EFFECT OF SEED SIZE AND SPACING ON GROWTH AND YIELD OF MUNGBEAN

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EFFECT OF SEED SIZE AND SPACING ON GROWTH AND YIELD OF MUNGBEAN

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CERTIFICATE

*This is to certify that thesis entitled, "**EFFECT OF SEED SIZE AND SPACING ON GROWTH AND YIELD OF MUNGBEAN.**" submitted to the, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY, (M.S.)** embodies the result of a piece of bona fide research work carried out by TASLIMA AKTER, Registration No.: 09-03625 under my supervision and 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 been duly been acknowledged by her.

Dated: June, 2015

Place: Dhaka, Bangladesh

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Dedicated to

My

Beloved Parents

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EFFECT OF SEED SIZE AND SPACING ON GROWTH AND YIELD OF MUNGBEAN

ABSTRACT

An experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka, during March to May, 2014 to study the effect of seed size and spacing on the growth and yield of mungbean. The experiment was consisted of three seed sizes; viz., small (3.2mm), medium (3.2 mm to 4mm) and large (>4mm) and four row spacings (20cm, 25cm, 30cm and 35cm). The experiment was laid out in Randomized Complete Block Design (RCBD) (factorial) with three replications. The results showed that growth, yield and yield attributes of mungbean significantly influenced by seed sizes, spacings and their combinations. At harvest, medium seed sized gave the longest plant height (44.8 cm), maximum number of leaves plant^{-1} (10.0), the highest leaf dry weight plant^{-1} (7.6g), flower and pod dry weight plant^{-1} (3.4g), total plant dry weight (15.5g), biological yield plant^{-1} (3.0g), harvest index (0.38) and seed yield (1.58t ha^{-1}). The plant of 30cm spacing gave the highest seed yield (1.57t ha^{-1}), biological yield (3.8 t ha^{-1}), harvest index (0.39). The combined effect of medium seed size (3.2-4mm) and sowing at 30 cm spacing showed maximum grain yield (2.4 t ha^{-1}) with higher value of harvest index (40.00%).

CHAPTER 1

INTORDUCTION

Mungbean (*Vigna radiate* (L.)Wilczek) is one of the most important pulse crops in Bangladesh. 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 atmospheric nitrogen fixation. Mungbean contains 51% carbohydrate, 24–26% protein, 4% mineral, and 3% vitamins (Afzal *et al*., 2008). Besides providing protein in the diet, mungbean has the remarkable quality of helping the symbiotic root rhizobia to fix atmospheric nitrogen and hence to enrich soil fertility (Anjum *et al.*, 2006). Its edible grain is characterized by good digestibility, flavor, high protein content and absence of any flatulence effects (Ahmed *et al.*, 2008). It is widely used as "Dal" in the country like others pulses.

Bangladesh is a developing country. Due to the shortage of land, the scope of its extensive cultivation is very limited. Therefore, attempts must be made to increase the yield per unit area by applying improved technology and management practices. Mungbean has special importance in intensive crop production system of the country for its short growing period. In spite of the best efforts for improving the mungbean varieties, the yield of this crop remains low. Several studies have been made to understand their performances which mainly include the contribution of various yield components towards yield (Sarwar *et al*., 2004; Hakim, 2008; Singh *et al*., 2009).

The yield components depend on some physiological traits. The reasons for low yield are manifold: some are varietals and some are agronomic management practices. It is cultivated in both season kharif-1 and kharif-2. It is traditionally grown throughout the country during the month of February to April in kharif-1 and from July to November in kharif-2. A significant number of farmers are still using broadcast method of seed sowing which causes uneven distribution of seed. The seeds at the bottom received more moisture in comparison to those in the top, which may produce uneven emergence of seedlings and also uneven maturity of plants. Ultimately it creates a difficult situation for harvesting. This can easily be overcome by maintaining proper row spacing.

Seed size is one of the components of seed quality which affects the performance of crop (Ojo, 2000; Adebisi, 2004; Adebisi *et al*., 2011). Size is a widely accepted measure of seed quality and large seeds have high seedling survival growth and establishment (Jerlin and Vadivelu, 2004). A wide array of different effects of seed size has been reported for seed germination, emergence and related agronomical aspects in many crop species (Kaydan and Yagmur, 2008). Generally, large seed has better field performance than small seed. Plant ecologists generally concur that larger seed size leads to larger initial plant vigor.

Different seed sizes of a cultivar having different labels of starch and other food storage may be one of the factor which influences the expression of physiological- dependent character (Chiangmai *et al*., 2000). Large seed had an advantage of having more stored energy and supply that to the seedling that leads to increased seedling vigour.

Various experimental work on spacing of mungbean have been carried out in Bangladesh, as well as in other countries to find out the suitable plant population to get maximum yield (Mondal, 2007). Improper spacing reduced the yield of mungbean up to 20 to 40%(Mondal, 2007). Plant spacing directly affects the physiological activities through intra-specific competition. The optimum plant density is a pre-requisite for obtaining higher productivity (Rafiei, 2009). Plant density affects the plant growth (Jahan and Hamid, 2005). Ihsanullah *et al.*, (2002) found significant influence of spacing on plant height of mungbean.

Narrowing of plant spacing by increasing seed rate generally means a more uniform distribution of plants over a given area, thus matching the plant canopy effective in intercepting radiant energy and shading weeds. Though wider space allows individual plants to produce more branches and pods, but it provides smaller number of pods per unit area due to fewer plants per unit area.

Research work with various seed size and spacing of mungbean seed under Bangladesh condition is limited.

The present study was therefore, undertaken with the following objectives.

a) To study the effect of seed size and spacing on growth and yield of mungbean.

b) To study the interaction effect of spacing and seed size on the growth and yield of mungbean.

CHAPTER 2

REVIEW OF LITERATURE

A field experiment was conducted at the Sher-e-Bangla Agricultural University farm to study the effect of seed size and spacing on water relations, growth and yield of mungbean. Some related research findings of different researchers of home and abroad have been cited below:

2.1. Effect of seed size on the growth parameters of legumes

2.1.1. Plant height

Hojjat (2011) reported that the germination parameters were significantly related by seed weight and large seeds germinated early and showed better germination than small seeds of Lentil genotypes. However the studies of Kaydan and Yagmur (2008) on Triticale showed that the seedling growth of larger seeds was rather than of small seeds.

Mut and Akay (2010) reported that decreasing the seed size can cause to decrease the germination percentage, root and shoot length of Naked oat. An experiment was conducted with soybean to examine the effect of different seed size (small, medium and large). In that experiment, it was found that with increasing the seed size, plant height was found to be increased significantly. The highest plant height was obtained from sowing large sized seed (Kabir, 2000).

2.1.2. Number of leaf plant^{-1}

Number of leaves plant^{-1} was examined under different seed size of soybean (Kabir, 2000). Results showed that the seed size had no significant effect on number of leaves plant^{-1}. But, with increasing the seed size, the number of leaves per plant was found to be increased. The highest number of leaves per plant was obtained from using the large sized seed and the lowest number was found using small seeds.

2.1.3. Total dry matter

Kabir (2000) reported that the shoot dry weight of soybean increased significantly due to the sowing of large sized seeds. In another experiment, Kabir (2000) found that seed size (small, medium and large) had significant effect on total dry weight showing the highest dry weight from using the large sized seeds.

2.2. Effect of seed size on yield attributes

2.2.1. Number of pods plant^{-1}

Kabir (2000) reported that the highest number of pods plant^{-1} of soybean was obtained using the large sized seeds. It was also seen that with increasing the seed size and decreasing the sowing depth, number of pods plant^{-1} of soybean was found to be decreased. The highest number of pods plant^{-1} was obtained from using the large sized seeds when sown in 2 cm depth. Similar result was also found by Islam (2004) in mungbean.

2.2.2. Number of seeds pod^{-1}

Kabir (2000) stated that seed size of soybean had significant effect on number of seed per pod. In his study, it was seed that the highest number of seeds per pod was obtained from using the large sized seeds. Likewise, Islam (2004) reported that with increasing the seed size, number of seeds per pod of mungbean was increased.

2.2.3. 1000 seeds weight

Kabir (2000) in his study with soybean showed that the highest 1000 seeds weight was obtained when large sized seeds were sown. Similar result was also obtained by Islam (2004) who worked with mungbean. Vishvanath *et al*. (2006) noticed significantly higher seed quality parameters viz. 100 seed weight, field emergence, seedling length, vigour index with the increase in sieve size in french bean.

2.2.4. Seed yield

Pedersen (2006), in soybean, reported that smaller and larger seeds of a same variety will have the same yield potential. Gan *et al*. (2003) postulated that seed size had no significant impact on plant growth, development and seed yield of large-seeded crops such as chickpeas. However, in other crops, Stougaard and Xue (2005) reported that the use of higher larger seed sizes improved yields by 18%, and the use of small seeds reduced yield by 16% in wheat. This was also reported by Royo *et al*. (2006). In chickpea and lentil, were observed that plants from large seeds yielded 6% more than medium seeds and 10% more than mixed seeds (Bicer, 2009).

2.2.5. Harvest index

In soybean, Kabir (2000) found that seed size had significant effect on harvest index. With increasing the seed size, the harvest index was increased. In that study, it was also found that sowing different sized seeds affected differently when sown at different depth. In another study, Islam (2004), however, found that seed size had no significant effect on harvest index although, with increasing the seed size, harvest index was found to be increased.

2.3. Effect of spacing on the growth parameters of legumes

2.3.1. Plant height

Increasing the plant density was positively correlated to yield and plant height and negatively related with flowering as significant reduction was noticed in flowering. According to Reddy and Reddi (2006), plant density brings out certain modifications in the growth of plants. Plant height increases with the increase in plant population in extreme level due to competition for highest plant height. Mokhtar (2001) reported that increasing plant density vestige negatively influences numbers of branches and pods per plant. In addition, Ben (2003) found the same results. Dahmardeh *et al.* (2010) reported that plant height was not affected by increasing plant density.

2.3.2 Number of leaf plant^{-1}

Moniruzzaman (2011) conducted an experiment on cabbage at the Agricultural Research Station, Raikhali, Rangamati hill district to find out the optimum plant spacing and suitable cabbage variety(s). He found that the wider spacing of 60 × 45 cm resulted in significantly maximum number of folded leaves and head weight (without unfolded leaves) in comparison to closer spacing of 60 × 30 cm.

Maboko and Plooy (2009) conducted an experiment on lettuce and found that there was a significant interaction between spacing and cultivar regarding leaf fresh and dry mass. Plant population significantly affected plant height, fresh and dry leaf mass, leaf area and leaf number m^{-2}, with significantly higher values of all variables at the closest spacing (50 plants m^{-2}). The results indicate that an increase in plant population results in a significant increase in yield and yield components of leafy lettuce, with all cultivars producing the highest yield at a spacing of 50 plants m^{-2} during winter production.

2.3.3. Total dry matter

Dry matter production per unit land area increases with increase in plant population up to a limit growth of a plant is more than compensated in the number of plants per unit area Reddy and Reddi,(2006). Muchow and Edwards (1982) reported significantly positive linear trends of dry matter production in three varieties of mungbean to increasing density. Narrow spacing significantly increased dry matter production in pigeonpea (Madhavan *et al.,* 1986).

2.4. Effect of seed size on yield attributes

2.4.1. Number of pods plant^{-1}

Dordas and Lithourgidis (2011) found that a decrease in yield with higher density of 8 plant m^{-2} , number of seeds pod^{-1} and the number of pods plant^{-1}, poor concentration and lack of efficient use of space is feeding on the plant. Idris (2008) indicated that increasing plant spacing increased number of pods per plant and consequently gave the highest seed yield.

Bakry *et al*., (2011) and Yucel (2013), who reported that pod number decreased with increasing plant density. Adebisi *et al*., (2013) reported that in tropical soybean lots with small seed size had maximum seed germination (97%) and emergence (90%) while those with large seed size produced the highest seed (88) per plant, pods (54) per plant and seed yield (9.72 g) per plant.

2.4.2. Number of seeds pod^{-1}

Bakry *et al*., (2011) reported that the plant more seeds per pod, and this trend moderately reduced in most tributaries of the main branch. This review will also increase the number of pods m^{-2} at high densities relative reduction in pod and seed weight was increased. Planting pattern showed non-significant effect on the number of seeds per pod. The non-significant effect of row spacing on the number of seeds per plant has also been reported by Ali *et al*. (2001) and Sharar *et al*., (2001).

2.4.3. 1000 seeds weight

Dahmardeh *et al*.,(2010) showed that some characters were markedly affected by plant density, except plant height, height of the lowest pods of surface, 100 seeds weight, number of pods per plant and number of seed per pod. Increasing plant density from 12.5 to 20 plant m^{-2} significantly increased economical yield and biological yield. Eman, Ahmed (2004) reported that sowing 25 plants m^{-2} produced the highest bulk density and stewing %. However, sowing 33 plants m^{-2} gave the highest values of seed, straw and biological yields/feddan, total carbohydrates, tannin, ash, 100 seeds weight. Ahmed *et al.* (2010) reported that decreased plant population had a significant increase on most yield components and increased 100 seeds weight. This may be due to better availability of nutrients and better translocation of photosynthates from source to sink and may be due to higher accumulation of photosynthates in the seeds. Crops sown in 40 cm apart rows produced significantly higher 1000 seeds weight than 60 cm apart double row strips. Significant effect of row spacing on 1000 seeds weight has also been reported by Ali *et al*., (2001).

2.4.4.Seed yield

Row spacing at 22.5 cm resulted in higher grain yields in both crops (Tickoo *et al*., 2006). Malekmelki *et al*. (2012) reported that, with increasing plant density increased biological yield and seed yield of lentil. Ahmad *et al.* (2005) conducted a field experiment in Faisalabad, Punjab, Pakistan, during 2000 to study the effect of P fertilizer f(0, 30, 60 and 90 kg per hectare) and row spacing (30 and 45 cm) on the yield and yield components (pods plant^{-1}, seeds pod^{-1} and 1000- seed weight) of mungbean line NM-92. Seed yield was the highest with 30 cm row spacing while pods per plant, seeds per pod and 1000 seeds weight were highest with 45 cm row spacing. Osman et al (2010) stated that the maximum yield was obtained with the highest density of plants ha^{-1}. Ahmed *et al.* (2010) reported that increasing population density decreased number of pods per plant and the seed yield per plant. They further stated that plant population had a significant effect on most yield components. With respect to the varieties, IT89KD-391 had significantly higher number of pods per plant, length of pods per plant and number of seed per pod followed by IT97K-499-35 while IT89KD-288 recorded the lowest numbers.

Bhatti *et al.* (2005) conducted a field experiment on a sandy-clay loam soil in Faisalabad, Pakistan for two consecutive years (2001 and 2002) to evaluate the effect of intercrops and planting patters on the agronomic traits of sesame. The effect intercrops and planting patterns on the agronomic traits of sesame. The planting patterns comprised 40 cm spaced single rows, 60 cm spaced 2-row strips and 100 cm spaced 4-row stripes, while the cropping systems were sesame + mungbean, sesame + mashbean (*Vigna aconitifolia),* sesame + soyabean, sesame + cowpea and sesame alone. Among the intercropping patterns , sesame intercropped with mungbean, mashbean, soyabean and cowpea in the pattern of 100 cm spaced 4-row strips (mungbean 25 cm apart) proved to be feasible, easily workable and more productive than sesame monocropping.

Researchers in Arkansas, Louisiana, and Texas summarized 21 field experiments conducted over 14 years to determine the effect of row spacing on seed yield in soybean (Bowers *et al.*, 2000). For all environments tested, narrow rows (<40 cm) yield equal to or greater than wider rows. These researchers concluded that narrow rows should be used to optimize yield in soybean in the Midsouthern USA.

Asghar *et al.* (2009) conducted a field studies in Faisalabad, Pakistan, to determine the effect of different sowing dates and row spacing on the growth and yield of sesame cv.92006. Four sowing dates (8, 15, 22 and 29 July) and 3 row spacings (30, 45, 60 cm) were used. Effect of sowing dates was highly significant and maximum branches/plant and seed yield was produced when the crop was sown on 8 and 15 July due to higher number of capsules per plant and more seeds per capsule. Seed yield was increased with an increase in row spacing from 30 to 45 cm. however further increase in spacing decreased the seed yield.

Krishna *et al.* (2008) conducted a field trial during the summer at Tirupati, Andhra Pradesh, India, to assess the superiority of skip row planting of base crop of sesame over uniform row spacing at the same population level and to evaluate the feasibility of introducing green gram as intercrop under irrigated conditions. Green gram yield was reduced when it was intercropped with. Sesame and 100% green gram population recorded higher yield than 50%

green gram population. The highest net returns were obtained in sesame single row single skip +100% green gram in skip row.

Raghuwanshi (2009) conducted a field trial at Tikamagarh, Madhya Pradesh in 2008 kharif (monsoon) season, sesame cv. TKG-9, tkg-21, JLSC-8 and JT-7 produced mean seed yields of 2.53, 2.80, 2.92 and 1.86 t^{-1}ha, respectively. Yield averaged 2.05 and 3.00 t with spacings of 30x15 and 10x10cm, and 3.99, 1.85 and 1.75 t when sownat the onset of monsoon (1 July) or 10 or 20 d after this date. Asghar *et al.* (2009) and Krishna *et al.* (2008) also reported about similar kind of result for sesame.

Cakmakc and Aydnoglu (2002) conduct a field studies during 2000-2002 in Anatolia, Turkey, to determine the influence of different row spacing (15, 30, 45 and 60 cm) and N fertilizer application rates (0, 50, 100 and 150 kg/ha) to the yield of chickling vetch (*Lathyrus sativus*). The treatment with 30 cm row spacing and 150 kg N ha^{-1} produced the highest forage and dry matter yield. The lowest forage yield was observed at 45 cm row spacing with no N fertilizer applier, while the lowest dry matter yield was observed at 30 cm row spacing and no N fertilizer application. It is concluded that chickling vetch is an alternative legume crop for rotation in terms of yield. Researchers in Arkansas, Louisiana, and Texas summarized 21 field experiments conducted over 14 years to determine the effect of row spacing on seed yield in soybean (Bowers *et al.,* 2000). For all environments tested, narrow rows (<40 cm) yield equal to or greater than wider rows. These researchers concluded that narrow rows should be used to optimize yield in soybean in the Midsouthern USA.

CHAPTER 3

MATERIALS AND METHODS

A field experiment was conducted at the Sher-e-Bangla agricultural University farm to study the effect of seed size and spacing on the growth and yield of mungbean. The details of the experimental materials and methods used in this experiment have been described below:

3.1. Site description

3.1.1. Geographical location

The experimental area was situated at 23°77´N and $90^0$35´E longitude at an altitude of 8.6 meter above the sea label.

3.1.2. Agro-Ecological Zone

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur tract leaving small hillocks of red soils as 'islands' surrounded by floodplain. The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3. Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace soils under Tejgaon series. Soil pH was 7.1 and had organic matter 1.08%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depth were collected from experimental fields. The analyses were done by Soil Resource and Development Institute (SRDI, Dhaka. The chemical properties of the soil are presented in Appendix II.

3.2. Source of seed

The seeds of mungbean variety, BARI mung-6, were collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

3.3. Treatments

Two sets of treatment were included in the experiment as follows:

A. Spacing:4

B_1: 20cm

B_2: 25cm

$B_{3:}$ 30 cm

$B_{4:}$ 35cm

B. Seed size:

A_1: Small (<3.2 mm)

$A_{2:}$ Medium (3.2 mm to 4mm)

A_3: Large (>4 mm)

As such the total numbers of treatments were 36.

3.4. Experimental design and lay out

The experiment was conducted following Randomized Complete Block design with 3 replications. The size of each plot was 3.75×1.78 m. Block to block distance was 50cm and plot to plot distance was 30 cm (Appendix III).

3.5. Land preparation

The land was first ploughed by a tractor drawn disc plough and subsequently cross ploughed four times with power tiller and ladder. The corners of the land were spaded. It was then harrowed to bring the soil in a good tilth condition. The land was then thoroughly leveled by a ladder. Weeds and stubbles were removed from the field. All the clods were broken into small pieces. The unit plots were also prepared smoothly with spade before sowing.

3.6. Fertilizer dose

Fertilizers were applied at the rate of 21-46-33 kg of N, P_2O_5 and K_2O ha^{-1}, respectively (BARI, 2006).

3.7. Method of fertilizer application

Whole amount of Urea, TSP and MoP fertilizers were applied as basal dose during final land preparation.

3.8. Seed grading

Seeds were graded by mashes into three sizes as per experimental treatments.

3.9. Sowing of seeds

Mungbean seeds were sown on 11 March 2014 in furrows continuously by hand maintaining line to line distance as per treatment.

In each furrow, the seeds were sown in solid line and were then covered properly with soil.

3.10. Thinning

The thinning was done 15 days after sowing maintaining plant to plant distance of 10 cm.

3.11. Intercultural operations

3.11.1. Weeding

The experimental crop plants were found to be infested with weeds of different kinds which were controlled manually by nirani. Weeding was done two times; 15 and 25 days after sowing (DAS).

3.11.2. Application of insecticides

The mungbean plants were infested at seedling stage by cutworm and at vegetative stage by hairy caterpillars. They were controlled by spraying Nogos and Savin-85 SP respectively, as per recommendation. Irrigation was given as per necessity of the crop.

3.12. Harvesting

Mungbean pods were harvested on 20 May 2014. Three plants from each plot were selected at random before harvesting and were uprooted for data recording. The harvested pods were dried in sun for consecutive three days.

3.13. Threshing

The pods were then threshed by a bamboo stick and seeds were separated from the plants.

3.14. Drying

The separated seeds were then dried in sun for consecutive three days.

3.15. Cleaning and weighing

The threshed and dried seeds were then cleaned by using a winnower.

3.16. General observations

The crop was frequently monitored to note any change in plant characters. The crop looked promising since the initial stage and in maintained a satisfactory growth till harvest.

3.17. Determination of maturity

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

3.18. Recording of data

Different growth and yield data were recorded from the experiment.

A. Growth characters

i. Seedling shoot and total fresh weight (g)

ii. Plant height at different growth stages (cm)

iii. Leaf dry weight per plant (g)

iv. Shoot dry weight per plant (g)

v. Total dry matter production (g)

vi. Number of leaflet per plant

B. Yield and yield components

i. Number of pods per plant

ii. Pod length (cm)

iii. Number of seeds per pod

iv. Weight of 1000 seeds (g)

v. Seed yield (ton per hectare)

vii. Harvest index (%)

3.19. Procedure of recording data

The detail outline of data recording is given below.

3.19.1. Plant height (cm)

The height of pre-selected five plants were measured from the ground level to tip of the plants and then averaged. Plant height was taken at 25, 35, 45, 55 and 65 days after sowing from the selected plants.

3.19.2. Number of leaflets plant^{-1}

The number of leaflets from the five sampled plants were counted at all the growth stages (25, 35, 45, 55and 65 DAS) and their mean values were calculated.

3.19.3. Dry weight plant^{-1} (g)

Five plants were collected randomly from each plot at 25, 35, 45, 55 and 65 days after sowing. Those were then segmented into leaf and stem. At 45 and 60 days after sowing, inflorescences and immature pods were also separated from the plants. Leaflets contained petioles with them.

The sampled plants were oven dried for 72 hours at 70° C and the dry weight per plant was determined by using the following formula:

Dry weight per plant =Dry weight (g)/Number of plants

The dry weight of each segment was measured individually. The total weight was calculated by summing up the weight of all segments al all the growth stages.

3.19.4. Number of pods plant^{-1}

The number of pods of five plants was counted and their mean were calculated.

3.19.5. Number of seeds pod^{-1}

The number of seed of each randomly selected ten pod was counted and the mean was found out by dividing the number of pods.

3.19.6. Weight of 1000 seeds (g)

One thousand seeds were randomly taken from the harvest sample of each plot. The seeds were then sun dried for seven days and weighted with a sensitive electrical balance. The 1000 seeds weight was recorded at 12% moisture level.

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

The pods from the central four lines were harvested plot wise as per experimental treatments and threshed. Seeds were then cleaned and sun dried for seven days and weighted with a sensitive electrical balance.

3.19.8. Harvest index (HI)

Harvest index was calculated by using the dry weight of plant where the root weights were excluded. Harvest Index was taken plot wise as per experimental treatments by the following formula:

HI(%)=Grain yield (g per plant)x100/Straw yield (g per plant)+grain yield (g per plant)

3.20. Statistical analyses

The data collected on different parameters were statistically analyzed using the MSTAT-C computer package program. Least significant Difference (LSD) technique at 5% level of significance was used to compare the mean differences among the treatments (Gomez and Gomez, 1984)

CHAPTER 4

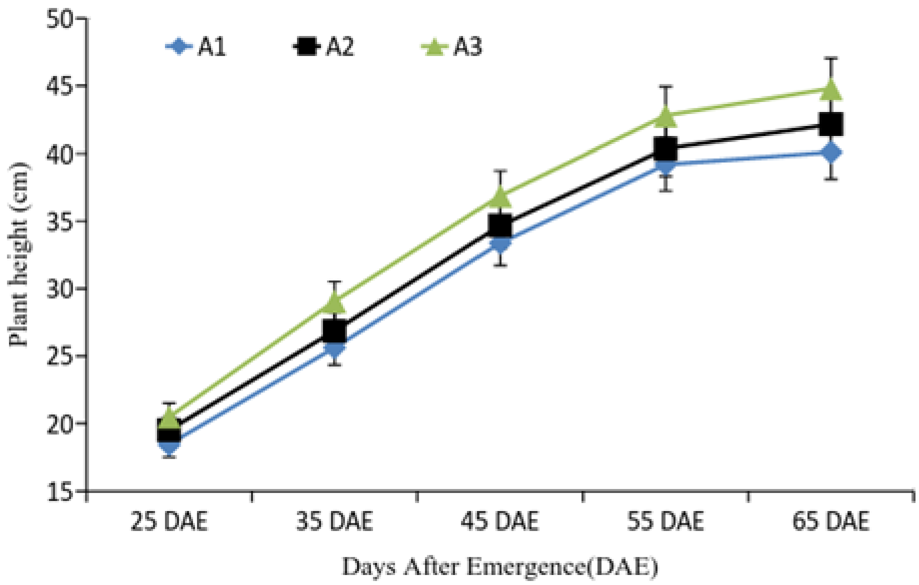
RESULTS AND DISCUSSION

The results of experiment were presented and discussed in this chapter. For easy understanding results were presented and discussed under subheading and data were presented in Table or Graph.

4.1. Growth parameters

4.1.1. Plant height

4.1.1.1. Effect of seed size

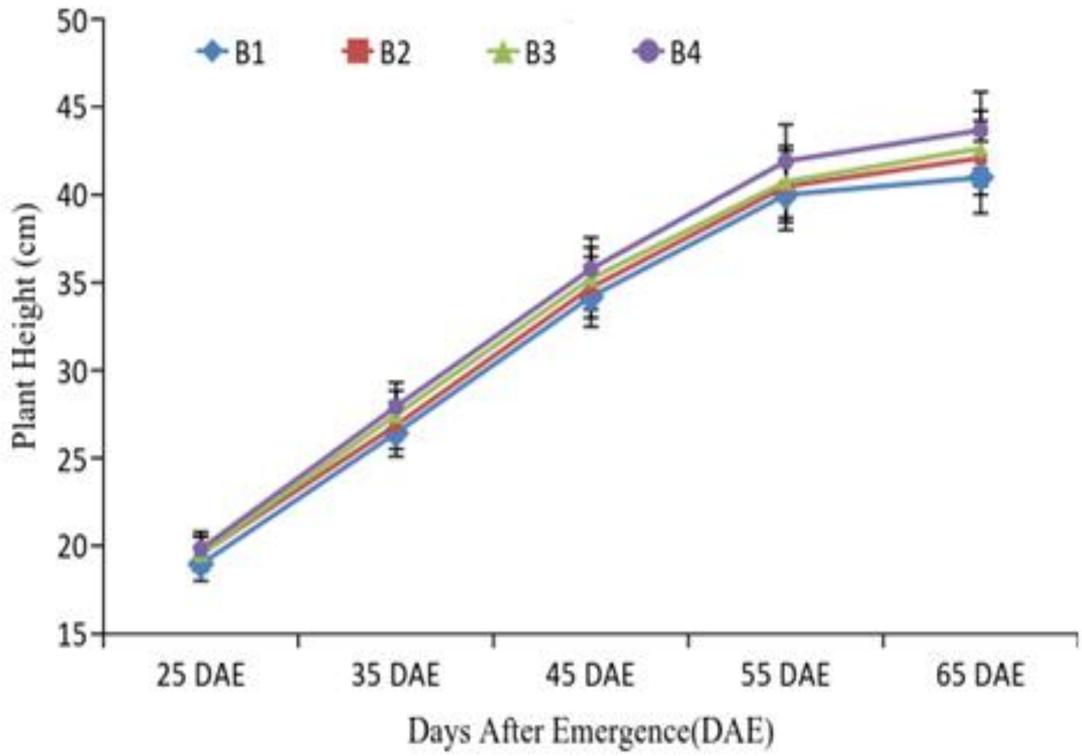


A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm)

Figure.1. Effect of seed size on plant height of BARI mung-6 at different days after emergence, $LSD_{(0.05)}$ showing 1.2, 1.4, 1.9, 1.6 & 2.0 at 25, 35, 45, 55, 65 DAE respectively.

The effect of seed size on plant height was significant at all the growth stages studied (Figure 1). The highest plant height was recorded for the largest seed size and it was decreased with the decreasing seed size.

4.1.1.2. Effect of spacing

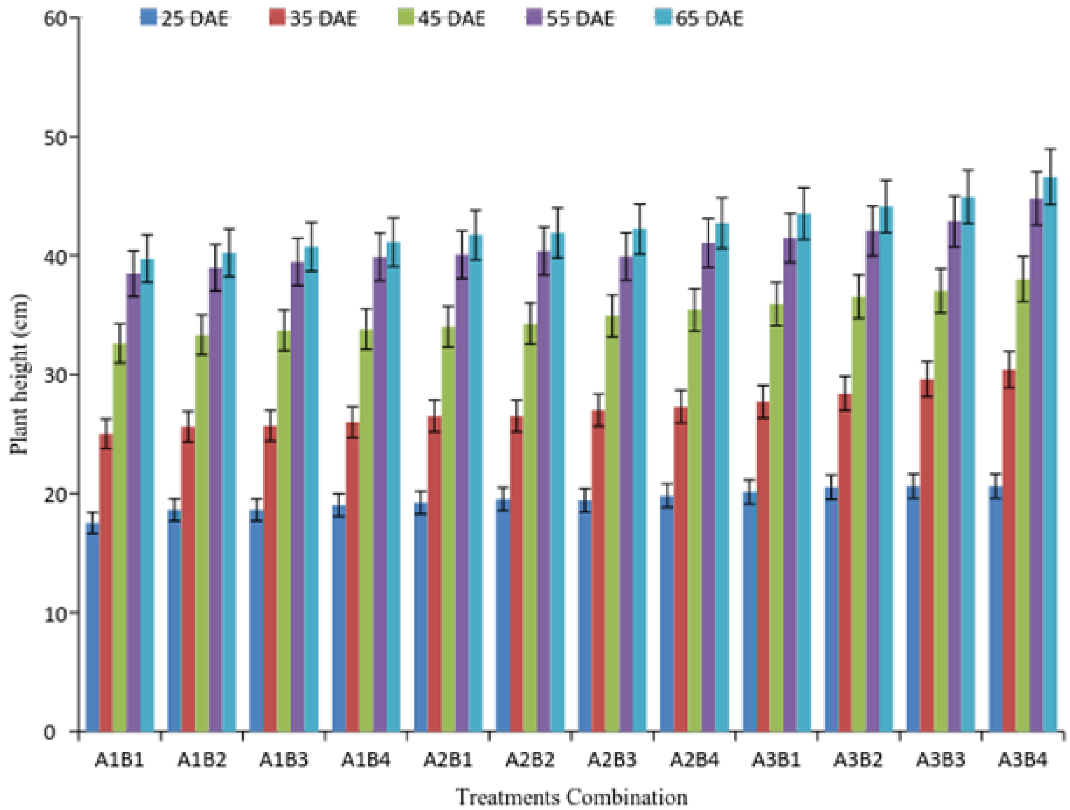


B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm ($LSD_{(0.05)}$ showing 1.3, 1.6, 2.2, 1.8 & 2.3 at 25, 35, 45, 55, 65 DAE respectively).

Figure.2. Effect of spacing on plant height of BARI mung-6 at different days after emergence .

The effect of spacing on plant height at different days after emergence has been presented in (Figure 2). At all the growth stages, sowing maintaining 35 cm row to row spacing (B_4) produced the tallest plant and the plant height was decreased with decreasing row to row spacing.

4.1.1.3. Combined effect of seed size and spacing on plant height



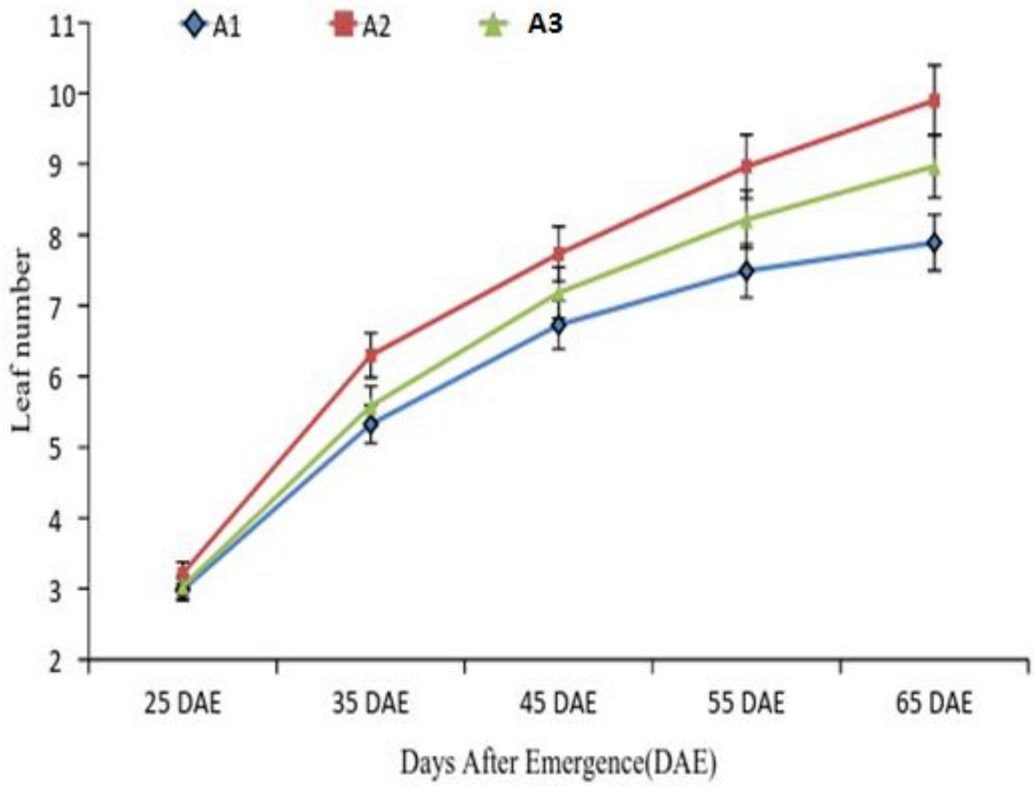
A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm), B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm ($LSD_{(0.05)}$ showing 2.3, 2.7, 3.8, 3.2 & 4.0 at25, 35, 45, 55, 65 DAE respectively).

Figure 3. Combined effect of seed size and spacing on plant height of BARI mung-6 at different days after emergence.

The combined effect of seed size and spacing had significant effect on plant height (Figure 3). It was observed that at the lowest spacing with small seed size produced the shortest (39.7 cm) plants among the all treatments. It was also observed that the highest spacing with medium seed size showed the highest result (46.6 cm) and it was significantly higher than the other combinations.

4.1.2. Leaf number plant^{-1}

4.1.2.1. Effect of seed size

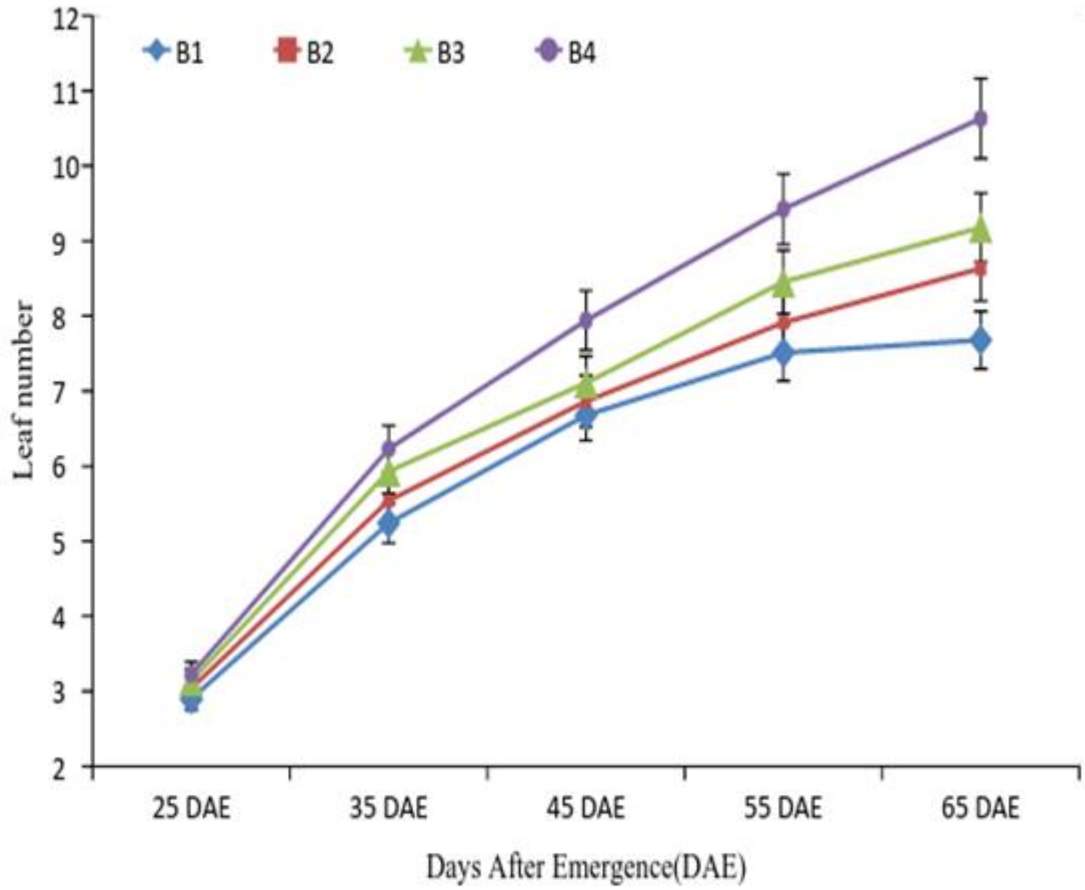


A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm) ($LSD_{(0.05)}$ showing 0.2, 0.3, 0.3, 0.4 & 0.4 at 25, 35, 45, 55 65 DAE respectively).

Figure 4. Effect of seed size on leaf number of BARI mung-6 at different days after emergence.

The effect of seed size on leaf number plant^{-1} has been shown in (Figure 4). At all the days after sowing studied the leaf number plant^{-1} was the highest in the treatment having medium seed size (A_2: 3.2-4mm) and the lowest in small sized seed. The leaf number plant^{-1} was intermediate in large sized seed. The variations in number of leaf plant^{-1} due to seed size were prominent with advancement of growing stages.

4.1.2.2. Effect of spacing

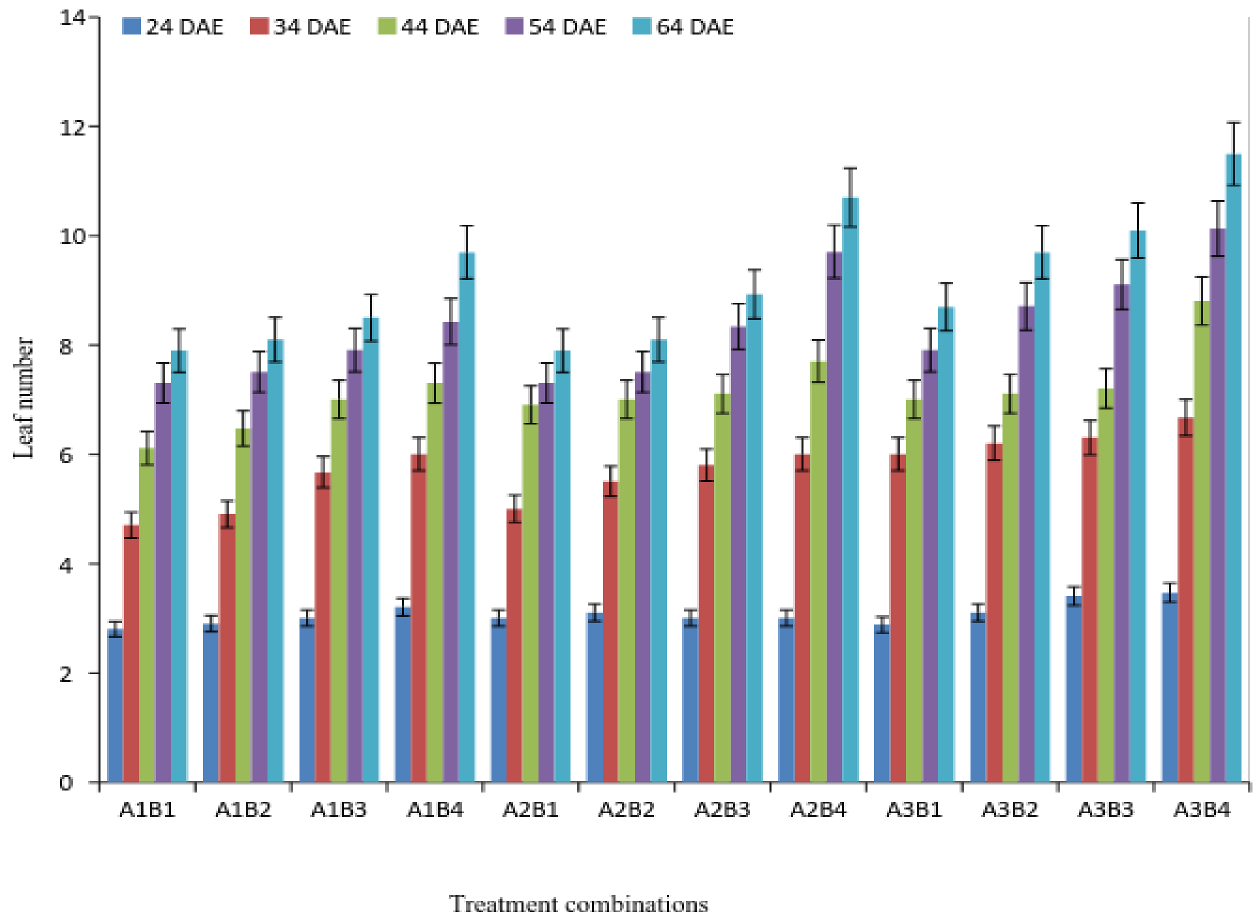


B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm) ($LSD_{(0.05)}$ showing 0.2, 0.3, 0.3, 0.5 & 0.5 at 25, 35, 45, 55, 65 DAE respectively).

Figure 5. Effect of spacing on leaf number of BARI mung-6 at different days after emergence.

At 25 DAE, the leaf number plant-1 was found to be increased with the increase of spacing up to 35 cm (Figure 5). The spacing had significant effect on leaf number plant^{-1}. The highest leaf number was found in B_4: (35cm) spacing at 65 DAE and it was higher than the other spacing as B_1: (20cm); B_2: (25cm); B_3: (30cm); and B4: (35cm).

4.1.2.3. Combined effect of seed size and spacing



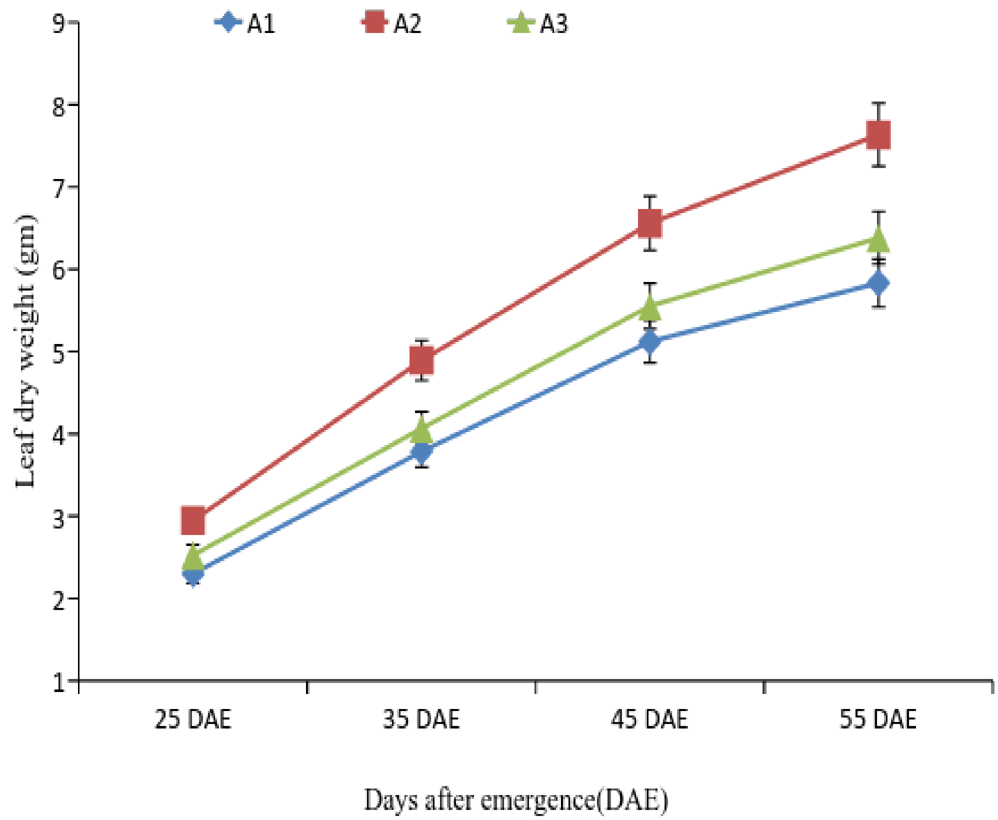
A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm), B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm ($LSD_{(0.05)}$ showing 0.4, 0.6, 0.5, 0.8 & 0.9 at 25, 35, 45, 55, 65 DAE respectively).

Figure 6. Combined effect of seed size and spacing on leaf number plant^{-1} of BARI mung-6 at different days after emergence.

The combined effect of seed size and spacing on leaf number plant^{-1} was significant (Figure 6). It was observed that at the lowest spacing, with small seed size produced the lowest number of leaves plant^{-1} (7.3), whereas at the highest spacing along with the medium seed size produced the highest number of leaves (11.5). The second highest leaf number was found on A_2B_4 treatment, which was significantly higher than the other combinations.

4.1.3. Leaf dry weight

4.1.3.1. Effect of seed size

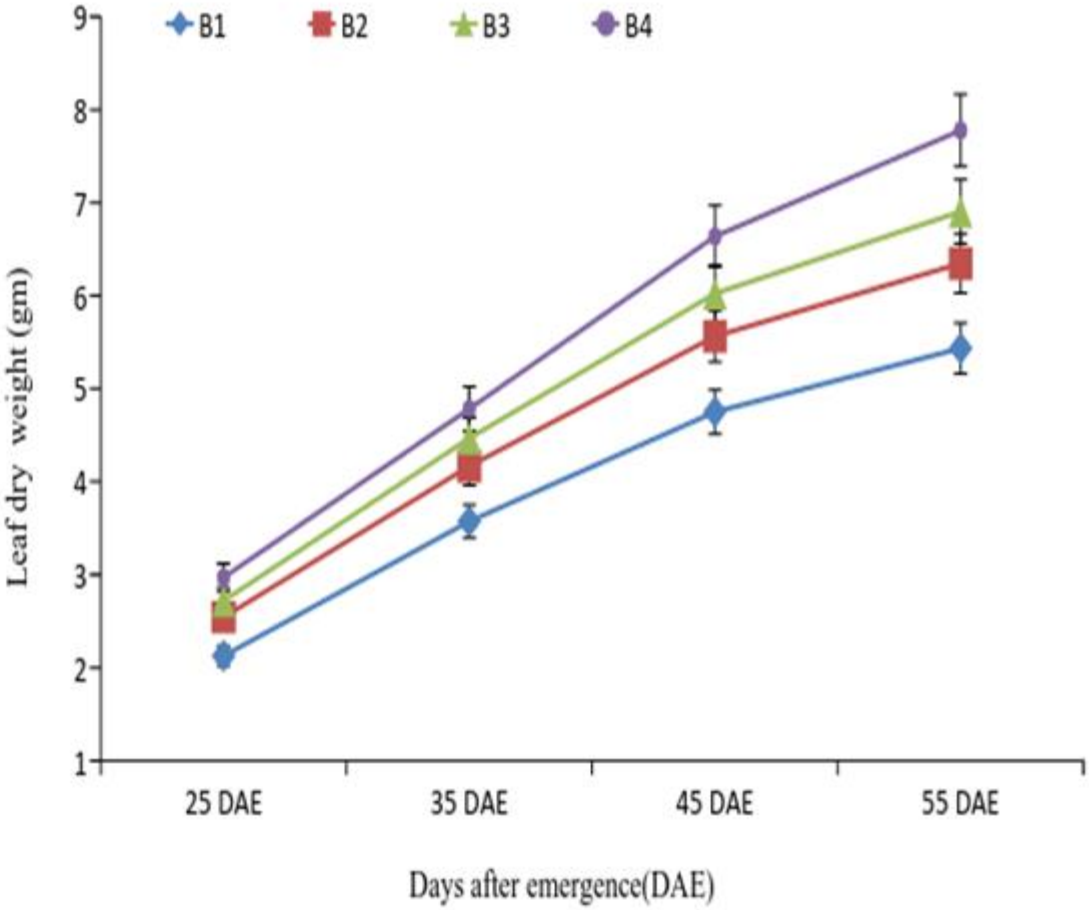


A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm) ($LSD_{(0.05)}$ showing 0.04, 0.01, 0.06 & 0.08 at 25, 35, 45, 55, 65 DAE respectively).

Figure 7. Effect of seed size on leaf dry weight of BARI mung-6 at different days after emergence.

Seed size had a significant effect on leaf dry weight (Figure 7). At 25 DAE, medium seed sized plant (A2: 3.2-4mm) showed more leaf dry weight than the others. The leaf dry weight of small seed sized (A1: <3.2 mm) and large seed sized (A3:>4mm) were increasing gradually up to 55 DAE. Leaf dry weight of medium seed sized plant showed about 8g at 55 DAE where, small and large seed sized plant were showing leaf dry weight less than 6g.

4.1.3.2. Effect of spacing

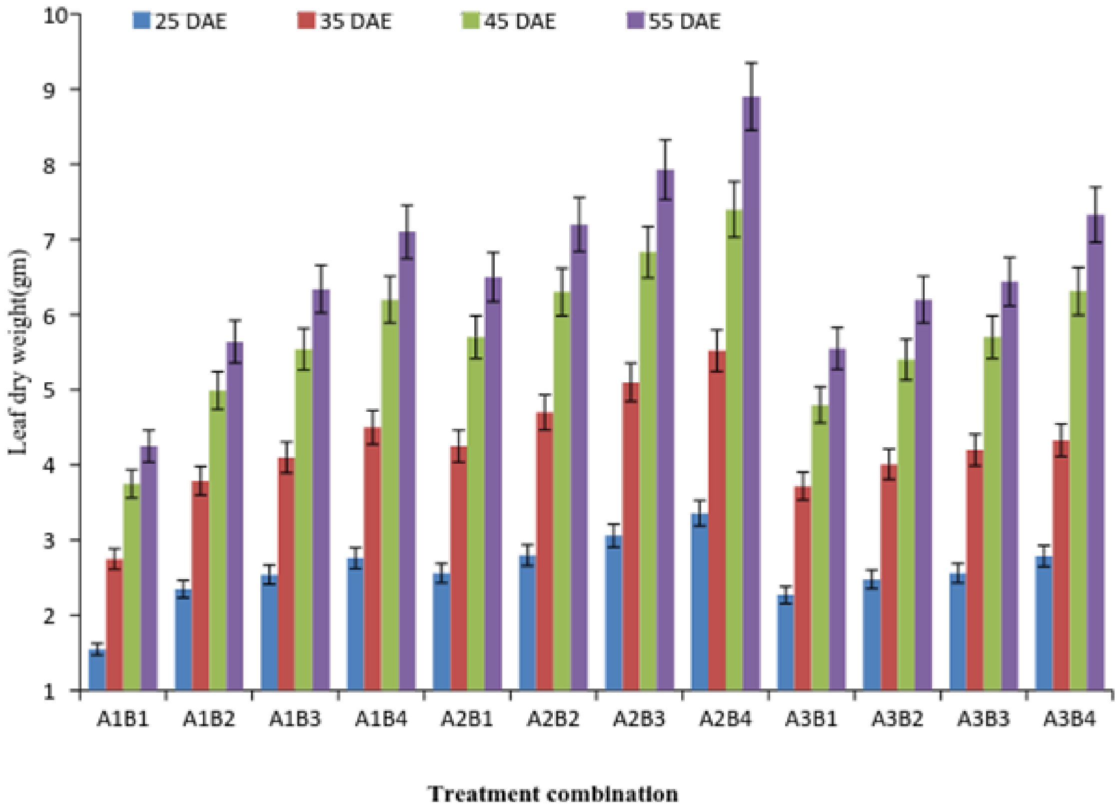


B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm ($LSD_{(0.05)}$ showing 0.04, 0.01, 0.07 & 0.09 at 25, 35, 45, 55, 65 DAE respectively).

Figure 8. Effect of spacing on leaf dry weight of BARI Mungbean-6 at different days after emergence.

Effect of spacing was significant on leaf dry weight. At 25 DAE, leaf dry weight of plant of B_1 (20cm) spacing were showing same (Figure 8). Leaf dry weight of all plants of different spacing was increasing with spacing gradually up to 55 DAE.

4.1.3.3. Combined effect of seed size and spacing



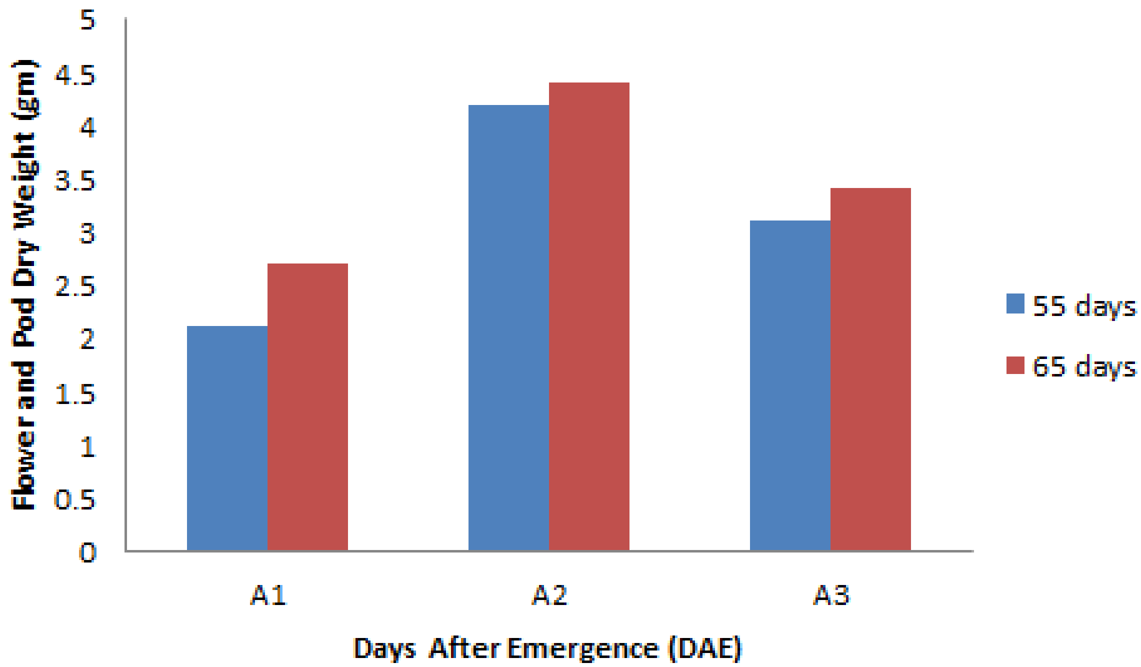
A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm), B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm ($LSD_{(0.05)}$ showing 0.01, 0.1, 0.2 & 0.6 at 25, 35, 45, 55, 65 DAE respectively).

Figure 9. Combined effect of seed size and spacing on leaf dry weight of BARI mung-6 at different days after emergence.

The interaction of seed size and spacing had significant effect on leaf dry weight (Figure 9). It was observed that the lowest spacing in combination with the plant of small seed size (A_1B_1) treatment showed the lowest result (4.3g) but the plant of medium seed size and higher spacing (A_2B_4) showed the highest result (8.9 g) among the all treatments. The lowest leaf dry weight was found in A_1B_1 (4.3g), which was significantly lower than other interaction and highest leaf dry weight was also significantly higher.

4.1.4. Flower and pod dry weight

4.1.4.1. Effect of seed size

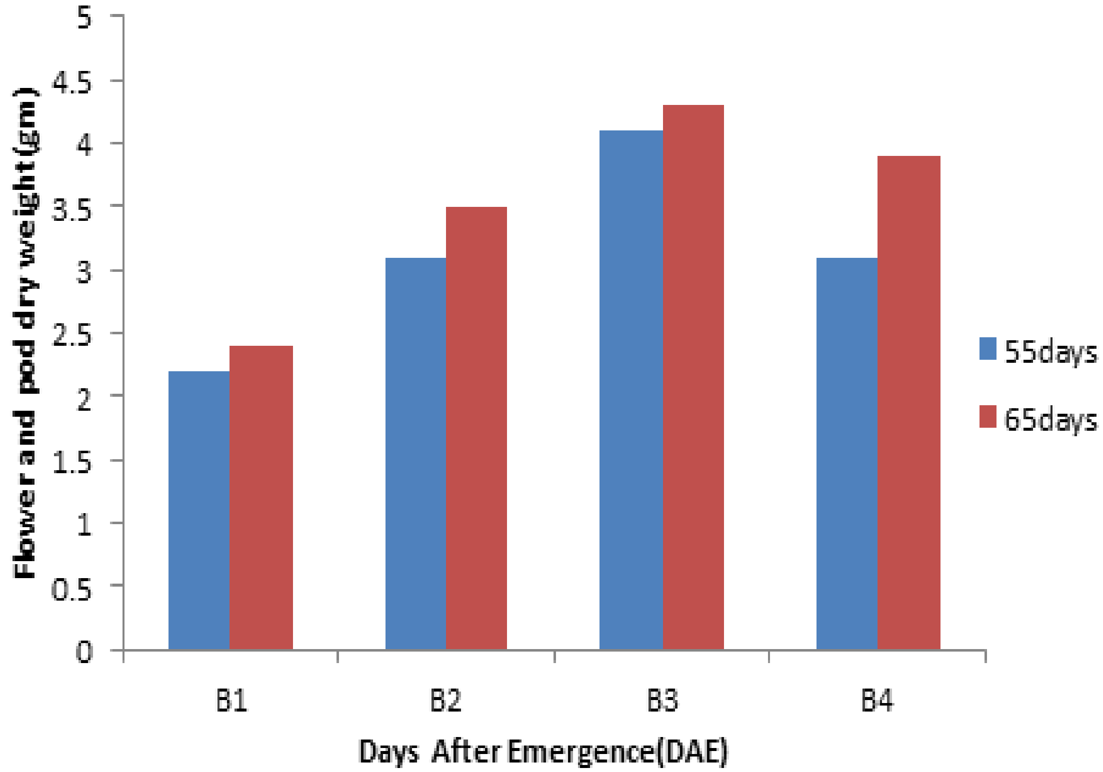


A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm) ($LSD_{(0.05)}$ showing 0.1 & 0.1 at 25, 35, 45, 55, 65 DAE respectively).

Figure 10. Effect of seed size on flower and pod dry weight of BARI mung-6 at different days after emergence.

The effect of seed size on plant was significant at all the growth stages studied (Figure 10). The highest flower and pod dry weight was recorded for the medium seed size and it was decreased with the decreasing seed size but the large seed size showed lower result than the medium seed size.

4.1.4.2. Effect of spacing

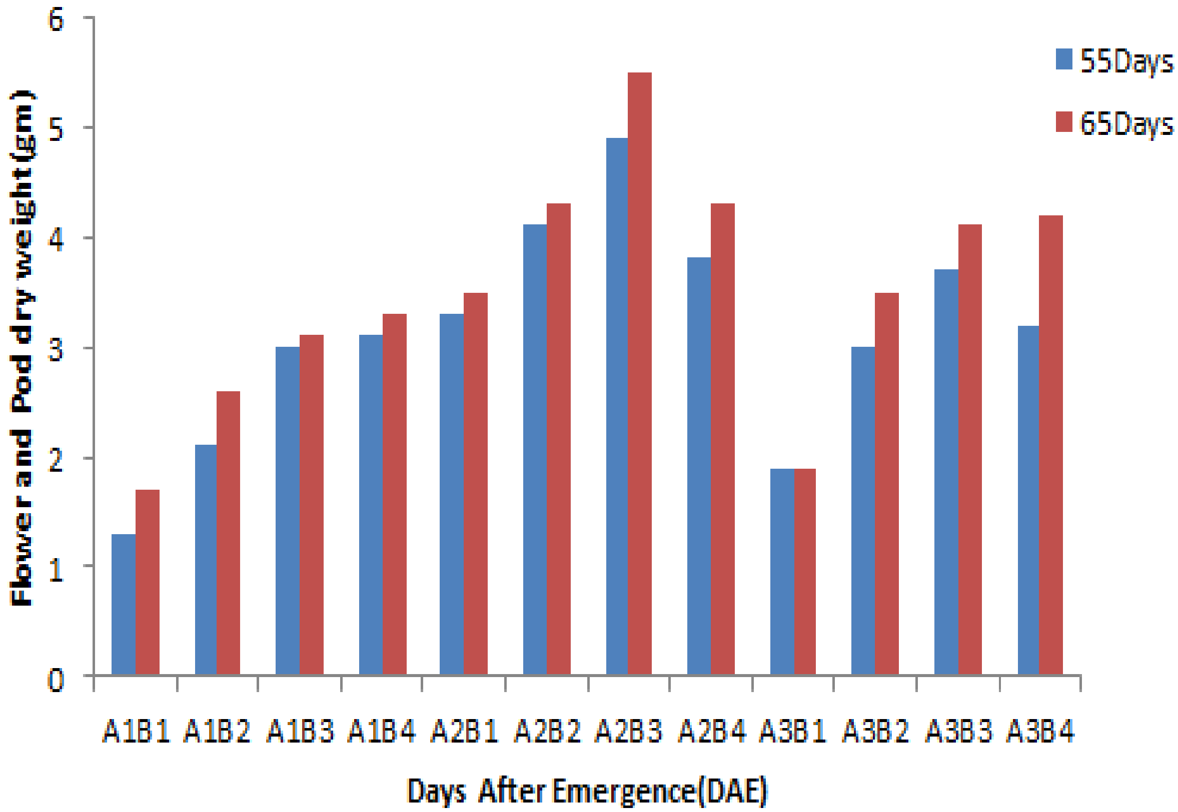


B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm ($LSD_{(0.05)}$ showing 0.1, & 0.1at 25, 35,45, 55, 65 DAE respectively).

Figure 11. Effect of spacing on flower and pod dry weight of BARI mung-6 at different days after emergence.

The effect of spacing on flower and pod dry weight at different days after emergence has been presented in (Figure 11). At all the growth stages, sowing maintaining 30 cm row to row spacing (B_3) produced the flower and pod dry weight and it was decreased with decreasing row to row spacing but more row to row spacing (B_4) gave lower result than (B_3).

4.1.4.3. Combined effect of seed size and spacing



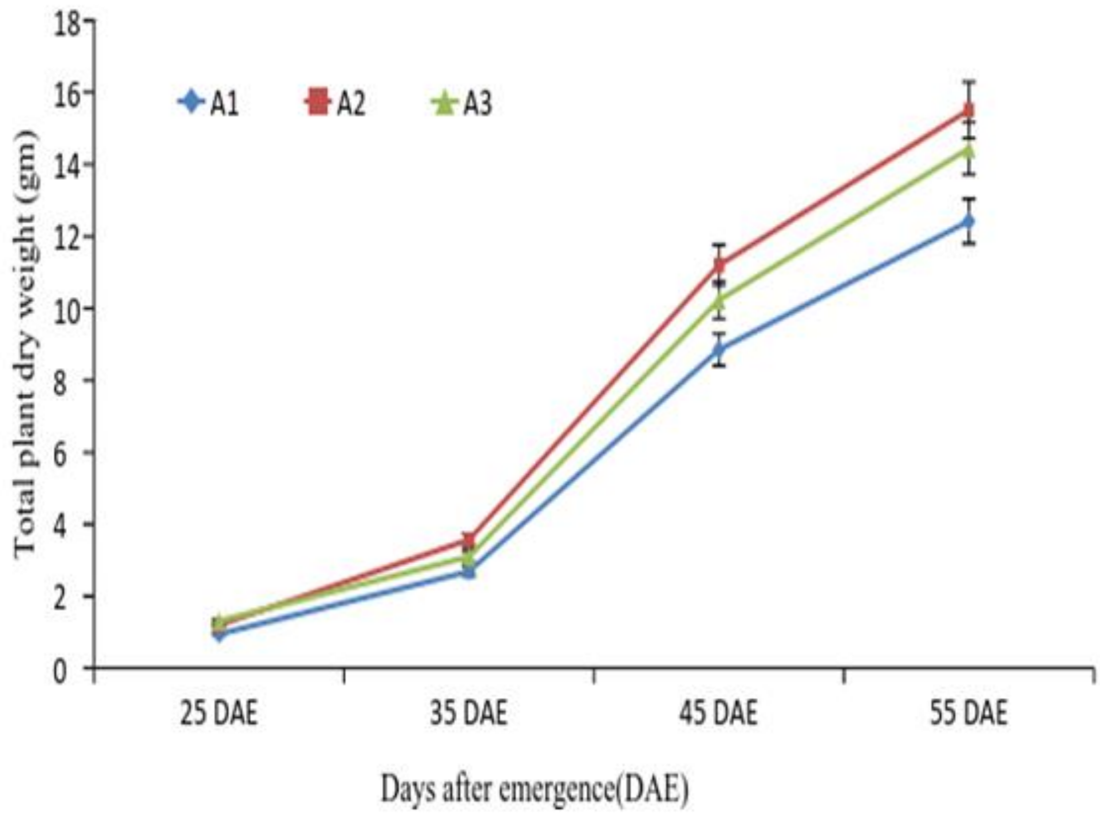
A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm), B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm ($LSD_{(0.05)}$ showing 0.02 & 3.6 at 25, 35, 45, 55, 65 DAE respectively).

Figure 12. Combined effect of seed size and spacing on flower and pod dry weight of BARI mung-6 at different days after emergence.

The differences in flower and pod dry weight among the treatments were significant due to combined effect of seed size and spacing (Figure 12). At the lowest spacing with small seeded plant showed the lowest dry weight. At 55 DAE and 65DAE, the plant of medium seed size and higher spacing showed the highest result.

4.1.5. Total plant dry weight

4.1.5.1. Effect of seed size

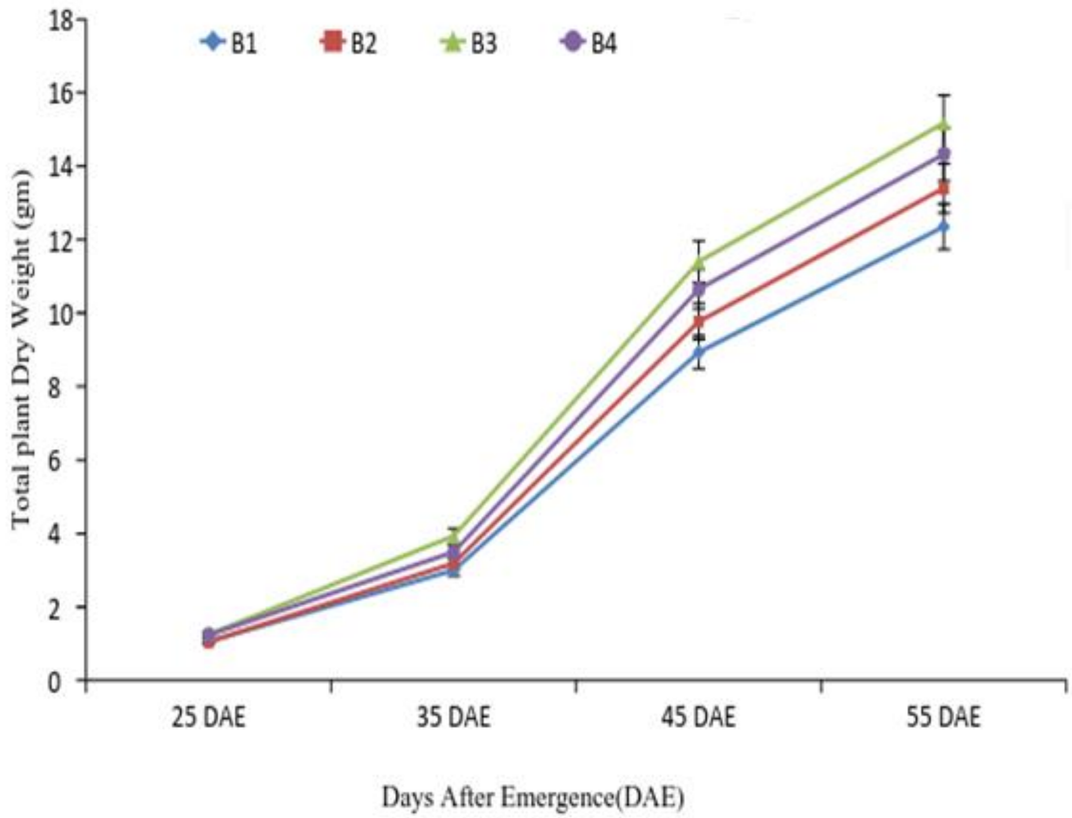


A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm) ($LSD_{(0.05)}$ showing 0.05, 0.1, 0.4 & 0.5 at 25, 35, 45, 55, 65 DAE respectively).

Figure 13. Effect of seed size on total plant dry weight of BARI mung-6 at different days after emergence.

Seed size had a significant effect on total plant dry weight at different days after emergence (Figure 13). At 25 DAE, large (A_3: >4mm), medium (A_2: 3.2-4mm) and small (A_1:<3.2mm) seed size were showing same total dry weight. At 55 DAE, total plant dry weight of medium seed size (A_2: 3.2-4.0 mm) were more than the others. The total plant dry weight of small and large seed sized plants were less than medium seed sized plant the total plant dry weight of medium seed sized plant was more than 14 g at 55 DAE.

4.1.5.2. Effect of spacing

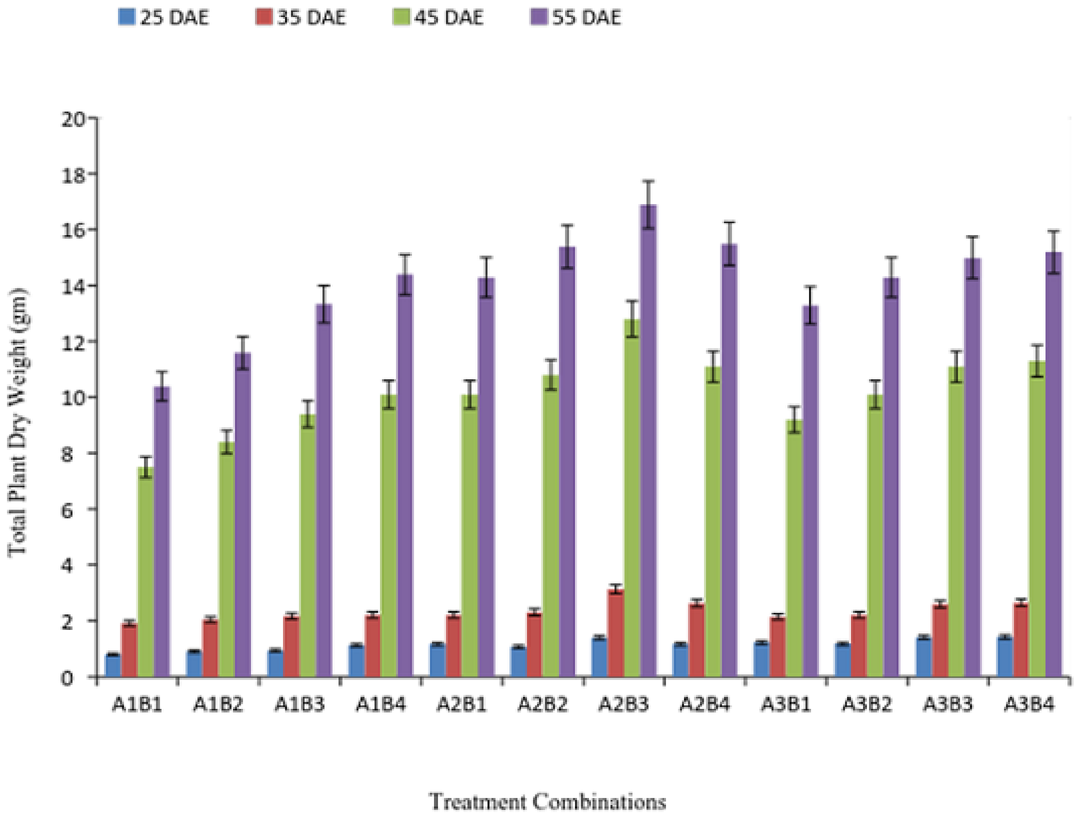


B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm ($LSD_{(0.05)}$ showing 0.1, 0.1, 0.5 & 0.5 at 25, 35, 45, 55, 65 DAE respectively).

Figure 14. Effect of spacing on total plant dry weight of BARI mung-6 at different days after emergence.

Spacing had significant effect on total plant dry weight. At 25 DAE, all plants of different spacing were showing same result (Figure 14). At 35 DAE, totals dry weight of the treatments B_1: (20 cm) and B_2: (25 cm) were statistically similar. Total plant dry weight was increased significantly due to spacing with the advancement of growing stage. At 55 DAE, total plant dry weight was the highest in B_3: (30 cm) spacing compared to the treatments with other spacing.

4.1.5.3. Combined effect of seed size and spacing



A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm), B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm ($LSD_{(0.05)}$ showing 0.1, 0.2, 0.9 & 0.9 at 25, 35, 45, 55, 65 DAE respectively).

Figure 15. Combined effect of seed size and spacing on total plant dry weight of BARI mung-6 at different days after emergence.

The differences in total plant dry weight among the treatments were significant due to interaction of seed size and spacing (Figure 15). At the lowest spacing with small seeded plant showed the lowest total plant dry weight (10.4 g). At 35 DAE, it showed about same total plant dry weight as the others. At 45 DAE and 55DAE, this treatment showed the lowest total plant dry weight. .The plant of medium seed size and higher spacing showed the highest result (16.9 g). The lowest total plant dry weight was found in A_1B_1 (10.4g), which was significantly lower than other interaction and the highest result on A_2B_4 treatment was significantly higher.

4.2. Yield contributing parameter and seed yield

4.2.1. Pod length

4.2.1.1. Effect of seed size

It was observed that seed size had a significant effect on pod length of mungbean (Table 1). The plant from medium seed size (A_2) produced the longest pod (9.1cm) and it was significantly different from that of A_1 and A_3. A_1 (small seed size) produced the shortest pod.

Table 1. Effect of seed size yield related attributes of BARI mung-6

Treatments	Pod length (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Weight of 1000 seeds (g)
A_1	7.3 c	12.6 c	8.0c	35.1 c
A_2	9.1 a	16.1 a	10.6a	42.8 a
A_3	8.2b	13.2 b	9.1b	40.5 b
$LSD_{0.05}$	0.20	0. 30	0.30	1.1
CV%	3.3	2.4	4.2	3.1

A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm)
In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.2.1.2. Effect of spacing

The effect of spacing on pod length of mungbean was significant (Table 2). The longest pod (8.6 cm) was produced from the plant maintaining 30 cm row spacing (B_3) and was followed by that of B_4 (8.2 cm), B_2 (7.6 cm) and B_1 (7.5 cm). The treatments B_2 and B_1 showed the statistically identical results.

4.2.1.3 Combined effect of seed size and spacing

The pod length of mungbean was significantly influenced by combination of seed size and spacing (Table 3). It was observed that medium sized seed sowing with 30 cm spacing (A_2B_3) produced the longest pod (9.9 cm) and was significantly different from that of all other combination. Sowing small sized seed with narrowest row spacing (A_1B_1) produced the shortest pod (6.8 cm).

Table 2. Effect of spacing on seed yield and yield related attributes of BARI mung-6

Treatments	Pod length (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Weight of 1000 seeds(g)
B_1	7.5 c	12.2 d	8.0 d	30.7 d
B_2	7.6 c	13.8 b	9.1 c	38.9 c
B_3	8.6 a	16.2 a	10.1 a	42.3 a
B_4	8.2 b	13.4 c	9.6 b	40.4 b
$LSD_{0.05}$	0.3	0.3	0.3	1.3
CV%	3.3	2.4	4.2	3.1

B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.2.2. Pods plant^{-1}

4.2.2.1. Effect of seed size

It was observed that seed size had a significant effect on pod number of mungbean (Table 1). The plant from medium seed size (A_2) produced more pods plant^{-1} (16.1) and was significantly different from that of A_1 and A_3. A_1 (small seed size) produced the lowest number of pod.

4.2.2.2. Effect of spacing

The effect of spacing on pod number of mungbean was significant (Table 2). The highest number of pod (16.2) was produced from the plant maintaining 30 cm row spacing (B_3) and was followed by that of B_4 (13.4), B_2 (13.8) and B_1 (12.2).

4.2.2.3 Combined effect of seed size and spacing

The pod number plant^{-1} of mungbean was significantly influenced by combination of seed size and spacing (Table 3). It was observed that medium sized seed sowing with 30 cm spacing (A_2B_3) produced the highest number of pods plant^{-1} (18.4) and was significantly different from that of all other combination. Sowing small sized seed with narrowest row spacing (A_1B_1) produced the shortest number of pods plant^{-1} (10.9).

4.2.3. Seeds pod^{-1}

4.2.3.1. Effect of seed size

It was observed that seed size had a significant effect on seed number pod^{-1} of mungbean (Table 1). The plant from medium seed size (A_2) produced the more seed (10.6) and was significantly different from that of A_1 and A_3. A_1 (small seed size) produced the lowest number of pod.

4.2.3.2. Effect of spacing

The effect of spacing on seed number pod^{-1} of mungbean was also significant (Table 2). The highest number of seeds pod^{-1} (10.1) was produced from the plant maintaining 30 cm row spacing (B_3) and was followed by that of B_4 (9.6), B_2 (9.1) and B_1 (8.0).

Table 3. Combined effect of seed size and spacing on seed yield and yield related attributes of BARI mung-6

Combination	Pod length (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Weight of 1000 seeds(g)	Seed yield (t ha^{-1})
A_1B_1	6.8 f	10.9 g	6.5 g	32.6 f	1.0 h
A_1B_2	7.1 ef	12.6 f	8.2 e	35.7 e	1.3 fg
A_1B_3	7.8 cd	15.0 c	8.3 e	35.3 e	1.7 d
A_1B_4	7.3 e	13.3 e	9.1 cd	36.9 e	1.4 ef
A_2B_1	8.2 c	14.4 d	10.1 b	37.2 e	1.7 bcd
A_2B_2	8.9 b	16.3 b	10.2 b	38.6 d	1.9 b
A_2B_3	9.9 a	18.4 a	11.8 a	42.7 a	2.4 a
A_2B_4	9.2 b	15.2 c	10.2 b	39.7 c	1.1 bc
A_3B_1	7.5 de	11.3 g	7.51 f	40.2 b	1.3 g
A_3B_2	7.9 cd	12.7 f	9.07 d	40.3 b	1.6 de
A_3B_3	8.7 b	15.3 c	10.2 b	40.6 b	1.7 cd
A_3B_4	8.9 b	12.8 ef	9.5 c	39.3 c	1.6 de
$LSD_{0.05}$	0.5	0.6	0.5	2.2	0.2
CV%	3.3	2.4	4.2	3.1	2.6

A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm), B_1: 20cm, B_2: 25cm, B3: 30cm, B_4: 35cm

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.2.3.3. Combined effect of seed size and spacing

The seeds number pod^{-1} of mungbean was significantly influenced by combination of seed size and spacing (Table 3). It was observed that medium sized seed sowing with 30 cm spacing (A_2B_3) produced the highest number of seeds pod^{-1} (11.8) and was significantly different from that of all other combination. Sowing small sized seed with narrowest row spacing (A_1B_1) produced the lowest number of seeds pod^{-1} (6.3).

4.2.4. Weight of 1000 seeds

4.2.4.1. Effect of seed size

It was observed that seed size had a significant effect on weight of 1000 seeds of mungbean (Table 1). The plant from medium seed size (A_2) produced the highest seed weight (47.8g) and was significantly different from that of A_1 and A_3. A_1 (small seed size) produced the lowest seed weight.

4.2.4.2. Effect of spacing

The effect of spacing on seed weight of mungbean was also significant (Table 2). The highest weight of 1000 seeds (42.3g) was produced from the plant maintaining 30 cm row spacing (B_3) and was followed by that of B_4 (40.4g), B_2 (38.9g) and B_1 (30.7g). The treatments B_2 and B_1 showed the statistically identical results.

4.2.4.3. Combined effect of seed size and spacing

The weight of 1000 seeds of mungbean was significantly influenced by combination of seed size and spacing (Table 3). It was observed that medium sized seed sowing with 30 cm spacing (A_2B_3) produced the highest weight of 1000 seeds (42.7g) and was significantly different from that of all other combination. Sowing small sized seed with the narrowest row spacing (A_1B_1) produced the lowest weight (32.6g).

4.2.4.4. Combined effect of seed size and spacing on seed yield

Seed yield was significantly influenced by the combination effect of seed size and spacing (Table 3). It was observed that treatment A_2B_3 (medium seed size 3.2-4mm and spacing 30 cm) showed the highest seed yield (2.4 t ha^{-1}). The lowest yield was found from A_1B_1 treatment (1.0t ha^{-1}).

Table 4. Effect of seed size on biological yield and harvest index and relative water content of BARI mung-6

Treatments	Biological yield (t ha^{-1})	Harvest index
A_1	2.4 c	0.29 c
A_2	3.0 a	0.38 a
A_3	2.8 b	0.30 b
$LSD_{0.05}$	0.1	0.03
CV%	3.3	2.48

A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm)

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.2.5. Biological yield $plant^{-1}$ (t ha^{-1})

4.2.5.1. Effect of seed size

Seed size had an effect on biological yield per plant (Table 4). Plants of medium seed size (A_2) showed the highest biological yield (3.0 t ha^{-1}). But, it was observed that plants of smaller seed (A_1) gave the lowest result (2.4 t ha^{-1}).

4.2.5.2. Effect of spacing

Spacing had an effect on biological yield (Table 5). Plants of B_3 (30 cm) spacing showed the highest result (3.5 t ha^{-1}). Plants of B_1 (20 cm) spacing showed the lowest result (3.0 t ha^{-1}) which was significantly identical.

4.2.5.3. Combined effect of seed size and spacing

There was a significant combined effect of seed size and spacing on biological yield (Table 6).Treatment A_2B_3 (medium seed size 3.2-4mm and spacing 30 cm) showed the highest biological yield per plant (4.1 ton). Treatment A_1B_1 (small seed size <3.2 mm and lower spacing 20 cm) showed the lowest biological yield per plant (3.1 ton).

Table 5. Effect of spacing on biological yield and harvest index of BARI mung-6		
Treatments	**Biological yield plant^{-1} (t ha^{-1})**	**Harvest index**
B_1	3.0 c	0.32 d
B_2	3.2 b	0.37 c
B_3	3.5 a	0.40 a
B_4	3.2 b	0.39 b
$LSD_{0.05}$	0.1	0.03
CV%	3.3	2.48

B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.2.6. Harvest Index

4.2.6.1. Effect of seed size

Seed size had a significant effect on harvest index (Table 4). Plants of medium seed size (A_2) showed the highest harvest index (0.38). Small seed (A_1) showed the lowest harvest index (0.29) which was drastically significant.

4.2.6.2. Effect of spacing

Spacing had a significant effect on harvest index (Table 5). Plants of B_3 spacing showed the highest harvest index (0.40) and plants of B_1 spacing showed the lowest harvest index (0.32).

4.2.6.3. Combined effect of seed size and spacing

There was a significant combined effect of seed size and spacing on harvest index (Table 6). Treatment A_2B_3 (medium seed size 3.2-4mm and spacing 30 cm) showed the highest harvest index (0.40). Treatment A_1B_1 (small seed size <3.2 mm and lower spacing 20 cm) showed the lowest harvest index (0.27).

Table 6. Combined effect of seed size and spacing on biological yield and harvest index of BARI mung-6

Combination	Biological yield plant^{-1}(tha^{-1})	Harvest index
A_1B_1	3.1 h	0.27 g
A_1B_2	3.4 fg	0.32 f
A_1B_3	3.7 cde	0.35 def
A_1B_4	3.4 fg	0.35 ef
A_2B_1	3.7 bcd	0.34 ef
A_2B_2	3.9 b	0.36cde
A_2B_3	4.1 a	0.40 a
A_2B_4	3.9 bc	0.39 ab
A_3B_1	3.3 gh	0.38 ef
A_3B_2	3.6 def	0.33 abcd
A_3B_3	3.7 bcd	0.35 bcde
A_3B_4	3.5 ef	0.37 abc
$LSD_{0.05}$	0.2	0.05
CV%	3.3	2.48

A_1: Small (Less than 3.2mm), A_2: Medium (3.2-4mm), A_3: Large (Greater than 4mm), B_1: 20cm, B_2: 25cm, B_3: 30cm, B_4: 35cm

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

The difference of seed yield, biological yield, harvest index were due to the influence of different seed size and spacing coupled with other growing environments, small seed size gave small plant and lower yield by interacting with lower spacing. At lower spacing plant get lower light interception and get lower nutrition. So it gave lower seed yield, biological yield, harvest index.

CHAPTER 5

SUMMARY OF CONCLUSION

The experiment was conducted at the agronomy field of Sher-e-Bangla Agricultural University, Dhaka to study the effect of spacing and seed size on growth and yield of mungbean (Cv. BARI mung-6). The experiment comprised with two factors viz. (i) spacing (ii) seed size. Four spacing (B_1=20cm, B_2=25cm, B_3=30cm, B_4=35cm) and three seed size treatments (A_1=small seed size <3.2 mm, A_2=medium seed size 3.2-4mm and A2= large seed size>4mm) were used. There were 12 treatment combinations under the present study. Data were collected from the experimental field and analyzed statistically.

The experiment was laid out in a two factors randomized complete block design (RCBD) with three replications. The seeds of BARI mung-6 variety were sown were sown at the rate of 45kg ha^{-1} in the furrow maintaining distances between furrows (rows as per treatment).

In this study, it was observed that the plant height was significantly influenced due to the different spacing and seed size. The tallest plant height at widest spacing (B_4:35cm) was found 43.7cm. The plant height was also influenced by different seed size. Medium seed size (A2: 3.2-4mm) gave the tallest plant height (44.8cm). Interaction effect of different spacing and seed size had a significant effect on plant height. The tallest plant (46.6cm) was obtained from A_2B_4 treatment.

Medium seed sized plants (A_2:3.2-4mm) gave the highest leaf number $plant^{-1}$ (10.0), leaf dry weight $plant^{-1}$ (7.6g) and total plant dry weight (15.5g) at 35 cm (B_4) spacing. But medium seed sized plants (A_2) gave the highest flower and pod dry weight (4.4g) at 30 cm (B3) spacing. In terms of combined effect of seed size and spacing, the highest number of leaves plant^{-1} (11.5), leaf dry weight plant^{-1}(8.9g), total plant dry weight (16.9g) was obtained from A_2B_4 treatment. But, A_2B_3 treatment gave the highest flower and pod dry weight (4.4g).

Seed size had a significant effect on yield attributes. Medium seed sized (A_2:3.2-4mm) plants gave the highest pod length (9.1cm), seeds pod^{-1} (10.6), pods plant^{-1} (16.1) and weight of 1000 seeds (42.8g). Small seed sized plant (A_1:<3.2mm) gave the lowest pod length (7.3cm), number of seeds pod^{-1} (8.0), number of pods plant^{-1} (12.6), the lowest weight of 1000 seeds (35.1g). Spacing had also a significant effect on yield attributes. Treatment of B_2 spacing (30cm) gave the highest pod length (8.6cm), number of seeds pod^{-1} (10.1), number of pods plant^{-1} (16.2) and the highest weight of 1000 seeds (40.3g). Treatment of B_1 spacing (20cm) gave the lowest pod length (7.5cm), seeds pod^{-1} (8.0), pods plant^{-1} (12.2), the lowest weight of 1000 seeds (38.7g). The combined effect of seed size and spacing had a significant effect on yield related attributes. A_2B_3 treatment gave the highest pod length (9.9cm), number of seeds pod^{-1} (11.8), number of pods plant^{-1} (18.4), weight of 1000 seeds (42.7g), seed yield (2.4t ha^{-1}). The lowest pod length (6.8cm) and seed yield (1.0t ha^{-1}) was found in A_1B_1 treatment. But, A_3B_1 treatment gave the lowest number of seeds pod^{-1} (7.51), A_3B_2 treatment gave the lowest number of pods plant^{-1} (12.7).

Seed size had an effect on seed yield, biological yield and harvest index. Medium seed sized plants (A_2: 3.2-4mm) gave the highest seed yield (1.58t ha^{-1}), biological yield (3.9t ha^{-1}), harvest index (0.40). Seed sized plant (A_1:<3.2mm) gave the lowest seed yield (1.1t ha^{-1}) and biological yield (3.4t ha^{-1}).

Effect of spacing on seed yield, biological yield and harvest index. Plant of B_3 spacing (30cm) showed the highest seed yield (1.57t ha^{-1}), biological yield (3.5 t ha^{-1}) and harvest index (0.40). But the plants of lowest spacing gave the lowest seed yield (1.07t ha^{-1}), biological yield (3.4t ha^{-1}), harvest index (0.32). There was a significant interaction effect on yield related attributes. The highest biological yield (4.1t ha^{-1}) and harvest index (0.40) were found in A_2B_3 treatment. But A_1B_1 treatment gave the lowest biological yield (1.1t ha^{-1}), harvest index (0.27).

From the results of the study, it may be concluded that the performance of mungbean (Cv. BARI mung-6) was better in medium seed size (3.2-4mm) and 30 cm row spacing.

CHAPTER 6

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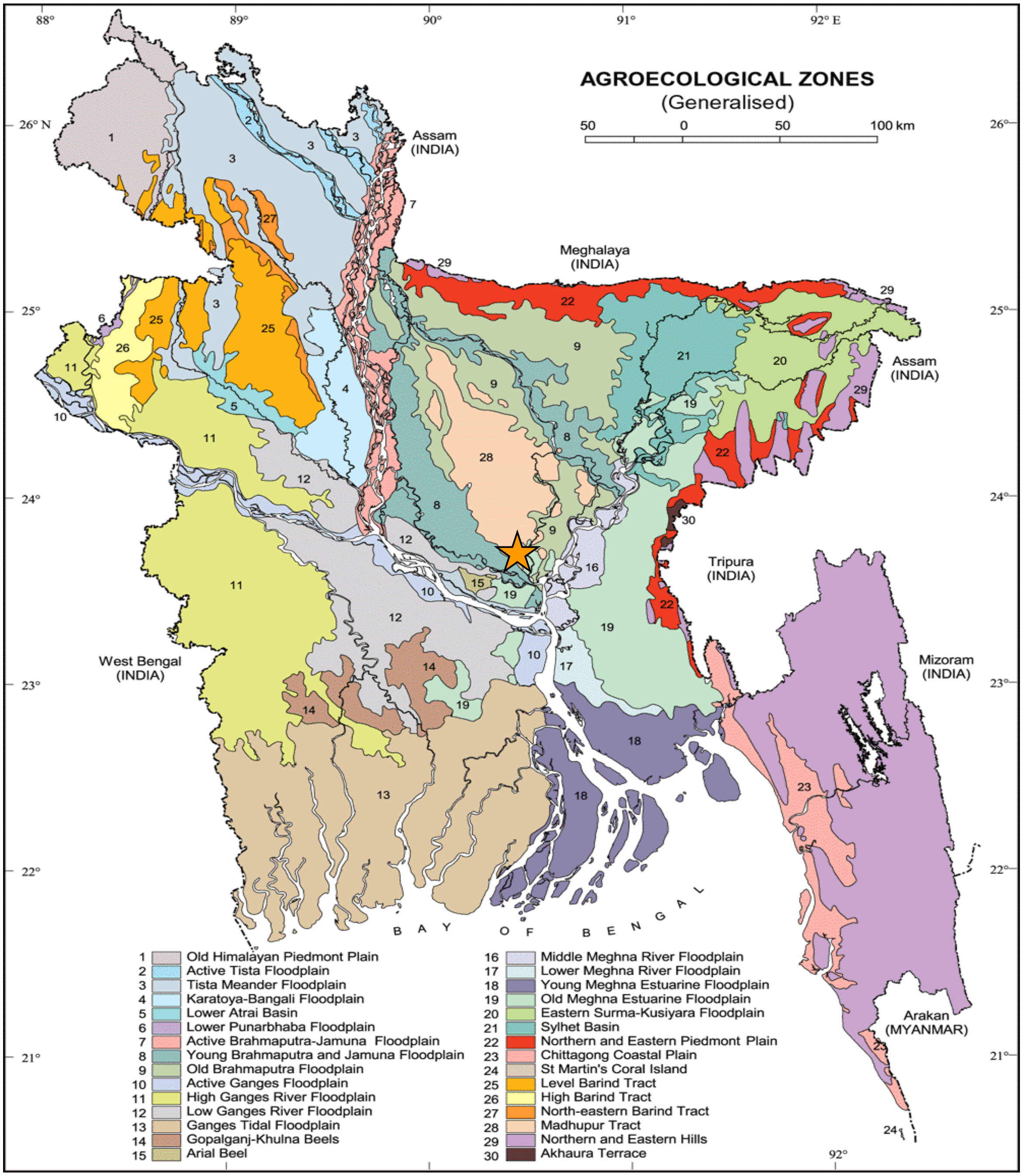
APPENDIX

Appendix I: Map showing the experimental sites under study



☆ **The experimental site under study**

Appendix II: **Particularities of the agro-ecological zone of the experimental site**

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	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: Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

B. The physical and chemical characteristics of initial soil of the experimental plot.

Particle size constitution:

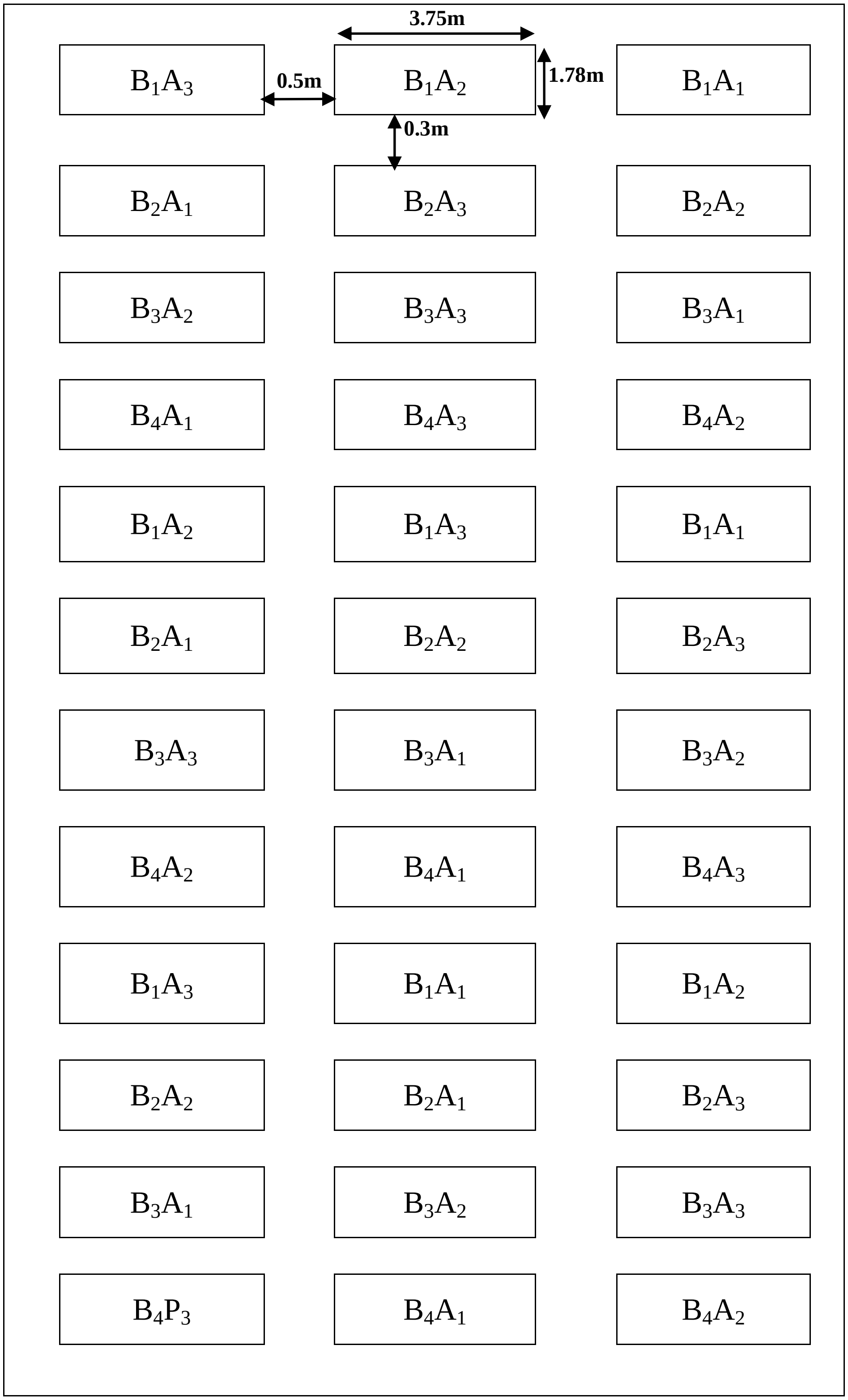
Sand	:	40 %
Silt	:	40 %
Clay	:	20 %
Texture	:	Loamy

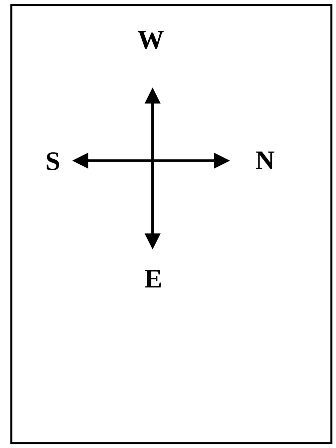
Chemical composition:

Constituents	:	0-15 cm depth
P^H	:	5.45-5.61
Total N (%)	:	0.07
Available P (µ gm/gm)	:	18.49
Exchangeable K (meq)	:	0.07
Available S (µ gm/gm)	:	20.82
Available Fe (µ gm/gm)	:	229
Available Zn (µ gm/gm)	:	4.48
Available Mg (µ gm/gm)	:	0.825
Available Na (µ gm/gm)	:	0.32
Available B (µ gm/gm)	:	0.94
Organic matter (%)	:	0.83

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix III. Layout of the experimental site





A1=Seed size (<3.2mm)

A2=Seed size (3.2-4mm)

A3=Seed size (>4mm)

B1=Spacing (20cm)
B2=Spacing (25cm)
B3=Spacing (30cm)
B4= Spacing (35cm)

Plot size = 3.75 x 1.78 m^2
Distances:
Block to Block = 0.5 m
Plot to Plot = 0.3 m

Appendix IV. Analysis of variances of the data on plant height of BARI mung- 6

Source of variation	Degrees of freedom(df)	Mean square				
		25DAE	35DAE	45DAE	55DAE	65DAE
Factor A (Seed size)	2	12.307	36.61*	37.59*	40.729*	57.702*
Factor B (Spacing)	3	1.21	3.916 *	4.074*	5.962*	5.634*
Interaction(A×B)	6	0.197	0.723 *	0.19*	1.131*	0.742*
Error	22	1.851	1.611	4.039	2.573	4.463

* : Significant at 0.05 level of probability

Appendix V. Analysis of variances of the data on leaf number of BARI mung- 6

Source of variation	Degrees of freedom(df)	Mean square				
		25DAE	35DAE	45DAE	55DAE	65DAE
Factor A (Seed size)	2	0.185	3.058*	1.955*	4.244*	6.848*
Factor B (Spacing)	3	0.18	1.695*	2.796*	6.178*	10.305*
Interaction(A×B)	6	0.07*	0.126*	0.314*	0.339*	0.283*
Error	22	0.051	0.116	0.094	0.223	0.281

* : Significant at 0.05 level of probability

Appendix VI. Analysis of variances of the data on leaf dry weight of BARI mung-6

Source of variation	Degrees of freedom (df)	Mean square				
		25DAE	35DAE	45DAE	55DAE	65DAE
Factor A (Seed size)	2	0.163 *	1.286*	3.979*	6.527*	10.217*
Factor B (Spacing)	3	0.122*	1.134*	2.389*	5.687*	8.703*
Interaction (A×B)	6	0.009*	0.096*	0.195*	0.16*	0.247*
Error	22	0.002	0.001	0.005	0.009	0.126

* : Significant at 0.05 level of probability

Appendix VII. Analysis of variances of the data on total plant dry weight of BARI mung-6

Source of variation	Degrees of freedom(df)	Mean square			
		25DAE	35DAE	45DAE	55DAE
Factor A (Seed size)	2	0.421*	0.72*	17.207*	29.528*
Factor B (Spacing)	3	0.106*	0.58*	8.989*	11.975*
Interaction(A×B)	6	0.028*	0.094*	0.834*	1.581*
Error	22	0.003	0.021	0.261	0.296

* : Significant at 0.05 level of probability

Appendix VIII. Analysis of variances of the data on plant characters of BARI mung- 6

Source of variation	Degrees of freedom(df)	Mean square				
		Pod length	Seeds pod^{-1}	Pods $plant^{-1}$	weight of 1000 seed	Flower and pod dry weight $plant^{-1}$
Factor A (Seed size)	2	9.759*	19.551*	38.056*	487.672*	9.088*
Factor B (Spacing)	3	2.829*	6.994*	24.995*	69.2*	6.159*
Interaction(A×B)	6	0.193*	1.297*	0.566*	11.332*	0.448*
Error	22	0.073	0.147	0.115	1.705	0.016

* : Significant at 0.05 level of probability

Appendix IX. Analysis of variances of the data on yields and harvest index of BARI mung- 6

Source of variation	Degrees of freedom(df)	Mean square		
		seed yield (ha^{-1})	Biological yield $plant^{-1}$	Harvest index
Factor A (Seed size)	2	0.174*	1.009*	201.876*
Factor B (Spacing)	3	0.115*	0.458*	162.554*
Interaction(A×B)	6	0.004*	0.024*	13.252*
Error	22	0.001	0.009	0.878

*: Significant at 0.05 level of probability