Interaction effect of variety and sowing time

Interaction of variety and sowing time had a significant influence on number of pods plant^{-1}. The maximum number of pods plant^{-1} (11.04) was obtained from V_1S_2 (BARI mung-4 sowing on 24 March), while the minimum (7.98) from V_2S_1 (BARI mung-5 sowing on 9 March) (Table 7).

Table 5. Effect of variety on yield contributing characters of mungbean

Treatment	Pod length (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000-seed wt. (g)
V_1	6.84	10.25	10.90	47.79
V_2	6.79	10.05	10.23	45.91
V_3	7.01	9.75	10.53	45.47
V_4	7.18	9.56	8.27	45.19
LSD (0.05)	0.33	0.56	2.16	NS
CV (%)	5.65	13.90	8.31	8.47

V_1 = BARI mung-4 V_2 = BARI mung-5 V_3 = BARI mung-6 V_4 = BU mung-4

LSD $_{(0.05)}$ = Mean were separated by least significant difference at 5% level of significance.

NS= Non-significant

Table 6. Effect of sowing time on yield contributing characters of mungbean

Treatment	Pod length (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000-seed wt. (g)
S_1	6.92	10.16	9.61	45.51
S_2	6.99	10.73	10.38	46.87
S_3	6.95	8.82	9.97	45.89
LSD (0.05)	NS	0.75	NS	NS
CV (%)	5.65	13.90	8.31	8.47

S_1 = 9 March S_2 = 24 March S_3 = 8 April

LSD $_{(0.05)}$ = Mean were separated by least significant difference at 5% level of significance.

NS= Non-significant

Table7. Interaction effect of variety and sowing time on yield contributing characters of mungbean

Treatment	Pod length (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000-seed wt. (g)
V_1S_1	5.97	9.60	8.12	45.20
V_1S_2	7.83	11.04	11.38	51.17
V_1S_3	7.47	9.97	11.22	46.03
V_2S_1	7.53	7.98	8.03	45.03
V_2S_2	6.99	10.67	9.34	44.33
V_2S_3	5.85	10.04	11.29	48.37
V_3S_1	6.85	8.78	11.07	48.40
V_3S_2	6.36	10.61	10.62	43.37
V_3S_3	7.09	9.88	11.02	45.80
V_4S_1	7.33	8.95	7.37	48.83
V_4S_2	7.37	10.60	10.18	44.33
V_4S_3	6.83	10.78	10.20	42.20
LSD $_{(0.05)}$	1.19	0.36	1.41	6.61
CV (%)	5.65	13.90	8.31	8.47

V_1 = BARI mung-4 V_2 = BARI mung-5 V_3 = BARI mung-6 V_4 = BU mung-4

S_1 = 9 March S_2 = 24 March S_3 = 8 April

LSD $_{(0.05)}$ = Mean were separated by least significant difference at 5% level of significance.

4.9. Number of seeds pod^{-1}

4.9.1. Effect of variety

The number of seeds pod^{-1} was significantly influenced by variety. The highest number of seeds pod^{-1} (10.9) was recorded in V_1 (BARI mung-4) and the minimum (8.28) in V_4 (BU mung-4) (Table 5). The number of seeds pod^{-1} in BARI mung-4 and BU mung-4 statistically identical to that found in V_2 (BARI mung-5) and V_3 (BARI mung-6) but significantly different from each other.

4.9.2. Effect of sowing time

There was no significant influence in the number of seeds pod^{-1} due to the sowing time. The maximum number of seeds pod^{-1} (10.38) was obtained from S_2 treatment, which was followed by S_3 and the minimum (9.61) was from S_1 treatment (Table 6).

4.9.3. Interaction effect of variety and sowing time

Interaction of variety and sowing had a significant effect on number of seeds pod^{-1}. The highest number of seeds pod^{-1} (11.38) was obtained from V_1S_2 (BARI mung-4 sowing on 24 March) while the lowest (7.37) from V_4S_1 (BU mung-4 sowing on 9 March) (Table 7).

4.10. 1000- seed weight

4.10.1. Effect of variety

There was no significant difference in 1000- seed weight of mungbean differed no significantly due to variety. The highest thousand seed weight (47.79 g) was obtained from V_1 (BARI mung-4) and the lowest (45.19 g) from V_4 (BU mung-4) (Table 5). This result was in agreement with the result of Sarkar *et al*. (2004).

4.10.2. Effect of sowing time

There was no significant influence in the thousand seed weight due to the sowing time. The maximum thousand seed weight (46.87 g) was obtained from S_2 treatment and the minimum (45.51 g) from S_1, which was followed by S_3 (Table 6).

4.10.3. Interaction effect of variety and sowing time

Interaction effect of variety and sowing time had a significant influence on 1000-seed weight. The highest 1000-seed weight (41.10 g) was obtained from V_1S_2 (BARI mung-4 sowing on 24 March) while the lowest (42.2 g) from V_4S_3 (BU mung-4 sowing on 8 April) (Table 7).

4.11. Seed yield

4.11.1. Effect of variety

The seed yield of mungbean was significantly influence by variety (Table 8). The maximum seed yield (1.50 t ha^{-1}) was found in V_1 (BARI mung-4). The lowest yield (1.46 t ha^{-1}) was found both in V_2 (BARI mung-5) and V_4 (BU mung-4).

4.11.2. Effect of sowing time

There was significant influence in seed yield due to sowing time. The maximum seed yield (1.56 t ha^{-1}) was obtained from S_2 (sowing on 24 March) and the minimum (1.40 t ha^{-1}) in S_3 (sowing on 8 Aril) treatment (Table 9).

4.11.3. Interaction effect of variety and sowing time

Interaction of variety and sowing time had a significant influence on seed yield of mungbean. The highest seed yield (1.68 t ha^{-1}) was obtained from V_1S_2 (BARI mung-4 sowing on 24 March) while the lowest (1.34 t ha^{-1}) from V_4S_3 (BU mung-4 sowing on 8 April) (Table 10).

4.12. Stover yield

4.12.1. Effect of variety

The stover yield was significantly influenced by variety (Table 8). The maximum stover yield (1.12 t ha^{-1}) was found in V_4 (BU mung-4). The lowest stover yield (0.51 t ha^{-1}) was observed in V_1 (BARI mung-4) (Table 8). It was remarkable that the highest and lowest stover yield.

4.12.2. Effect of sowing time

There was significant influence in the stover yield due to sowing time. The maximum stover yield (1.27 t ha^{-1}) was obtained from S_2 (sowing on 24 March) and the minimum (0.69 t ha^{-1}) from S_3 (sowing on 8 April) (Table 9). The stover yield recorded in S_1 (sowing on 9 March) was statistically identical to that in S_3 (sowing on 8 April) and significantly different from that recorded in S_2 (sowing on 24 March).

4.12.3. Interaction effect of variety and sowing time

Interaction of variety and sowing time had a significant influence on stover yield. The highest stover yield (2.27 t ha^{-1}) was obtained from V_1S_2 (BARI mung-4 sowing on 24 March) while the lowest (0.23 t ha^{-1}) from V_1S_1 (BARI mung-4 sowing on 8 March) (Table 10).

Table 8. Effect of variety on yields and harvest index of mungbean

Treatment	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
V_1	1.50	0.51	1.99	75.39
V_2	1.46	1.07	2.52	59.66
V_3	1.49	1.04	2.54	62.57
V_4	1.46	1.12	2.58	63.82
LSD $_{(0.05)}$	0.03	0.18	0.33	6.43
CV (%)	5.80	7.78	5.01	6.33

V_1 = BARI mung-4 V_2 = BARI mung-5 V_3 = BARI mung-6 V_4 = BU mung-4

LSD $_{(0.05)}$ = Mean were separated by least significant difference at 5% level of significance.

Table 9. Effect of sowing time on yields and harvest index of mungbean

Treatment	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest Index (%)
S_1	1.46	0.84	2.30	67.80
S_2	1.56	1.27	2.75	59.32
S_3	1.40	0.69	2.10	68.95
$LSD_{(0.05)}$	0.08	0.18	0.33	6.43
CV (%)	5.80	7.78	5.01	6.33

S_1 = 9 March S_2 = 24 March S_3 = 8 April

$LSD_{(0.05)}$ = Mean were separated by least significant difference at 5% level of significance.

Table 10. Interaction effect of variety and sowing time on yields and harvest index of mungbean

Treatment	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
V_1S_1	1.53	0.23	1.77	86.79
V_1S_2	1.68	2.27	3.62	46.88
V_1S_3	1.45	0.77	2.22	65.34
V_2S_1	1.46	0.47	1.93	75.77
V_2S_2	1.52	1.50	3.02	50.27
V_2S_3	1.39	1.23	2.62	52.94
V_3S_1	1.50	1.90	3.40	44.07
V_3S_2	1.56	0.80	2.36	66.12
V_3S_3	1.44	0.42	1.86	77.53
V_4S_1	1.37	0.75	2.12	64.58
V_4S_2	1.47	0.52	1.99	74.03
V_4S_3	1.34	0.34	1.68	79.98
LSD $_{(0.05)}$	0.05	0.12	0.21	4.19
CV (%)	5.80	7.78	5.01	6.33

V_1 = BARI mung-4 V_2 = BARI mung-5 V_3 = BARI mung-6 V_4 = BU mung-4

S_1 = 9 March S_2 = 24 March S_3 = 8 April

LSD $_{(0.05)}$ = Mean were separated by least significant difference at 5% level of significance.

4.13. Biological yield

4.13.1. Effect of variety

Biological yield was significantly influenced by variety (Table 8). The maximum biological yield (2.58 t ha^{-1}) was found in V_4 (BU mung-4). The lowest yield (1.99 t ha^{-1}) was observed from V_1 (BARI mung-4) (Table 8).

4.13.2. Effect of sowing time

There was a significant influence in the biological yield due to sowing time. The maximum biological yield (2.75 t ha^{-1}) was found from S_2 (sowing on 24 March) and the minimum (2.10 t ha^{-1}) from S_3 (sowing on 8 April) (Table 9).

4.13.3. Interaction effect of variety and sowing time

Interaction of variety and sowing time had a significant influence on biological yield of mungbean. The highest biological yield (3.62 t ha^{-1}) was obtained from V_1S_2 (BARI mung-4 sowing on 24 March) while the lowest (1.68 t ha^{-1}) from V_4S_3 (BU mung-4 sowing on 8 April) (Table 10).

4.14. Harvest index (HI)

4.14.1. Effect of variety

Harvest index indicates the ratio of partitioning of dry matter towards reproductive and vegetative parts. The ratio of economic yield to biological yield is termed as harvest index. Higher HI might be beneficial in obtaining higher economic yield. A significant variation in HI was found in mungbean due to different variety. The highest HI (75.39%) was found in V_1 (BARI mung-4) and the lowest (59.66%) in V_2 (BARI mung-5) (Table 8).

4.14.2. Effect of sowing time

There was a significant influence in harvest index due to sowing time. The maximum HI (68.95%) was obtained from S_3 (sowing on 8 April) treatment and the minimum (59.32%) was obtained in S_2 (sowing on 24 March) (Table 9). Harvest index (HI) in S_1 (sowing on 9 March) was statistically identical to that in S_3 (sowing on 8 April) but significantly different from that in S_2

4.14.3. Interaction effect of variety and sowing time

Interaction of variety and sowing time had a significant influence on HI. The highest HI (89.79%) was obtained from V_1S_1 (BARI mung-4 sowing on 9 March) while the lowest (44.07%) from V_3S_1 (BARI mung-6 sowing on 24 March) (Table 10).

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy Field of Sher-e-Bangla Agricultural University, Dhaka during the *kharif* -1 season from March to June, 2010 to study the water relations and yield of four mungbean cultivars under different date of sowing. In experiment, the treatment consisted of four variety viz., V_1 = BARI mung-4, V_2 = BARI mung-5, V_3 = BARI mung-6, V_4 = BU mung-4, and three different date of sowing**,** S_1 = 9 March, S_2 = 24 March, S_3 = 8 April. 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 influence was observed among the treatments regarding majority of the parameters observed. The collected data were statistically analyzed for evaluation of the treatment effect.

The relative water content was significantly influenced due to the different variety. The highest RWC (85.16%) was obtained from V_2 (BARI mung-5). The highest RWC (84.69%) was obtained from S_2 (24 March). The highest RWC (88.54%) was obtained from V_3S_1 (BARI mung-6 with 9 March of sowing) treatment.

The highest exudation rate (24.19 mg hr^{-1}) was obtained from V_1 (BARI mung-4). Exudation rate was not significantly influenced by sowing time. The highest exudation rate (24.59 mg hr^{-1}) was obtained from S_2 (24 March). Interaction effect of different variety and sowing time had a significant influence on exudation rate. The highest exudation rate (47.03 mg hr^{-1}) was obtained from V_4S_1 (BU mung-4 with 9 March of sowing) treatment.

Variety had a significant influence on the dry weight of leaves, stem, root and total dry mater weight $plant^{-1}$. The highest dry weight of leaves $plant^{-1}$ (17.96 g) was recorded in V_1. The maximum dry weight of leaves $plant^{-1}$ (19.67 g) was obtained from S_2 treatment. The highest dry weight of leaves $plant^{-1}$ (36.58 g) was obtained from V_1S_2 treatment. The highest dry weight of stem $plant^{-1}$ (18.43 g) was recorded in V_4. The maximum dry weight of stem $plant^{-1}$ (16.48 g) was obtained from S_2 treatment. The highest dry weight of stem $plant^{-1}$ (31.18 g) was obtained from V_3S_3 treatment. The highest dry weight of root $plant^{-1}$ (8.31 g) was recorded in V_3. The maximum dry weight of root $plant^{-1}$ (7.20 g) was obtained from S_2 treatment. The highest dry weight of root $plant^{-1}$ (10.55 g) was obtained from V_3S_2 treatment. The highest total dry mater weight (47.08 g) was recorded in V_3. The maximum total dry mater weight (47.86 g) was obtained from S_2 treatment. The highest total dry mater weight (80.10 g) was obtained from V_3S_2 treatment.

Variety showed significant influence on pod length. The longest pod length (7.18 cm) was recorded in V_4. There was not significant influence in the pod length due to the sowing time. Numerically the longest pod length (6.99 cm) was obtained from S_2 treatment. The longest pod length (7.83 cm) was obtained from V_1S_2 treatment.

Variety had a significant influence on the number of pods plant^{-1}. The highest number of pods plant^{-1} (10.25) was recorded in V_1. Numerically maximum number of pods plant^{-1} (10.73) was obtained from S_2 treatment. The highest number of pods plant^{-1} (11.04) was obtained from V_1S_2 treatment. The highest number of seeds pod^{-1} (10.9) was recorded in V_1. The maximum number of seeds pod^{-1} (10.38) was obtained from S_2 treatment. The highest number of seeds pod^{-1} (11.38) was obtained from V_1S_2 treatment.

1000- seed weight of mungbean differed no significantly due to variety. The highest 1000- seed weight (47.79 g) was obtained from V_1. There was no significant influence in the 1000- seed weight due to the sowing time. The maximum 1000- seed weight (46.87g) was obtained from S_2 treatment. The highest 1000- seed weight (41.10 g) was obtained from V_1S_2 treatment.

The seed yield hectare^{-1} was significantly influenced by variety. The maximum seed yield hectare^{-1} (1.49 t) was observed in V_4, The lowest yield hectare^{-1} (1.45 t) was observed from V_2. There was significant influence in the seed yield hectare^{-1} due to sowing time. The maximum seed yield hectare^{-1} (1.56 t) was obtained from S_2 treatment and the minimum (1.40 t) was obtained in S_3 treatment. Combined effect of different Variety and sowing time had a significant influence on seed yield hectare^{-1}. The highest seed yield hectare^{-1} (1.68 t) was obtained from V_1S_2 treatment while the lowest (1.34 t) from V_4S_3 combination.

The straw yield hectare^{-1} was significantly influenced by variety and sowing time. The maximum straw yield hectare^{-1} (1.12 t) was observed in V_1. The maximum straw yield hectare^{-1} (1.27 t) was obtained from S_2 treatment. The highest straw yield hectare^{-1} (2.27 t) was obtained from V_1S_2 treatment.

The maximum biological yield hectare^{-1} (2.58 t) was observed in V_4. The maximum biological yield hectare^{-1} (2.75 t) was obtained from S_2 treatment. The highest biological yield hectare^{-1} (3.62 t) was obtained from V_1S_2 treatment.

A significant increase in HI was found in mungbean due to different variety. The highest HI of 75.39% was observed in treatment $V_{4.}$ The maximum HI (68.95%) was obtained from S_3 treatment. The highest HI (89.79%) was obtained from V_1S_1 treatment.

Consider the stated findings, it may be concluded that BARI mung-4 planted on March 24 would be beneficial for the farmers; BU mung-4, BARI mung-5 and BARI mung-6 would be suitable at planting date March 24 throughout the entire period of the study under Dhaka conditions.

However, in this experiment performance of only three BARI released mungbean varieties and one Bangabandhu Sheikh Mujibur Rahman Agricultural University released variety were observed only at three sowing dates. So, the response of other varieties to different planting dates should be studied in order to make a clear recommendation on the subject.

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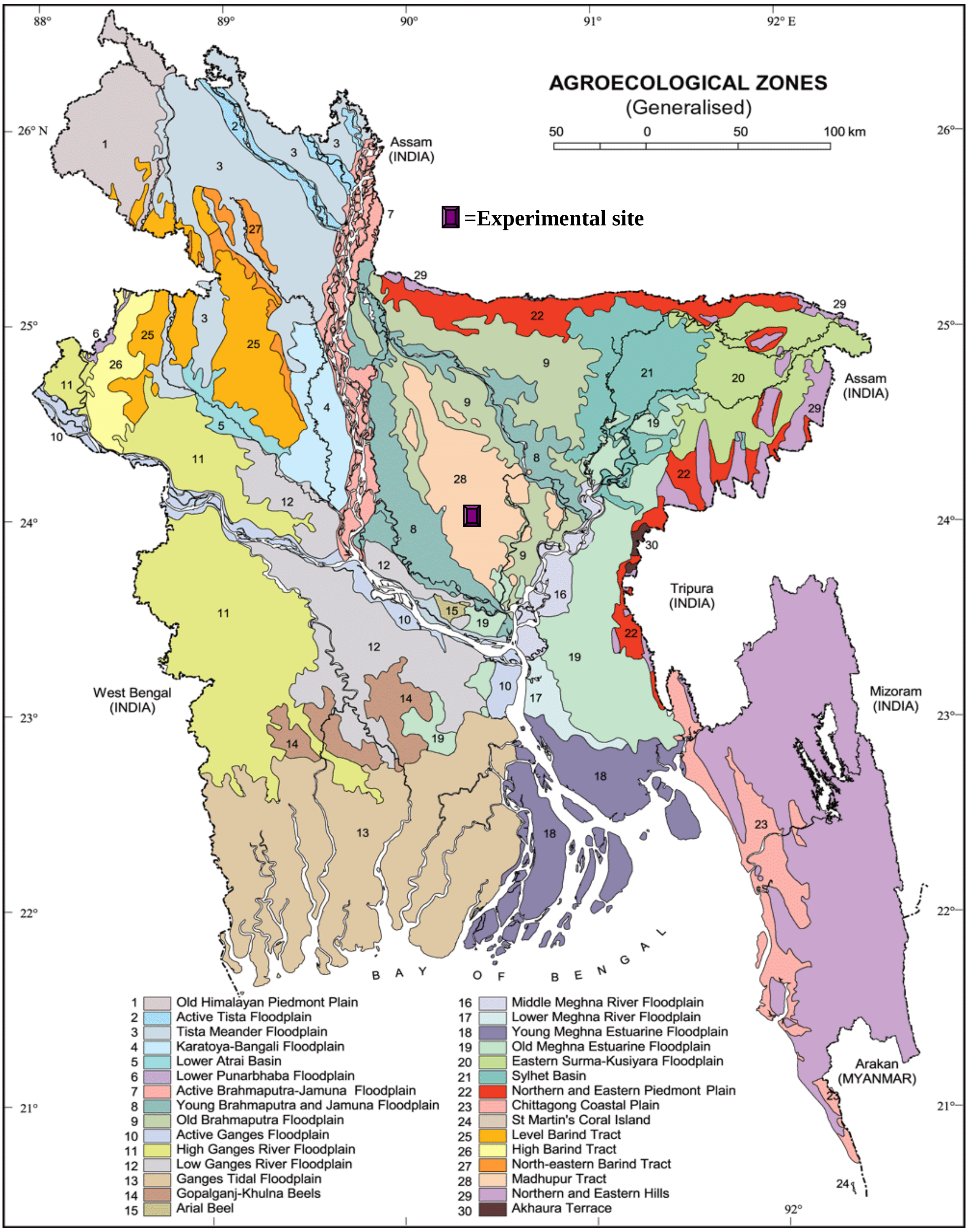
APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from March to June 2011

Month	Air temperature (^0C)			RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
March 2011	32.25	22.55	27.40	75.65	36
April 2011	33.98	24.72	29.35	89.24	67
May 2011	35.00	25.65	34.33	79.55	159
June 2011	34.85	27.15	30.0	70.05	189
July 2011	35.20	25.50	29.35	90.5	286

Source: Bangladesh Meteorological Department, Agargaon, Dhaka (Climate Division)

Appendix III. The physical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0- 15 cm depth)

Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Soil characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.07
Phosphorus	22.08 µg/g soil
Sulphur	25.98 µg/g soil
Magnesium	1.00 meq/100 g soil
Boron	0.48 µg/g soil
Copper	3.54 µg/g soil
Zinc	3.32 µg/g soil
Potassium	0.30 µg/g soil

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka