EFFECT OF VARIETY AND FLOWER REMOVAL ON THE PERFORMANCE OF MUNGBEAN

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MY BELOVED PARENTS

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of Variety and Flower Removal On the Performance of Mungbean'** 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. Hasan Imam**, Registration number: **06-01854** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
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ABSTRACT

The experiment was conducted during the period from March to June 2013 at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to study the effect of variety and flower removal at 3 intervals out of the cropping duration of mungbean. The varieties like BARI mung-3, BARI mung-4, BARI mung-5 and BARI mung-6 were used as the test crop. The experiment consists of two factors designated: Factor A (Mungbean variety 4; V_1: BARI mung-3, V_2: BARI mung-4, V_3: BARI mung-5 & V_4: BARI mung-6) and Factor B (Flower removal 4 levels; R_0: No removal of flower, R_1: Removal of flower at 30-35 DAE, R_2: Removal of flower at 40-45 DAE & R_3: Removal of flower at 50-55 DAE). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The tallest plant (54.05 cm) was recorded from V_4, whereas the shortest plant (44.13 cm) was recorded from V_1. The maximum number of pods per plant (19.98) was recorded from V_4, whereas the minimum number of pods per plant (18.16) was recorded from V_1. The highest seed yield (1.99 t/ha) was recorded from V_4, whereas the lowest seed yield (1.63 t/ha) was observed from V_1. The highest stover yield (2.47 t/ha) was recorded from V_4 whereas the lowest stover yield (2.24 t/ha) was recorded from V_1.The tallest plant (51.86 cm) was found from R_0 and the shortest plant (47.96 cm) was observed from R_3. The maximum number of pods per plant (21.21) was recorded from R_2, while the minimum number of pods per plant (16.10) was found from R_3. The highest seed yield (1.92 t/ha) was recorded from R_2, while the lowest seed yield (1.36 t.ha) was observed from R_3. The highest stover yield (2.77 t/ha) was observed from R_2, while the lowest stover yield (1.61 t/ha) was observed from R_3.The tallest plant (57.85 cm) was recorded from V_4R_0, while the shortest plant (41.15 cm) from V_1R_3. The maximum number of pods per plant (22.57) was recorded from V_4R_2, while the minimum number of pods per plant (14.90) from V_4R_3. The highest seed yield (2.20 t/ha) was found from V_4R_2, while the lowest seed yield (1.40 t/ha) from V_4R_3. The highest stover yield (3.02 t/ha) was recorded from V_4R_2, while the lowest stover yield (1.87 t/ha) was recorded from V_4R_3. It was revealed that the combination of V_4R_2 appeared best in terms of yield contributing characters and yield of mungbean.

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CHAPTER I

INTRODUCTION

Mungbean, grass pea, lentil, blackgram, chickpea, field pea and cowpea are the major pulse crops of Bangladesh. Among them mungbean (*Vigna radiata* L.) is one of the most important pulse crops of Bangladesh and belongs to the family Leguminosae and sub-family Papilionaceae. The area under pulse crops in Bangladesh is 0.406 million hectares with a production of 0.322 million tones where mungbean is cultivated in the area of 0.108 million hectares with production of 0.03 million tons (BBS, 2010). It is considered as a quality pulse in the country but production per unit area is very low (736 kg/ha) as compared to other countries of the world (BBS, 2006). Mungbean ranks the fifth position considering both acreage and production.

It is an important food crop because it provides a cheap source of easily digestible dietary protein which complements the staple rice in the country. It's seed contains 24.7% protein, 0.6% fat, 0.9 fiber and 3.7% ash (Potter and Hotchkiss, 1997). Pulses, being leguminous crops, are capable of fixing atmospheric nitrogen in the soil and enrich soil fertility and productivity. Thus, they are considered as soil fertility development crops. It can also fix atmospheric nitrogen through symbiotic relationship with soil bacteria and improve the soil fertility (Yadav *et al*., 1994). The global mungbean growing area has increased during the last 20 years at an annual growth rate of 2.5% (Green and King, 1992). The crop has many advantages in cropping system because of its rapid growth, early maturation and short duration.

Mungbean plays an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, but the acreage production of mungbean is gradually declining (BBS, 2010). However, it is one of the least cared crops. Mungbean is cultivated with minimum tillage, local varieties with no or minimum fertilizers, pesticides and very early or very late sowing, no practicing of irrigation and drainage facilities etc. All these factors are responsible for low yield of mungbean which is incomparable with the yields of developed countries of the world (FAO, 1999). The low yield of mungbean besides other factors may partially be due to lack of knowledge and nutrition and modern production technology (Hussain *et al*., 2008). Moreover, lack of attention on fertilizer use is also instrumental in lowering mungbean yields (Mansoor, 2007).

Mungbean generally flowers profusely, but only a small portion of the flowers mature to pods. Most of the abscission of reproductive structures of legume crops occurs during the bud to full bloom stages of development (Mondal *et al*., 2011a). Most mungbean cultivars are indeterminate where flowering proceeds acropetally on the racemes and also on the branches as new racemes develop (Mondal *et al*., 2011b). Under favorable conditions, the earlier-formed flowers set more pods than the later formed ones. In general, most of the pods develop on the proximal nodes of the racemes, and flowers that produced at the distal nodes of racemes abscise. It seems to be a worthwhile problem to investigate whether source (leaves) or sink (flower and pod) limit crop yield (Yasari *et al*., 2009). In mungbean, seed yield is principally determined by pod and seed number suggesting that yield may be sink-limited (Mondal *et al*., 2011c). However, there are reports that within limits, yield is not influenced by sink capacity (Egli, 1999).

Thus, it is disputable whether seed yield in grain legume is limited by source or sink. In an attempt to define the compensatory mechanism in mungbean yield, research investigated the effects of removing reproductive organs at various stages of development on seed yield and reported that mungbean plants tolerated pod removal up to 80% without significant loss of seed yield if carried out before the initiation of pod filling stage (Kokubun and Asahi, 1984). Moreover, seed size was increased enough to compensate for 20% fewer pods in mungbean (Kokubun and Watanabe, 1983). However, increasing source-sink ratios by decreasing sink size through pod removal usually results in increased leaf carbohydrate levels. Branch, leaf and dry matter production, irrespective of seasons and genotypes generally increase with increasing levels of deflowering (Mondal *et al*., 2013). In deflowered plants, dry matter production was increased yet seed yield was decreased with increasing level of flower removal. Decreased yield attended with fewer pods $plant^{-1}$ and seeds pod^{-1}, and reduced pod and seed sizes. Although number of racemes was increased following flower removal but total flower production was decreased due to reduced flowering duration and ultimately resulting in poor pod and seed yields (Mondal *et al*., 2013).

Therefore, experimental evidences indicate that there are scopes to increase the productivity by managing flowering dropping of mungbean. Considering the above factors the present experiment was conducted to evaluate flower removal to maximize the reproductive behavior and yield attributes of mungbean varieties with the following objectives:

i. To observe the effect of flower removal on growth and yield of mungbean.

ii. To find out the interaction effect of different mungbean variety and flower removal on growth and yield of mungbean.

CHAPTER II

REVIEW OF LITERATURE

Mungbean is an important pulse crop in Bangladesh and as well as many countries of the world although the crop has conventional less attention by the researchers on various aspects because normally it grows without care or management practices. Based on this a very few research work related to growth, yield and development of mungbean have been carried out in our country. However, researches are going on in home and abroad to maximize the yield of mungbean. Variety and different management practices play an important role in improving mungbean yield. But research works related to variety and flower removal as a management practices on mungbean are limited in Bangladesh context. However, some of the important and informative works and research findings related to the variety and flower removal so far been done at home and abroad have been reviewed in this chapter under the following headings-

2.1. Effects of varieties on plant characters of mungbean

Four mungbean accessions from the Asian Vegetable Research and Development Centre (AVRDC) were grown by Agugo *et al*. (2010). Results showed a significant difference in the yield of the varieties with VC 6372 (45-8-1) producing the highest seed yield of 0.53 t/ha. This was followed by NM 92, 0.48 t/ha; NM 94, 0.40 t/ha; and VC 1163 with 0.37 t/ha. The variety, VC 6372 (45-8-1), also formed good agronomic characters.

Field studies were conducted by Kumar *et al*. (2009) in Haryana, India to determine the growth behaviour of mungbean genotypes sown on different dates under irrigated conditions. The treatments consisted of 2 genotypes (SML 668 and MH 318) and 6 sowing dates starting from 1 March to 19 April, at of 10-day intervals. Results showed that SML 668 had higher plant height than MH 318 and the less height of both the genotypes during summer was due to low average temperature during the initial growth stage. SML 668 accumulated more dry matter than MH 318. The contribution of leaves and stem was more in SML 668, whereas the contribution of pods towards total aboveground biomass at harvest was higher in MH 318.

Quaderi *et al*. (2006) carried out an experiment in the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh to evaluate the influence of seed treatment with Indole Acetic Acid (IAA) at a concentration of 50 ppm, 100 ppm and 200 ppm on the growth, yield and yield contributing characters of two modern mungbean (*Vigna radiata* L.) varieties viz. BARI moog 4 and BARI moog 5. The two-factor experiment was laid out in Randomized Complete Block Design (RCBD) (factorial) with 3 replications. Among the mungbean varieties, BARI moog 5 performed better than that of BARI moog 4.

To study the nature of association between *Rhizobium phaseoli* and mungbean an experiment was conducted by Muhammad *et al*. (2006). Inocula of two Rhizobium strains, Tal-169 and Tal-420 were applied to four mungbean genotypes viz., NM-92, NMC-209, NM-98 and Chakwal Mung-97. A control treatment was also included for comparison. The experiment was carried out at the University of Arid Agriculture, Rawalpindi, Pakistan, during kharif. Both the strains in association with NM-92 had higher nodule dry weight, which was 13% greater than other strains × mungbean genotypes combinations. Strain Tal-169 was specifically more effective on genotype NCM-209 and NM-98 compared with NM-92 and Chakwal Mung-97. Strain Tal-420 increased branches plant^{-1} of all the genotypes. Strain Tal-169 in association with NCM-209 produced the highest yield of 670 kg ha^{-1} which was similar (590 kg ha^{-1}) in case of NCM-209 either inoculated with strain Tal-420 or uninoculated. Variety NM-92 produced the lowest grain yield (330 kg ha^{-1}) either inoculated with strain Tal-420 or uninoculated.

Islam *et al*. (2006) carried out an experiment at the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh to evaluate the effect of biofertilizer (*Bradyrhizobium*) and plant growth regulators (GA_3 and IAA) on growth of 3 cultivars of summer mungbean (*Vigna radiata* L.). Among the mungbean varieties, BINA moog 5 performed better than that of BINA moog 2 and BINA moog 4.

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

To evaluate the effects of crop densities (10, 13, 20 and 40 plants/m^2) on yield and yield components of two cultivars (Partow and Gohar) and a line of mungbean (VC-1973A), a field experiment was conducted by Aghaalikhani *et al*. (2006) at the Seed and Plant Improvement Institute of Karaj, Iran, in the summer of 1998. The results indicated that VC-1973A had the highest grain yield. This line was superior to the other cultivars due to its early and uniform seed maturity and easy mechanized harvest.

Rahman *et al*. (2005) carried out an experiment with mungbean in Jamalpur, Bangladesh, involving 2 planting methods, i.e. line sowing and broadcasting; 5 mungbean cultivars, namely Local, BARI moog 2, BARI moog 3, BINA moog 2 and BINA moog 5. Significantly the highest dry matter production ability was found in 4 modern mungbean cultivars, and dry matter partitioning was found highest in seeds of BINA moog 2 and lowest in Local. However, the local cultivar produced the highest portion of dry matter in leaf and stem.

Studies were conducted by Bhati *et al*. (2005) to evaluate the effects of cultivars and nutrient management strategies on the productivity of different kharif legumes (mungbean, mothbean and clusterbean) in the arid region of Rajasthan, India. The experiment with mungbean showed that K-851 gave better yield than Asha and the local cultivar. In another experiment, mungbean cv. PDM-54 showed 56.9%

higher grain yield and 13.7% higher fodder yield than the local cultivar. The experiment with mothbean showed that RMO-40 gave 34.8-35.2% higher grain yield and 30.2-33.4% higher fodder yield over the local cultivar as well as 11.8% higher grain yield and 9.2% higher fodder yield over RMO-257. The experiment with clusterbean showed that improved cultivars of RGC-936 gave 136.0 and 73.5% higher grain yield and 124.0 and 67.3% higher fodder yield over the local cultivar and Maru Guar, respectively.

A field experiment was conducted by Raj and Tripathi (2005) in Jodhpur, Rajasthan, India, during the kharif seasons, to evaluate the effects of cultivar (K-851 and RMG-62) as well as nitrogen and phosphorus on the productivity of mungbean. K-851 produced significantly higher values for seed and straw yields as well as yield attributes (plant height, pods plant^{-1}, seeds pod^{-1} and 1000-seed weight) compared with RMG-62. Higher net return and benefit:cost (B:C) ratio were also obtained with K-851 (Rs. 6544 ha^{-1} and 1.02, respectively) than RMG-62 (Rs. 4833 ha^{-1} and 0.76, respectively).

Chaisri *et al*. (2005) conducted a yield trial involving 6 recommended cultivars (KPS 1, KPS 2, CN 60, CN 36, CN 72 and PSU 1) and 5 elite lines (C, E, F, G, H) under Kasetsart mungbean breeding project in Lopburi Province, Thailand, during the dry (February-May 2002), early rainy (June-September 2002) and late rainy season (October 2002-January 2003). Line C, KPS 1, CN 60, CN 36 and CN 72 gave high yields in the early rainy season, while line H, line G, line E, KPS 1 and line C gave high yields in the late rainy session. Yield trial of the 6 recommended mungbean cultivars was also conducted in the farmer's field.

Two summer mungbean cultivars, i.e. BINA moog 2 and BINA moog 5, were grown during the kharif-1 season (February-May), in Mymensingh, Bangladesh, under no irrigation or with irrigation once at 30 days after sowing (DAS), twice at 30 and 50 DAS, and thrice at 20, 30 and 50 DAS by Shamsuzzaman *et al*. (2004). Data were recorded for days to first flowering, days to first leaf senescence, days to pod maturity, flower + pod abscission, root, stem+leaf, pod husk and seed dry matter content, pods plant^{-1}, seeds pod^{-1}, 100-seed weight, seed yield, biological yield and harvest index. The two cultivars tested were synchronous in flowering, pod maturity and leaf senescence, which were significantly delayed under different irrigated frequencies. BINA moog 2 performed slightly better than BINA moog 5 for most of the growth and yield parameters studied.

An experiment was conducted by Abid *et al.* (2004) in Peshawar, Pakistan to study the effect of sowing dates on the agronomic traits and yield of mungbean cultivars NM-92 and M-1. Data were recorded for days to emergence, emergence/m^2, days to 50% flowering, days to physiological maturity, plant height at maturity and grain yield. Sowing on 15 April took more number of days to emergence but showed maximum plant height. The highest emergence/m^2 and higher mean grain yield was recorded in NM-92 than M-1.

A field experiment was conducted by Apurv and Tewari (2004) during kharif season in Uttaranchal, India, to investigate the effect of *Rhizobium* inoculation and fertilizer on the yield and yield components of three mungbean cultivars (Pusa 105, Pusa 9531 and Pant mung 2). Pusa 9531 showed higher yield components and grain yield than Pusa 105 and Pant mung 2.

To find out the effects of *Rhizobium* inoculation on the nodulation, plant growth, yield attributes, seed and stover yields, and seed protein content of six mung bean (*Vigna radiata*) cultivars were investigated by Hossain and Solaiman (2004). The mungbean cultivars were BARI mung-2, BARI mung-3, BARI mung-4, BARI mung-5, BINA mung-2 and BU mung-1. Among the cultivars, BARI mung-4 performed the best in all aspects showing the highest seed yield of 1135 kg/ha. *Rhizobium* strain TAL169 did better than TAL441 in most of the studied parameters. It was concluded that BARI mung 4 in combination with TAL169 performed the best in terms of nodulation, plant growth, seed and stover yields, and seed protein content.

The performance of 20 mungbean cultivars were evaluated by Madriz-Isturiz and Luciani-Marcano (2004) in a field experiment conducted in Venezuela. Data on plant height, clusters per plant, pods per plant, pod length, seeds per pod, grain yield by plant and yield/ha were recorded. Significant differences in the values of the parameters measured due to cultivar were recorded. The average yield was 1342.58 kg/ha. VC 1973C, Creole VC 1973A, VC 2768A, VC 1178B and Mililiter 267 were the most promising cultivars for cultivation in the area.

Effect of sowing rates on the growth and yield of mungbean cultivars NM-92, NARC mung-1 and NM-98 was evaluated by Riaz *et al*. (2004) in Faisalabad, Pakistan. NM-98 produced the maximum pod number of 77.30, grain yield of 983.75 kg/ha and harvest index value of 24.91%. NM-92 also produced the highest seed protein content of 24.64%.

Brar *et al*. (2004) introduced SML 668 high yielding variety of summer mungbean selection from AVRDC line NM 94, is a cultivar recommended for general cultivation in irrigated areas of Punjab, India. This early maturing cultivar flowers in 34 days and matures in 60 days. It has an average plant height of 44.6 cm and bears an average of 16 pods per plant and 10.4 seeds per pod. Seeds are bold with 100-seed weight of 5.7 g and devoid of hard seeds. Protein content is 22.7% and water absorption capacity is high (91%).

Seed treatment with biofertilizers in controlling foot and root rot of mungbean cultivars BINA moog-3 and BINA moog-4 was investigated by Mohammad and Hossain (2003) under field conditions in Pakistan. Treatment of seeds of BINA moog-3 with biofertilizer showed a 5.67% increase in germination over the control, but in case of BINA moog-4 10.81% increase in germination over the control was achieved by treating seeds with biofertilizer. The biofertilizers caused 77.79% reduction of foot and root rot disease incidence over the control along with BINA moog-3 and 76.78% reduction of foot and rot disease in BINA moog-4. Seed treatment with biofertilizer also produced up to 20.83% higher seed yield in BINA moog-3 and 12.79% higher seed yield BINA moog-4 over the control.

Three mungbean cultivars (LGG 407, LGG 450 and LGG 460) and two urd bean [black gram] cultivars (LBG 20 and LBG 623) were sown in Lam, Guntur, Andhra Pradesh, India, by Durga *et al*. (2003) and subjected to severe moisture stress during the first 38 days after sowing (DAS) and only a rainfall of 21.4 mm was received during this period. Mungbean registered higher root length (11.83%), root volume (37.50), root weight (31.43%), lateral roots (81.71%), shoot length (13.04%), shoot weight (84.62%), leaf number (25.75%), leaf weight (122.86%) and leaf area (108.60%) than the urd bean. Mungbean recorded better leaf characters than urd bean, but root and shoot characters were better in the latter. Among the mungbean cultivars, LGG 407 recorded the highest yield. Between the urd bean cultivars, LBG 20 had a higher yield than LBG 623. Among the mung bean cultivars, LGG 407 was the most tolerant, while in urd bean, LBG 20 was more efficient in avoiding early drought stress than LBG 623.

Taj *et al*. (2003) carried out an experiment to find out the effects of sowing rates (10, 20, 30 and 40 kg seed/ha) on the performance of 5 mungbean cultivars (NM-92, NM 19-19, NM 121-125, N/41 and a local cultivar) were studied in Ahmadwala, Pakistan, during the summer season. Among the cultivars, NM 121-125 recorded the highest average pods per plant (18.18), grains per pod (9.79), 1000-grain weight (28.09 g) and grain yield (1446.07 kg ha^{-1}).

Satish *et al*. (2003) conducted an experiment in Haryana, India to investigate the response of mung bean cultivars Asha, MH 97-2, MH 85-111 and K 851 to different P levels. Results revealed that the highest dry matter content in the leaves, stems and pods was obtained in Asha and MH 97-2. The total above-ground dry matter as well as the dry matter accumulation in leaves, stems and pods increased with increasing P level up to 60 kg P ha^{-1}. MH 97-2 and Asha produced significantly more number of pods and branches/plant compared to MH 85-111 and K 851.

The development phases and seed yield were evaluated by Infante *et al*. (2003) in mungbean cultivars ML 267, Acriollado and VC 1973C under the agroecological conditions of Maracay, Venezuela. The differentiation of the development phases and stages, and the morphological changes of plants were studied. The variable totals of pod clusters, pods per plant, seeds per pods and pod length were also studied. The earliest cultivar was ML 267 with 34.87 days to flowering and 61.83 to maturity. There were significant differences for total pod clusters per plant and pods per plant, where ML 267 and Acriollado had the highest values. The total seeds per pod of VC 1973C and Acriollado were significantly greater than ML 267. Acriollado showed the highest yield with 1438.33 kg/ha.

Seeds of mungbean cultivars BM-4, S-8 and BM-86 were inoculated with *Rhizobium* strains M-11-85, M-6-84, GR-4 and M-6-65 before sowing in a field experiment conducted by Navgire *et al*. (2001) in Maharashtra, India during the kharif season. S-8, BM-4 and BM-86 recorded the highest mean nodulation (16.66), plant biomass (8.29 q/ha) and grain yield (4.79 q/ha) during the experimental years. S-8, BM-4 and BM-86 recorded the highest nodulation, plant biomass and grain yield.

Hamed (1998) carried out two field experiments in Shalakan, Egypt, to evaluate mung bean cultivars Giza 1 and Kawny 1 under 3 irrigation intervals after flowering (15, 22 and 30 days) and 4 fertilizer treatments: inoculation with *Rhizobium* (R) + Azotobacter (A) + 5 (N_1) or 10 kg N/feddan (N_2), and inoculation with R only +5 (N_3) or 10 kg N/feddan (N_4). Kawny 1 surpassed Giza 1 in pod number per plant (24.3) and seed yield (0.970 t/feddan), while Giza 1 was superior in 100-seed weight (7.02 g), biological and straw yields (5.53 and 4.61 t/feddan, respectively). While Kawny 1 surpassed Giza 1 in oil yield (35.78 kg/feddan), the latter cultivar recorded higher values of protein percentage and yield (28.22% and 264.6 kg/feddan). The seed yield of both cultivars was positively and highly significantly correlated with all involved characters, except for 100-seed weight of Giza 1 and branch number per plant of Kawny 1.

2.2. Effects of flower removal and pruning in crop plant

Field experiments were conducted by Mondal *et al*. (2013) under sub-tropical condition to investigate the effect of seven levels of deflowering durations (0, 5, 10, 15, 20, 25 and 30 days after commencement of flowering) on morpho-physiological features and yield attributes in two high and two low yielding mungbean genotypes during Kharif-I. Results showed increasing levels of deflowering parallely increased branch, leaf and dry matter (DM) production, irrespective of seasons and genotypes. In deflowered plants, DM production was increased yet seed yield was decreased with increasing level of flower removal. Decreased yield attended with fewer pods plant^{-1} and seeds pod^{-1}, and reduced pod and seed sizes. Although number of racemes was increased following flower removal but total flower production was decreased due to reduced flowering duration and ultimately resulting in poor pod and seed yields. However, TDM and seed yield plant^{-1} remained unaffected when deflowered for 10 consecutive days, constitute about 80% of total flower loss.

A field experiment was conducted by Sultana *et al*. (2013) at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from March 2007 to June 2007 to study the influence of different leaf clipping and fertilizer doses on growth and seed yield of mungbean. The trial comprised four treatments on leaf clipping (No removal, removal of new leaves developed after first flowering, removal of subtending leaves beneath the inflorescences and removal of empty leaves), and three treatments on fertilizer doses per hector. Results showed that the leaf clipping treatments had significant effect on growth and yield parameters. Removal of empty leaves resulted in the highest dry matters from root, inflorescences with yield and the entire yield attributes as well. In case of interaction of treatments, removal of empty leaves coupled with 20 kg N + 40 kg P_2O_5 + 30 kg K_2O (ha) showed significantly highest values on root dry weight (2.49 g/plant), stover weight (2.10 g/plant), pod length (12.98 cm), number of seeds/pod (12.31), 1000 seed weight (40.67 g), grain yield (1.12 t/ha) and harvest index (34.78 %). The higher yield was attributed to the absence of leaves having no inflorescence on their axils.

Experiments were carried out by Mondal *et al*. (2011a) with eight levels of defoliations (0, 25, 50 and 75% either from top or from base of the canopy, and 100%) to investigate the growth, reproductive characters, and yield attributes in two high and two low yielding mungbean genotypes. Results revealed that degrees of defoliations parallely decreased leaf area and total dry matter (TDM) production irrespective of seasons and genotypes. Defoliation not only reduced source sizes but also decreased total sink (flower) production resulting in lower pod and seed yields. However, basal 25% defoliation did not significantly decrease TDM and seed yield plant^{-1} indicating the fact that the mungbean plant, in general, can tolerate 25% basal leaf loss of the canopy. Furthermore, the high yielding genotypes showed higher compensatory mechanism of source loss than the low yielders. Exceeding this threshold limit (> 25%) either from the base or from the top of the canopy defoliation significantly reduced TDM and seed yield. Reduction in yield was higher with top defoliation than basal defoliation.

Mondal *et al*. (2011b) conducted an experiment to investigate deflowering effect on pod set probability and vasculature in the proximal and distal positions of raceme in mungbean plant. Four deflowering treatments were applied: control (No flower removal), all opened flowers were continuously removed from proximal 1-10, 1-20 and 1-30 nodes of the racemes. The anatomical investigation was made at two positions, basal and distal parts of the rachis of each treatment. Results indicated that mungbean plant compensated for yield loss upto 10-nodes flower removal following a significant yield reduction on further deflowering in the raceme. Results revealed that rachis of the control raceme tapers from proximal to distal end. In contrast, the rachis becomes thicker at distal end of the deflowered rachis than in the distal end of control rachis. It indicates that tissues particularly vascular bundles were poorly developed in the distal end of control raceme but it was well developed at the corresponding position under deflowered condition as indicated by anatomical study. Removal of proximal flowers from 10-30 nodes, however, allowed pod development in the distal end of the raceme, which would otherwise have abscised. Such pod set capacity in the distal end of the rachis was possibly due to development of adequate xylem and phloem tissues in the distal part of the deflowered rachis, like a control rachis in the proximal position. The presence of pods in the proximal end on racemes interfere the development of distal pods and increased the abscission probability of reproductive structures borne at distal position in mungbean.

In Poland, Ambroszczyk *et al*. (2008) carried out an experiment to find the relations between pruning methods and chosen parameters of vegetative eggplant development in greenhouse conditions. Independence between different pruning methods and vegetative plant development particularly leaves characteristics as well as pigments and photosynthesis products content in leaves was stated. Eggplant of Tania F_1 hybrid was used in the early spring-summer production in a heated greenhouse. The following pruning systems were applied: pruning to one shoot with leaving on every node 2 fruit sets and 1, 2 or 3 leaves, and pruning to two shoots with leaving on every node 1 fruit set and 1, 2 or 3 leaves. With the introduction of a greater number of leaves and fruit sets on eggplant shoots irradiation in plant profile was reduced. The value of leaf area index (LAI) depended on the way of pruning.

In Poland, Ambroszczyk *et al*. (2007) carried out an experiment under green house condition to determine the method of eggplant (aubergine) pruning, optimizing the proportions between vegetative and generative plant development. The following pruning systems were applied: pruning to one shoot with leaving on every node 2 fruit sets and 1, 2 or 3 leaves, and pruning to two shoots with leaving on every node 1 fruit set and 1, 2 or 3 leaves. Among the treatments the most beneficial light conditions were observed in treatments pruned to one shoot with two fruit sets per node. Pruning strongly affected the effectiveness of fruit setting, especially in treatments pruned to two shoots. Plants pruned to two shoots with one fruit set and three leaves per node set fruits the most evenly on subsequent nodes. Intensive plant pruning did not reduce the eggplant yield in the present experiment. Also earliness of production was not affected by the systems of pruning. Mean early yield from first four harvests was 4.06 kg m^{-2} (total) and 4.04 kg m^{-2} (marketable) without statistical differences among treatments. Also total (10.44 kg m^{-2}) and marketable (9.41 kg m^{-2}) yield was not affected by the pruning system. Plants pruned more intensively (one shoot, two fruit sets per node) produced more I class fruits. Less intensive pruning resulted in the increase of the number of unmarketable fruits. Pruning affected fruit qualities, assessed on the base of dry matter, total sugar, vitamin C, and chosen element contents.

Luo-LaiXin *et al*. (2005) conducted top pruning, a new inoculating method of bacterial canker of tomato, developed based on the traditional methods including leaf shearing, root soaking and needle penetrating. These results indicate that top pruning, as a convenient and efficient inoculation method is applicable for further evaluation as against the effects of chemical control of this disease.

An experiment was carried out by Pessarakli and Dris (2003) to observe the effects of pruning and spacing on the yield and quality of eggplants. Various suggestions on pruning and spacing of eggplants and the most suitable pruning as well as the optimum spacing to increase the yield and quality of eggplant given by different investigators are discussed in this manuscript. In general, proper pruning and optimum spacing substantially increase eggplant yield and improve its fruit quality.

In the greenhouse production the effect of various side shoots pruning on productivity of eggplant was investigated by Amroszczyk and Cebula (2003). They found that pruning has a positive effect on irradiation on PAR range in the plant profile. The significant increase of the eggplant total yield was obtained with the introduction of a greater height of the second shoot. Higher accumulation of dry mass and chlorophyll 'a' and 'b' in the leaves on upper levels of the plants was noted. This tendency was not confirmed for assimilative starch. It was not found a significant effect of plant pruning on the content of dry mass, total sugars and L-ascorbic acid in fruits.

Arin and Ankara (2001) conducted an experiment to determine the effect of low-tunnel, mulch and pruning treatments on yield and earliness tomato cv. Fuji F_1 tomato (*Lycopersicum esculentum* Mill.) in unheated glasshouse. Plant height, stem diameter, days to first harvest, early yield (g/plant), total yield (g/plant) and fruit weight (g/fruit) were determined during the growing period. Low-tunnel and mulching had a positive effect on plant growth development. The highest early yield was obtained from the plants pruned from the 4th truss and mulched with any mulch under low-tunnel. Total yield was highest in plants pruned from 8th truss and mulched with wheat straw.

Navarrete and Jeannequin (2000) conducted an experiment to determine the effect of de-shooting frequency on vegetative growth and fruit yield, in order to help growers to determining the optimal frequency. Four de-shooting frequencies were compared on two cultivars; every 7, 9, 10, 14 and 21 days. De-shooting frequency affected vegetative growth and yield; when de-shooting was performed seldom (every 21 days), the stem diameter was decreased; the number of fruit m^{-2} was also reduced, leading to significantly lower yield. When the auxiliary buds were eliminated frequently (7 days), even those located near the apex, it reduced vegetative growth, but not yields.

Going through the above reviews, it is concluded that the variety and flower removal is important considering growth and yield of crop. The literature reveals that the effects of variety and flower removal or pruning have not been studied well for the production of mungbean under Bangladesh condition.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during March to June 2013 to study the effect of variety and flower removal on the performance of mungbean. This chapter includes materials and methods those were used in conducting the experiment are presented below under the following headings:

3.1. Experimental site

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experimental site is situated between $23^0 74^/$N latitude and $90^0 35^/$E longitude (Anon., 1989).

3.2. Soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ- 28) and the General Soil Type is Deep Red Brown Terrace Soils (UNDP, 1988). A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, ground and passed through 2 mm sieve and analyzed for some important physical and chemical properties. The analytical data of the soil sample collected from the experimental area were determined in the SRDI, Soil Testing Laboratory, Khamarbari, Dhaka and presented in Appendix I.

3.3. Climate

The climate of experimental site is subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. Meteorological data related to the temperature, relative humidity and rainfalls during the period of the experiment were collected from the Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar and presented in Appendix II.

3.4. Planting material

The varieties BARI mung-3, BARI mung-4, BARI mung-5 and BARI mung-6 were used as the test crop. The seeds were collected from the Pulse Seed Division of Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. They grow both in *Kharif* and *Rabi* season. Life cycle of this variety ranges from 55-60 days. Maximum seed yield is 1.1-1.6 t/ha.

3.5. Land preparation

The land was irrigated before ploughing. After having 'zoe' condition the land was first opened with the tractor drawn disc plough. Ploughed soil was brought into desirable fine tilth by 4 ploughing and cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 20 March and 01 April, 2012, respectively. Experimental land was divided into unit plots following the design of experiment.

3.6. Treatments of the experiment

The experiment consists of two factors:

Factor A: Mungbean variety (4)

- i) V_1: BARI mung-3
- ii) V_2: BARI mung-4
- iii) V_3: BARI mung-5
- iv) V_4: BARI mung-6

Factor B: Flower removal (4 levels)

- i) R_0: No removal of flower
- ii) R_1: Removal of flower at 30-35 DAE
- iii) R_2: Removal of flower at 40-45 DAE
- iv) R_3: Removal of flower at 50-55 DAE

There were 16 (4×4) treatment combinations such as V_1R_0, V_1R_1, V_1R_2, V_1R_3, V_2R_0, V_2R_1, V_2R_2, V_2R_3, V_3R_0, V_3R_1, V_3R_2, V_3R_3, V_4R_0, V_4R_1, V_4R_2 and V_4R_3.

3.7. Fertilizer application

Urea, Triple super phosphate (TSP), Muriate of potash (MoP) and gypsum were used as a source of nitrogen, phosphorous, potassium and sulphur respectively. Urea, TSP, MP and gypsum were applied at the rate of 50, 35, 85 and 10 kg per hectare respectively following Bangladesh Agricultural Research Institute (BARI) recommendation. All of the fertilizers except urea were applied during final land preparation and urea was applied in three equal splits at 15, 25 and 35 days after sowing (DAS).

3.8. Experimental design and layout

The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 511.75 m^2 (44.50 m × 11.50 m) was divided into three equal blocks. Each block was divided into 16 plots to allocate 16 treatment combinations at random. There were 48 unit plots in the experiment. The size of unit plot was 3.0 m × 2.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.9. Sowing of seeds in the field

The seeds of mungbean were sown on April 01, 2013 in solid rows of furrows having a depth of 2-3 cm with 30 cm row to row distance. Before sowing seeds were treated with Bavistin to control the seed borne disease.

3.10. Intercultural operations

3.10.1. Thinning

Seeds started germination of four days after sowing (DAS). Thinning was done two twice, first thinning was done at 8 DAS and second was done at 15 DAS to maintain optimum plant population in each plot.

3.10.2. Irrigation and weeding

Irrigation was done as per requirements. The crop field was weeded as per treatment.

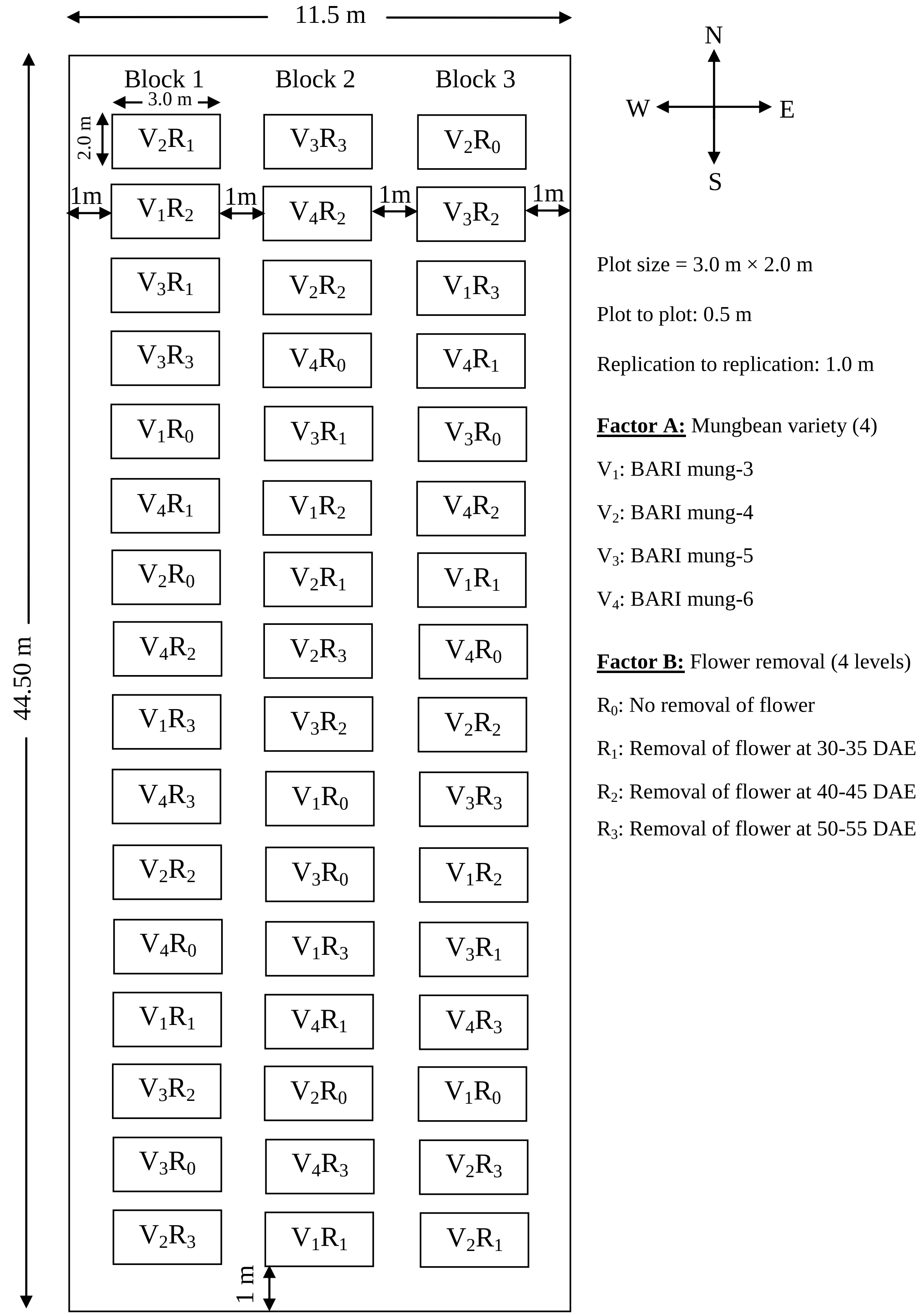


Figure 1. Field layout of the experimental plot.

3.10.3. Protection against insect and pest

At early stage of growth few worms (*Agrotis ipsilon*) and virus vectors (jassid) infested the young plants and at later stage of growth pod borer (*Maruca testulalis*) attacked the plant. Dimacron 50EC was sprayed at the rate of 1 litre/ha to control the insects.

3.10.4. Flower removal process

Flower were removal with a sharp knife based on the density of flower in mungbean plant as per the treatment.

3.11. Crop sampling and data collection

Five plants from each treatment were randomly selected and marked with sample card. Data were collected from sample plant during harvest.

3.12. Harvest and post harvest operations

Harvesting was done when 90% of the pods became brown to black in color**.** The matured pods were collected by hand picking from a marked area of three (3 m^2) meter at the center of each plot.

3.13. Data collection

The following data were recorded

i. Plant height
ii. Number of branches per plant
iii. Number of leaves per plant
iv. Dry matter content
v. Days to 1st flowering
vi. Number of pods per plant
vii. Number of seeds per pod
viii. Pod length
ix. Weight of 1000 seeds
x. Seed yield per hectare
xi. Stover yield per hectare
xii. Harvest index

3.14. Procedure of data collection

3.14.1. Plant height (cm)

The plant height was measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm during the harvest time of mungbean crop.

3.14.2. Number of branches per plant

The number of branches plant^{-1} was counted from selected plants. The average number of branches per plant was determined during the harvest time of mungbean crop.

3.14.3. Number of leaves per plant

The number of leaves plant^{-1} was counted from selected plants. The average number of leaves per plant was determined during the harvest time of mungbean crop.

3.14.4. Dry matter of plant

After harvesting, fresh weight of (150 g) plant samples were put into envelop and placed in oven maintained at 70^{0}C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents of plant were computed by simple calculation from the weight recorded by the following formula:

$$\text{\% Dry matter content of plant} = \frac{\text{Dry weight of plant}}{\text{Fresh weight of plant}} \times 100$$

3.14.5. Days to 1st flowering

Days to 1st flowering were recorded by counting the number of days required to start flower initiation in each plot.

3.14.6. Number of pods per plant

Numbers of total pods of selected plants from each plot were counted and the mean numbers were expressed as per plant basis. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.14.7. Number of seeds per pod

The number of seeds per pods was recorded randomly from selected pods at the time of harvest. Data were recorded as the average of 10 pods selected at random from each plot.

3.14.8. Pod length

Pod length was taken of randomly selected ten pods and the mean length was expressed on per pod basis.

3.14.9. Weight of 1000 seeds

One thousand cleaned, dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g).

3.14.10. Seed yield

The seeds collected from 2 (2 m ×1 m) square meter of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t/ha.

3.14.11. Stover yield

The stover collected from 2 (2 m ×1 m) square meter of each plot was sun dried properly. The weight of stover was taken and converted the yield in t/ha.

3.14.12 Harvest index (%)

Harvest index was calculated from the seed and stover yield of mungbean for each plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (seed weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.16. Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different mungbean variety and flower removal on yield and yield contributing characters of mungbean. The mean values of all the characters were calculated and the analysis of variance (ANOVA) was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the effect of variety and flower removal on the performance of mungbean under agro climatic condition of Sher-e-Bangla Agricultural University (SAU), Dhaka. The analyses of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendix III-V. The results have been presented and discussed in different tables and graphs and possible interpretations given under the following headings:

4.1. Plant height

Statistically significant variation was recorded on plant height of mungbean at harvest of varieties (Table 1). The tallest plant (54.05 cm) was recorded from V_4 (BARI mung-6) which was statistically similar (53.21 cm) with V_3 (BARI mung-5) and V_2 (BARI mung-4), whereas the shortest plant (44.13 cm) was recorded from V_1 (BARI mung-3). Different varieties showed different plant height on the basis of their varietal characters and an improved variety is the first and foremost requirement for initiation and accelerated production program of any crop. Brar *et al.* (2004) reported that SML 668 has an average plant height of 44.6 as an early maturing cultivar.

Plant height at harvest showed significant variation for flower removal (Table 1). The tallest plant (51.86 cm) was found from R_0 (no removal of flower), which was statistically similar (50.75 cm) with R_1 (removal of flower at 30-35 DAE) and closely followed (49.08 cm) by R_2 (removal of flower at 40-45 DAE). On the other hand, the shortest plant (47.96 cm) was observed from R_3 (removal of flower at 50-55 DAE). Plant growth as well as plant height, irrespective of seasons and genotypes generally increase with increasing levels of deflowering (Mondal *et al.*, 2013).

Table 1. Effect of variety and flower removal on plant height, number of branches per plant and number of leaves per plant of mungbean

Treatments	Plant height (cm) at harvest	Number of branches per plant at harvest	Number of leaves per plant at harvest
Variety			
V_1	44.13 c	3.67 b	15.88 c
V_2	48.26 b	4.10 a	17.56 b
V_3	53.21 a	4.14 a	18.66 a
V_4	54.05 a	4.27 a	19.49 a
$LSD_{(0.05)}$	2.164	0.196	1.034
Level of significance	0.01	0.01	0.01
Flower removal			
R_0	51.86 a	4.43 a	15.44 c
R_1	50.75 ab	4.02 b	18.23 b
R_2	49.08 bc	4.07 b	20.52 a
R_3	47.96 c	3.67 c	17.40 b
$LSD_{(0.05)}$	2.164	0.196	1.034
Level of significance	0.01	0.01	0.01
CV(%)	5.20	5.80	6.93

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

V_1: BARI mung-3
V_2: BARI mung-4
V_3: BARI mung-5
V_4: BARI mung-6

R_0: No removal of flower
R_1: Removal of flower at 30-35 DAE
R_2: Removal of flower at 40-45 DAE
R_3: Removal of flower at 50-55 DAE

Interaction effect of mungbean varieties and flower removal showed significant differences on plant height at harvest (Table 2). The tallest plant (57.85 cm) was recorded from V_4R_0 (BARI mung-6 + no removal of flower), while the shortest plant (41.15 cm) was recorded from V_1R_3 (BARI mung-3 + 3rd time removal of flower at 50 DAS).

4.2. Number of branches per plant

Different variety of mungbean showed statistically significant variation for number of branches per plant (Table 1). The maximum number of branches per plant (4.27) was found from V_4 which was statistically similar (4.14 and 4.10) with V_3 and V_2, while the minimum number (3.67) was observed from V_1. Management practices influence the number of branches per plant. Quaderi *et al*. (2006) reported that BARI moog 6 performed better than that of other variety.

Statistically significant variation was observed for number of branches per plant at harvest due to flower removal (Table 1). The maximum number of branches per plant (4.43) was recorded from R_0, which was closely followed (4.07 and 4.02) by R_2 and R_1 and they were statistically similar, again the minimum number of branches per plant (3.67) was found from R_3.

Varieties and flower removal showed significant differences on number of branches per plant of mungbean at harvest for their interaction effect (Table 2). The maximum number of branches per plant (4.83) was attained from V_3R_2, while the minimum number of branches per plant (3.23) from V_1R_0.

4.3. Number of leaves per plant

Statistically significant variation was recorded in terms of number of leaves per plant of mungbean for different variety (Table 1). The maximum number of leaves per plant (19.49) was recorded from V_4 which was statistically similar (18.66) with V_3 and closely followed (17.56) by V_2, whereas the minimum number of leaves per plant (15.88) was observed from V_1. Management practices influence the number of leaves per plant but varieties itself also manipulated it.

Table 2. Interaction effect of variety and flower removal on plant height, number of branches per plant and number of leaves per plant of mungbean

Treatments	Plant height (cm) at harvest	Number of branches per plant at harvest	Number of leaves per plant at harvest
V_1R_0	42.01 gh	3.23 g	11.30 g
V_1R_1	47.69 def	3.80 def	17.43 cdef
V_1R_2	45.65 efgh	3.93 def	18.73 cd
V_1R_3	41.15 h	3.73 f	16.07 ef
V_2R_0	53.18 abc	4.63 ab	15.50 f
V_2R_1	49.25 cde	4.03 def	17.77 cdef
V_2R_2	44.36 fgh	4.00 def	19.73 bc
V_2R_3	46.24 efg	3.73 f	17.23 def
V_3R_0	55.39 ab	4.53 abc	16.77 def
V_3R_1	52.25 abcd	4.03 def	18.03 cde
V_3R_2	53.64 abc	4.83 a	22.33 a
V_3R_3	51.57 bcd	3.77 ef	17.50 cdef
V_4R_0	57.85 a	4.23 bcd	18.20 cde
V_4R_1	53.80 abc	4.20 cde	19.67 bc
V_4R_2	52.65 abc	4.10 def	21.30 ab
V_4R_3	52.90 abc	3.93 def	18.80 cd
$LSD_{(0.05)}$	4.328	0.391	2.158
Level of significance	0.05	0.05	0.05
CV(%)	5.20	5.80	6.93

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

V_1: BARI mung-3 | R_0: No removal of flower
V_2: BARI mung-4 | R_1: Removal of flower at 30-35 DAE
V_3: BARI mung-5 | R_2: Removal of flower at 40-45 DAE
V_4: BARI mung-6 | R_3: Removal of flower at 50-55 DAE

Number of leaves per plant at harvest showed significant variation for flower removal (Table 1). The maximum number of leaves per plant (20.52) was found from R_2, which was closely followed (18.23 and 17.40) by R_1 and R_3 and they were statistically similar, while the minimum number of leaves per plant (15.44) was recorded from R_1.

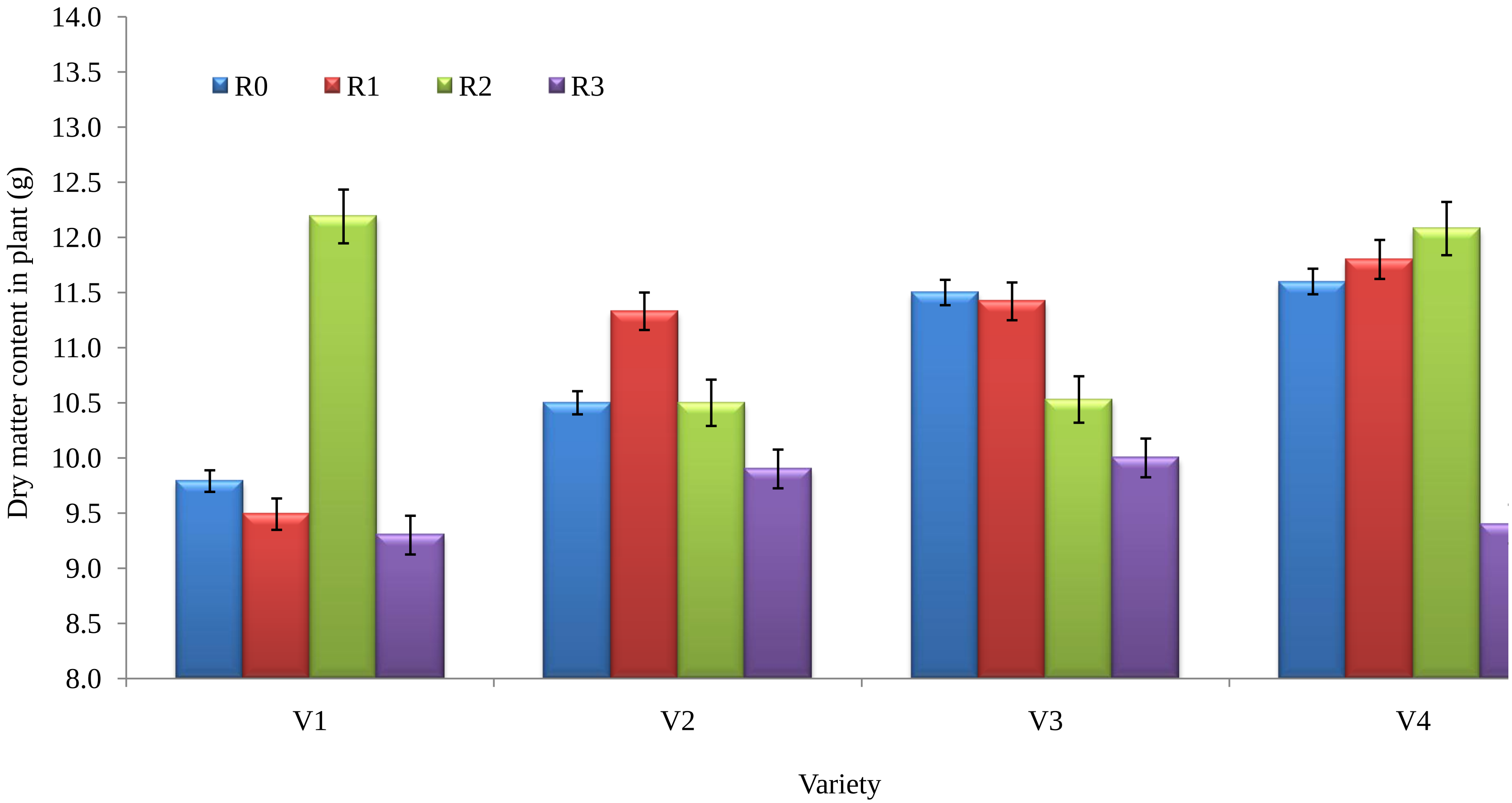
Interaction effect of mungbean varieties and flower removal showed significant differences on number of leaves per plant at harvest (Table 2). The maximum number of leaves per plant (22.33) was found from V_3R_2, while the minimum number of leaves per plant (11.30) from V_1R_0.

4.4. Dry matter content in plant

Statistically significant variation was recorded in terms of dry matter content per plant of mungbean for different variety (Figure 2). The highest dry matter content per plant (11.22%) was observed from V_4 which was statistically similar (10.86% and 10.56%) with V_2 and V_1, while the lowest dry matter content per plant (10.19%) was found from V_3.

Dry matter content per plant at harvest showed significant variation for flower removal (Figure 3). The highest dry matter content per plant (11.32%) was found from R_2, which was statistically similar (11.01% and 10.85%) by R_1 and R_0, while the lowest dry matter content per plant (9.65%) was recorded from R_3. Dry matter production, irrespective of seasons and genotypes generally increase with increasing levels of deflowering (Mondal *et al*., 2013).

Interaction effect of mungbean varieties and flower removal showed significant differences on dry matter content per plant at harvest (Figure 4). The highest dry matter content per plant (12.19%) was recorded from V_1R_2 and the lowest dry matter content per plant (9.30%) from V_1R_3.



V_1: BARI mung-3 V_2: BARI mung-4 R_0: No removal of flower R_1: Removal of flower at 30-35 DAE

V_3: BARI mung-5 V_4: BARI mung-6 R_2: Removal of flower at 40-45 DAE R_3: Removal of flower at 50-55 DAE

Figure 4. Interaction effect of variety and flower removal on dry matter content in plant of mungbean

4.5. Days to 1st flowering

Statistically significant variation was recorded in terms of days to 1st flowering for different variety (Table 3). The minimum days to 1st flowering (28.00) was recorded from V_4, whereas the maximum days to 1st flowering (33.25) was recorded from V_1 which was statistically similar (32.25 days and 31.00 days) with V_2 and V_3. Days to 1st flowering varied for different varieties might be due to genetical and environmental influences as well as management practices.

Days to 1st flowering showed non significant variation for flower removal (Table 3). The minimum days to 1st flowering (32.00) was found from R_2, while the maximum days to 1st flowering (33.83) was observed from R_0.

Interaction effect of mungbean varieties and flower removal showed significant differences on days to 1st flowering (Table 4). The minimum days to 1st flowering (24.33) was recorded from V_4R_1, while the maximum days to 1st flowering (37.00) from V_1R_1.

Interaction effect of mungbean varieties and flower removal showed significant differences on days to 80% pod maturity (Table 4). The minimum days to 1st flowering (63.67) was found from V_2R_0, while the maximum days to 80% pod maturity (78.00) from V_1R_0.

4.6. Number of pods per plant

Statistically significant variation was recorded in terms of number of pods per plant of mungbean for different variety (Figure 5). The maximum number of pods per plant (19.98) was recorded from V_4 which was statistically similar (19.92 and 19.30) with V_3 and V_2, whereas the minimum number of pods per plant (18.16) was recorded from V_1. Different varieties responded differently for pods per plant to input supply, method of cultivation and the prevailing environment during the growing season. Riaz *et al*. (2004) reported that NM-98 produced the maximum pod number of 77.30.

Table 3. Effect of variety and flower removal on yield contributing characters of mungbean

Treatments	Days to 1st flowering	Number of seeds per pod	Pod length (cm)
Variety			
V_1	33.25 a	8.24 c	5.87 b
V_2	32.25 a	8.39 bc	6.49 a
V_3	31.00 a	8.65 ab	5.94 b
V_4	28.00 b	8.81 a	6.98 a
$LSD_{(0.05)}$	2.521	0.379	0.510
Level of significance	0.01	0.05	0.01
Flower removal			
R_0	33.83	8.35 c	5.99 b
R_1	32.17	8.90 b	6.63 a
R_2	32.00	9.33 a	6.77 a
R_3	32.50	7.51 d	5.90 b
$LSD_{(0.05)}$	--	0.379	0.510
Level of significance	NS	0.01	0.01
CV(%)	7.35	5.34	9.67

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

V_1: BARI mung-3
V_2: BARI mung-4
V_3: BARI mung-5
V_4: BARI mung-6

R_0: No removal of flower
R_1: Removal of flower at 30-35 DAE
R_2: Removal of flower at 40-45 DAE
R_3: Removal of flower at 50-55 DAE

Table 4. Interaction effect of variety and flower removal on yield contributing characters of mungbean

Treatments	Days to 1st flowering	Number of seeds per pod	Pod length (cm)
V_1R_0	35.00 abc	8.17 def	5.51 cd
V_1R_1	37.00 a	8.30 def	5.79 cd
V_1R_2	32.67 bcde	8.93 bcd	6.61 bc
V_1R_3	32.67 bcde	7.57 f	5.57 cd
V_2R_0	36.00 ab	7.97 ef	5.85 cd
V_2R_1	33.33 abcd	9.30 bc	7.70 ab
V_2R_2	30.33 def	8.80 bcde	5.80 cd
V_2R_3	33.33 abcde	7.50 f	6.63 bc
V_3R_0	36.67 a	8.43 de	5.56 cd
V_3R_1	34.33 abc	8.53 cde	5.47 cd
V_3R_2	29.00 ef	9.40 b	6.11 cd
V_3R_3	28.00 ef	8.23 def	6.63 bc
V_4R_0	27.67 def	8.83 bcde	6.67 bc
V_4R_1	24.33 f	9.47 ab	7.57 ab
V_4R_2	32.00 cdef	10.20 a	8.55 a
V_4R_3	32.00 cdef	6.73 g	5.14 d
$LSD_{(0.05)}$	5.041	0.759	1.020
Level of significance	0.05	0.01	0.01
CV(%)	7.35	5.34	9.67

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

V_1: BARI mung-3

V_2: BARI mung-4

V_3: BARI mung-5

V_4: BARI mung-6

R_0: No removal of flower

R_1: Removal of flower at 30-35 DAE

R_2: Removal of flower at 40-45 DAE

R_3: Removal of flower at 50-55 DAE

Number of pods per plant showed significant variation for flower removal (Figure 6). The maximum number of pods per plant (21.21) was recorded from R_2, which was statistically similar (20.54) with by R_1 and closely followed (19.51) by R_3, while the minimum number of pods per plant (16.10) was found from R_3. Mondal *et al*. (2013) reported that number of racemes was increased following flower removal but total flower production was decreased due to reduced flowering duration and ultimately resulting in poor pod.

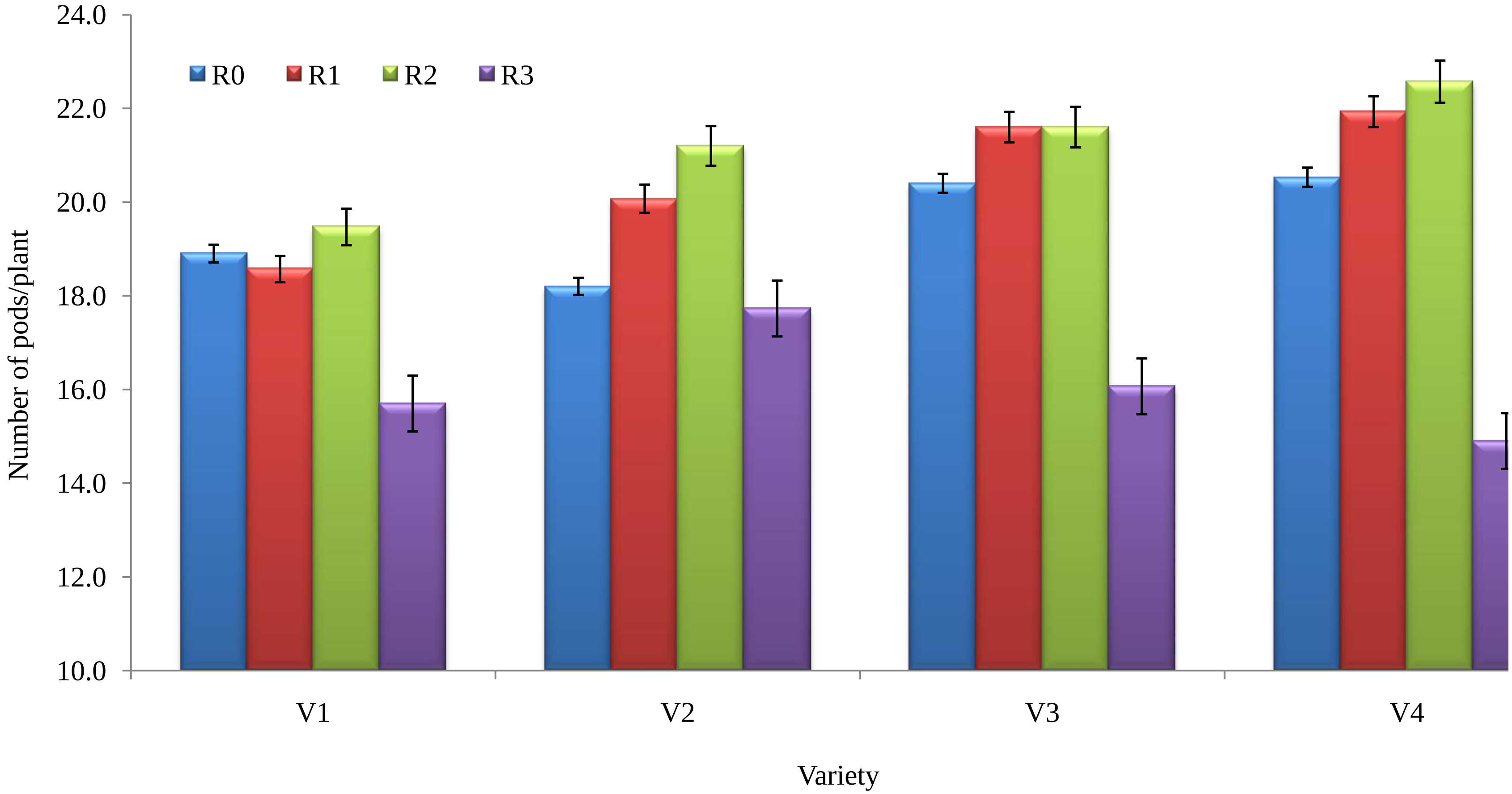
Interaction effect of mungbean varieties and flower removal showed significant differences on number of pods per plant (Figure 7). The maximum number of pods per plant (22.57) was recorded from V_4R_2, while the minimum number of pods per plant (14.90) from V_4R_3.

4.7. Number of seeds per pod

Statistically significant variation was recorded in terms of number of seeds per pod of mungbean for different variety (Table 3). The maximum number of seeds per pod (8.81) was recorded from V_4 which was statistically similar (8.65) with V_3 and closely followed (8.39) by V_2, whereas the minimum number of seeds per pod (8.24) was recorded from V_1.

Number of seeds per pod showed significant variation for flower removal (Table 3). The maximum number of seeds per pod (9.33) was found from R_2, which was closely followed (8.90) by R_1, while the minimum number of seeds per pod (8.35) was observed from R_0.

Interaction effect of mungbean varieties and flower removal showed significant differences on number of seeds per pod (Table 4). The maximum number of seeds per pod (10.20) was recorded from V_4R_2, while the minimum number of seeds per pod (6.73) from V_4R_3.



V_1: BARI mung-3 V_2: BARI mung-4 R_0: No removal of flower R_1: Removal of flower at 30-35 DAE

V_3: BARI mung-5 V_4: BARI mung-6 R_2: Removal of flower at 40-45 DAE R_3: Removal of flower at 50-55 DAE

Figure 7. Interaction effect of variety and flower removal on number of pods per plant of mungbean

4.8. Pod length

Statistically significant variation was recorded in terms of pod length mungbean for different variety (Table 3). The highest pod length (6.98 cm) was found from V_4 which was statistically similar (6.49 cm) with V_2 and closely followed (5.94 cm) by V_3, whereas the lowest pod length (5.87 cm) was observed from V_1.

Pod length showed significant variation for flower removal (Table 3). The highest pod length (6.77 cm) was attained from R_2, which was statistically similar (6.63 cm) with R_1 and closely followed (5.99 cm) by R_0, while the lowest pod length (5.90 cm) was obtained from R_3.

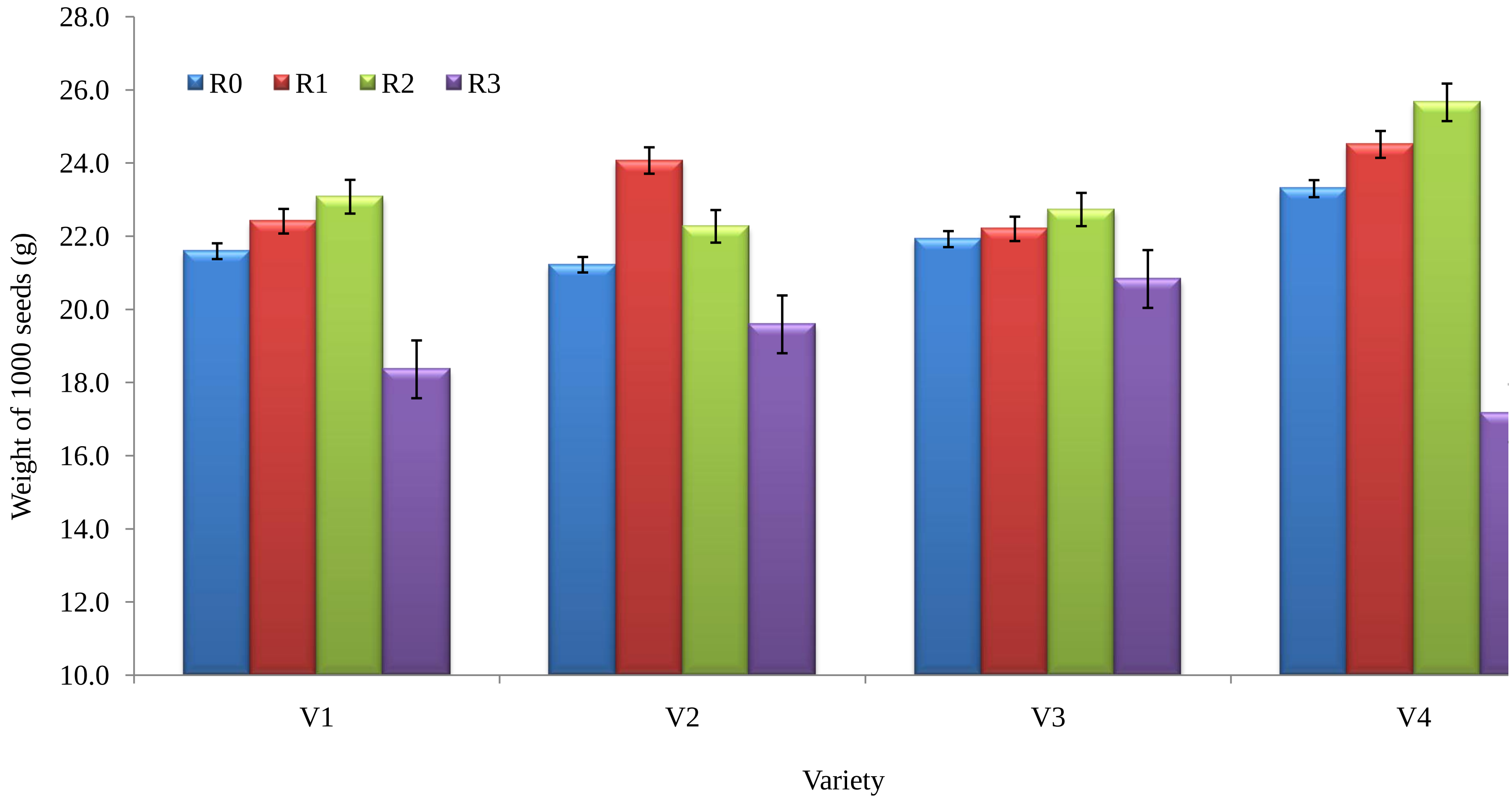
Interaction effect of mungbean varieties and flower removal showed significant differences on pod length (Table 4). The highest pod length (8.55 cm) was found from V_4R_2, while the lowest pod length (5.14 cm) from V_4R_3.

4.9. Weight of 1000 seeds

Statistically significant variation was recorded in terms of weight of 1000 seeds of mungbean for different variety (Figure 8). The highest weight of 1000 seeds (22.66 g) was recorded from V_4 which was statistically similar (21.92 g and 21.79 g) with V_3 and V_2, whereas the lowest weight of 1000 seeds (21.36 g) was recorded from V_1. Taj *et al.* (2003) recorded that highest average 1000-seeds weight 28.09 g from cultivars, NM 121-125.

Weight of 1000 seeds showed significant variation for flower removal (Figure 9). The highest weight of 1000 seeds (23.43 g) was found from R_2, which was statistically similar (23.30 g) with R_1 and closely followed (22.01 g) by R_0, while the lowest weight (18.99 g) from R_3. Seed size was increased enough to compensate for 20% fewer pods in mungbean (Kokubun and Watanabe, 1983).

Interaction effect of mungbean varieties and flower removal showed significant differences on weight of 1000 seeds (Figure 10). The highest weight of 1000 seeds (25.66 g) was recorded from V_4R_2, while the lowest weight of 1000 seeds (17.16 g) from V_4R_3.



V_1: BARI mung-3 V_2: BARI mung-4 R_0: No removal of flower R_1: Removal of flower at 30-35 DAE

V_3: BARI mung-5 V_4: BARI mung-6 R_2: Removal of flower at 40-45 DAE R_3: Removal of flower at 50-55 DAE

Figure 10. Interaction effect of variety and flower removal on weight of 1000 seeds of mungbean

4.10. Seed yield

Statistically significant variation was recorded in terms of seed yield of mungbean for different variety (Table 5). The highest seed yield (1.99 t/ha) was recorded from V_4, whereas the lowest seed yield (1.63 t/ha) was observed from V_1 which was statistically similar (1.66 t/ha and 1.71 t/ha) with V_2 and V_3. Varieties plays an important role in producing high yield of mungbean and yield varied for different varieties might be due to genetical and environmental influences as well as management practices. Tickoo *et al.* (2006) recorded highest seed yield (1.63 t/ha) from cultivar Pusa Vishal.

Seed yield showed significant variation for flower removal (Table 5). The highest seed yield (1.92 t/ha) was recorded from R_2, which was statistically similar (1.87 t/ha and 1.84 t/ha) with R_1 and R_0, while the lowest seed yield (1.36 t.ha) was observed from R_3. Kokubun and Asahi (1984) reported that removing reproductive organs at various stages of development on seed yield and reported that mungbean plants tolerated pod removal up to 80% without significant loss of seed yield if carried out before the initiation of pod filling stage. Mondal *et al.* (2013) reported that number of racemes was increased following flower removal but total flower production was decreased due to reduced flowering duration and ultimately resulting in poor pod and seed yields.

Interaction effect of mungbean varieties and flower removal showed significant differences on seed yield (Table 6). The highest seed yield (2.20 t/ha) was found from V_4R_2, while the lowest seed yield (1.40 t/ha) from V_4R_3.

4.11. Stover yield

Statistically significant variation was recorded in terms of stover yield of mungbean for different variety (Table 5). The highest stover yield (2.47 t/ha) was recorded from V_4 which was statistically similar (2.44 t/ha) with V_3, whereas the lowest stover yield (2.24 t/ha) was recorded from V_1 which was statistically similar (2.29 t/ha) with V_2.

Table 5. Effect of variety and flower removal on yields and harvest index of mungbean

Treatments	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
Variety			
V_1	1.63 b	2.24 c	42.17 b
V_2	1.66 b	2.29 bc	42.23 b
V_3	1.71 b	2.44 ab	41.54 c
V_4	1.99 a	2.47 a	43.42 a
$LSD_{(0.05)}$	0.126	0.154	0.625
Level of significance	0.01	0.01	0.01
Flower removal			
R_0	1.84 a	2.42 b	43.09 b
R_1	1.87 a	2.65 a	41.33 c
R_2	1.92 a	2.77 a	41.01 c
R_3	1.36 b	1.61 c	43.93 a
$LSD_{(0.05)}$	0.126	0.154	0.625
Level of significance	0.01	0.01	0.01
CV(%)	7.11	6.67	6.09

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

V_1: BARI mung-3
V_2: BARI mung-4
V_3: BARI mung-5
V_4: BARI mung-6

R_0: No removal of flower
R_1: Removal of flower at 30-35 DAE
R_2: Removal of flower at 40-45 DAE
R_3: Removal of flower at 50-55 DAE

Table 6. Interaction effect of variety and flower removal on yields and harvest index of mungbean

Treatments	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
V_1R_0	1.76 b	2.46 cd	41.71 cdef
V_1R_1	1.79 b	2.42 d	42.52 de
V_1R_2	1.83 b	2.58 bcd	41.50 efg
V_1R_3	1.13 d	1.50 g	42.97 b
V_2R_0	1.58 bc	2.08 e	43.17 b
V_2R_1	1.70 b	2.49 cd	40.57 fgh
V_2R_2	1.83 b	2.70 abcd	40.40 gh
V_2R_3	1.54 bc	1.90 ef	44.77 a
V_3R_0	1.82 b	2.56 bcd	41.55 defg
V_3R_1	1.81 b	2.78 abc	39.43 h
V_3R_2	1.84 b	2.76 abcd	40.00 h
V_3R_3	1.36 cd	1.65 fg	45.18 a
V_4R_0	2.19 a	2.58 bcd	45.91 a
V_4R_1	2.17 a	2.90 ab	42.80 bcd
V_4R_2	2.20 a	3.02 a	42.15 bcde
V_4R_3	1.40 cd	1.87 g	42.81 bc
$LSD_{(0.05)}$	0.253	0.308	1.250
Level of significance	0.05	0.01	0.01
CV(%)	7.11	6.67	6.09

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

V_1: BARI mung-3
V_2: BARI mung-4
V_3: BARI mung-5
V_4: BARI mung-6

R_0: No removal of flower
R_1: Removal of flower at 30-35 DAE
R_2: Removal of flower at 40-45 DAE
R_3: Removal of flower at 50-55 DAE

Seed yield showed significant variation for flower removal (Table 5). The highest stover yield (2.77 t/ha) was observed from R_2, which was statistically similar (2.65 t/ha) with R_1 and closely followed (2.42 t/ha) by R_0, while the lowest stover yield (1.61 t/ha) was observed from R_3.

Interaction effect of mungbean varieties and flower removal showed significant differences on stover yield (Table 6). Data revealed that the highest stover yield (3.02 t/ha) was recorded from V_4R_2, while the lowest stover yield (1.87 t/ha) was recorded from V_4R_3.

4.12. Harvest index

Statistically significant variation was recorded in terms of harvest index of mungbean for different variety (Table 5). The highest harvest index (43.42%) was recorded from V_4 which was closely followed (42.23% and 42.17%) by V_2 and V_1, whereas the lowest harvest index (41.54%) was recorded from V_3.

Harvest index showed significant variation for flower removal (Table 5). The highest harvest index (43.93%) was observed from R_3, which was closely followed (43.09%) by R_0, while the lowest harvest index (41.01%) was observed from R_2 which was statistically similar (41.33%) with R_1.

Interaction effect of mungbean varieties and flower removal showed significant differences on harvest index under the present trial (Table 6). The highest harvest index (45.91%) was recorded from V_4R_0, while the lowest harvest index (39.43%) was recorded from V_3R_1.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the period from March to June 2013 at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to study the effect of variety and flower removal after third flash of the performance of mungbean. The variety BARI mung-3, BARI mung-4, BARI mung-5 and BARI mung-6 was used as the test crops. The experiment consists of two factors: Factor A: Mungbean variety (4); V_1: BARI mung-3, V_2: BARI mung-4, V_3: BARI mung-5 & V_4: BARI mung-6 and Factor B: Flower removal (4 levels); R_0: No removal of flower, R_1: Removal of flower at 30-35 DAS, R_2: Removal of flower at 40-45 DAS & R_3: Removal of flower at 50-55 DAS. The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different yield contributing characters and yield was recorded and found significant variation for different treatment

The tallest plant (54.05 cm) was recorded from V_4, whereas the shortest plant (44.13 cm) was recorded from V_1. The maximum number of branches per plant (4.27) was found from V_4, while the minimum number of branches per plant (3.67) was observed from V_1. The maximum number of leaves per plant (19.49) was recorded from V_4, whereas the minimum number of leaves per plant (15.88) was observed from V_1. The highest dry matter content per plant (11.22%) was observed from V_4, while the lowest dry matter content per plant (10.19%) was found from V_3. The minimum days to 1st flowering (28.00) was recorded from V_4, whereas the maximum days to 1st flowering (33.25) was recorded from V_1. The maximum number of pods per plant (19.98) was recorded from V_4, whereas the minimum number of pods per plant (18.16) was recorded from V_1. The maximum number of seeds per pod (8.81) was recorded from V_4, whereas the minimum number of seeds per pod (8.24) was recorded from V_1. The highest pod length (6.98 cm) was found from V_4 whereas the lowest pod length (5.87 cm) was observed from V_1. The highest weight of 1000 seeds (22.66 g) was recorded from

V_4, whereas the lowest weight of 1000 seeds (21.36 g) was recorded from V_1. The highest seed yield (1.99 t/ha) was recorded from V_4, whereas the lowest seed yield (1.63 t/ha) was observed from V_1. The highest stover yield (2.47 t/ha) was recorded from V_4 whereas the lowest stover yield (2.24 t/ha) was recorded from V_1. The highest harvest index (43.42%) was recorded from V_4, whereas the lowest harvest index (41.54%) was recorded from V_3.

The tallest plant (51.86 cm) was found from R_0 and the shortest plant (47.96 cm) was observed from R_3. The maximum number of branches per plant (4.43) was recorded from R_0, again the minimum number of branches per plant (3.67) was found from R_3. The maximum number of leaves per plant (20.52) was found from R_2, while the minimum number of leaves per plant (15.44) was recorded from R_1. The maximum number of pods per plant (21.21) was recorded from R_2, while the minimum number of pods per plant (16.10) was found from R_3. The minimum days to 1^{st} flowering (32.00) was found from R_2, while the maximum days to 1^{st} flowering (33.83) was observed from R_0. The maximum number of seeds per pod (9.33) was found from R_2, while the minimum number of seeds per pod (8.35) was observed from R_0. The highest pod length (6.77 cm) was attained from R_2, while the lowest pod length (5.90 cm) was obtained from R_3. The highest weight of 1000 seeds (23.43 g) was found from R_2, while the lowest weight of 1000 seeds (18.99 g) was observed from R_3. The highest seed yield (1.92 t/ha) was recorded from R_2, while the lowest seed yield (1.36 t/ha) was observed from R_3. The highest stover yield (2.77 t/ha) was observed from R_2, while the lowest stover yield (1.61 t/ha) was observed from R_3. The highest harvest index (43.93%) was observed from R_3, while the lowest harvest index (41.01%) was observed from R_2

The tallest plant (57.85 cm) was recorded from V_4R_0, while the shortest plant (41.15 cm) from V_1R_3. The maximum number of branches per plant (4.83) was attained from V_3R_2, while the minimum number of branches per plant (3.23) from V_1R_0. The maximum number of leaves per plant (22.33) was found from V_3R_2, while the minimum number of leaves per plant (11.30) from V_1R_0. The highest dry matter content per plant (12.19%) was recorded from V_1R_2 and the lowest dry matter content per plant (9.30%) from V_1R_3. The highest dry matter content per plant (11.32%) was found from R_2, while the lowest dry matter content per plant (9.65%) was recorded from R_3. The minimum days to 1st flowering (24.33) was recorded from V_4R_1, while the maximum days to 1st flowering (37.00) from V_1R_1. The maximum number of pods per plant (22.57) was recorded from V_4R_2, while the minimum number of pods per plant (14.90) from V_4R_3. The maximum number of seeds per pod (10.20) was recorded from V_4R_2, while the minimum number of seeds per pod (6.73) from V_4R_3. The highest pod length (8.55 cm) was found from V_4R_2, while the lowest pod length (5.14 cm) from V_4R_3. The highest weight of 1000 seeds (25.66 g) was recorded from V_4R_2, while the lowest weight of 1000 seeds (17.16 g) from V_4R_3. The highest seed yield (2.20 t/ha) was found from V_4R_2, while the lowest seed yield (1.40 t/ha) from V_4R_3. The highest stover yield (3.02 t/ha) was recorded from V_4R_2, while the lowest stover yield (1.87 t/ha) was recorded from V_4R_3. The highest harvest index (45.91%) was recorded from V_4R_0, while the lowest harvest index (39.43%) was recorded from V_3R_1.

Above finding revealed that the combination of V_4R_2 was more suitable in consideration of yield contributing characters and yield of mungbean.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Another experiment may be carried out with other variety.
2. Others management practices also may be used for further study.
3. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.

REFERENCES

Abid, H., Khalil, S.K., Sartaj, K. and Haroon, K. (2004). Effect of sowing time and variety on grain yield of mungbean. *Sarhad J. Agric*., **20**(4): 481-484.

Aghaalikhani, M., Ghalavand, A. and Ala, A. (2006). Effect of plant density on yield and yield components of two cultivars and a line of mungbean [*Vigna radiata* (L.) Wilczek] in Karaj Region. *J. Sci, Tech. Agric. Natural Res*., **9**(4): 111-121.

Agugo B.A.C., Oguike, P.C. and Kanu, B.O. (2010). A preliminary field assessment of mungbean (*Vigna radiata* L. Wilczek) yield in the rain forest zone of southeastern Nigeria. *American Eurasian J. Agril. Env. Sci*., **8**(6): 752-757.

Ambroszczyk, A.M., Cebula S. and Sekara A. (2007). The effect of plant pruning on eggplant (*Solanum melongena* L.) yield and fruit quality in greenhouse cultivation. *Hort. Environ. Biotech*., **48**(5): 277-285.

Ambroszczyk, A.M., Cebula S. and Sekara A. (2008). The effect of plant pruning on the light conditions and vegetative development of eggplant (*Solanum melongena* L.) in greenhouse cultivation. *Vegetable Crops Res. Bul*., **68**: 57-70.

Amroszczyk, A.M., Cebula S. (2003). The effect of pruning and training on the productivity of eggplant (*Solanum melongena* L.) in greenhouse production. *Acta Agraria Silvestria/Agraria*. **41**: 71-81.

Anonymous. (1989). Annual Report 1987-88. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p. 133.

Apurv, P. and Tewari, S.K. (2004). Yield dynamics of mungbean (*Vigna radiata* L. Wilczek) varieties in poplar based agroforestry system. *Indian J. Agroforest*. **6**(2): 89-91.

Arin, L. and Ankara, S. (2001). Effect of low-tunnel mulch and pruning treatments on yield and earliness tomato cv. Fuji F_1 tomato (*Lycopersicum esculentum* Mill.) in unheated glasshouse. *J. Appl. Hort*., **3**(1): 23-27.

BBS. (2006). Statistical year book of Bangladesh.26th Edit. Bangladesh bureau of Statistics. Planning division ,Ministry of planning ,Govt. of the people's republic of Bangladesh, p.143.

BBS. (2007). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Govt. of Peoples Republic of Bangladesh. Dhaka. Bangladesh. p. 71.

BBS. (2010). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Govt. of Peoples Republic of Bangladesh. Dhaka. Bangladesh. p. 76.

Bhati, T.K., Rathore, S.S. and Gaur, N.K. (2005). Effect of improved varieties and nutrient management in kharif legumes under arid ecosystem in Institution Village Linkage Programme. *J. Arid Leg.*, **2**(2): 227-229.

Brar, J.S., Inderjit, S., Sarvjeet, S. and Bains, T.S. (2004). SML 668: A new early maturing and high yielding variety of summer mungbean. *J. Res. Punjab Agril. Univ*., **41**(1): 174.

Chaisri, P., Kaveeta, L., Chaisri, S. and Kaveeta, R. (2005). Mungbean yield trial for cropping system in Lopburi area. *Proceedings of 43rd Kasetsart University Annual Conference*, Thailand, 1-4 February, 2005: 214-222.

Durga, K.K., Rao, M.M., Reddy, M.V. and Rao, Y.K. (2003). Effect of early drought stress on morpho-physiological characters and yield of mungbean and urdbean cultivars. *Indian J. Pulses Res.*, **16**(2): 133-135.

Egli, D.B. (1999). Variation in leaf starch and sink limitations during seed filling in soybean. *Crop Sci*., **39**: 1361-1368.

FAO (Food and Agriculture Organization). (1999). FAO Production Yearbook. Basic Data Unit. Statistic Division, FAO. Rome, Italy.

Gomez, K.A. and Gomez, A.A. (1984). Statistical procedures for Agricultural Research. Jhon Wiley and Sons, New York.

Green, S.K. and King, D. (1992). Mungbean Yellow Mosaic Disease. 79p. In: AVRDC, Publication No. 92.

Hamed, M.F. (1998). Response of two mungbean varieties under irrigation intervals and certain fertilization treatments. *Ann. Agril. Sci*., **36**(1): 31-42.

Hossain, D. and Solaiman, A.R.M. (2004). Performances of mungbean varieties as affected by Rhizobium inoculants. *Bulletin of the Inst. Tropic. Agric.*, **27**: 35-43.

Hussain, N., Khan, M.B. and Ahmad, R. (2008). Improving wheat productivity in calcareous soils through band replacement of farmyard manure with phosphorus. *Intl. J. Agri Biol*., **10**: 709-714.

Infante, N., Madriz, P. and Gonzalez, T. (2003). Phases of development and yield components of three mungbean cultivars (*Vigna radiata* (L) Wilczek) in Maracay, Aragua state, Venezuela. *Revista Faculty of Agron*., **20**(4): 417-429.

Islam, M.K., Islam, S.M.A., Harun-or-Rashid, M., Hossain, A.F.M.G.F. and Alom, M.M. (2006). Effect of biofertilizer and plant growth regulators on growth of summer mungbean. *Intl. J. Bot.*, **2**(1): 36-41

Kokubun, M. and Asahi, Y. (1984). Source-sink relationships between the main stem and branches during reproductive growth in mungbean. *Japanese J. Crop. Sci*., **53**: 455-462.

Kokubun, M. and Watanabe, K. (1983). Effect of source and sink manipulations during reproductive growth on yield and yield components. *Japanese. J. Crop Sci*., **52**: 215-219.

Kumar, M., Lathwal, O.P. and Kumar, S. (2009). Growth behaviour of mungbean genotypes under varying sowing time during summer season. *Haryana J. Agron*., **25**(1/2): 79-81.

Luo, L.X., Li, J.Q. and Bolkan, H. (2005). Study on a new inoculating method for bacterial canker of tomato seedlings caused by *Clavibacter michiganensis*. China Agricultural University, Beijing, 100094, *China*. **35**(2): 123-128.

Madriz-Isturiz, P.M. and Luciani-Marcano, J.F. (2004). Agronomic characterization of 20 cultivars of mungbean, *Vigna radiata* (L.) Wilczek during three seasons, in Maracay, Aragua state, Venezuela. *Revista Fac. Agron*., **21**(1): 19-35.

Mansoor, M. (2007). Evaluation of various agronomic management practices for increased productivity of mungbean (*Vigna radiata* L.). Ph. D. Thesis, Department of Agronomy, Faculty of Agriculture, Gomal University, D.I. Khan.

Mohammad, D. and Hossain, I. (2003). Seed treatment with biofertilizer in controlling foot and root rot of mungbean. *Pakistan J. Plant Patho*., **2**(2): 91-96.

Mondal, M.M.A., Fakir, M.S.A. Puteh, A.B. and Malek, M.A. (2013). Deflowering effect on morpho-physiological features and yield in mungbean. *J. Food, Agric. & Env*., **11**(2): 557-562.

Mondal, M.M.A., Fakir, M.S.A., Ismail, M.R. and Ashrafuzzaman, M. (2011b). Deflowering effect on vasculature and yield attributes in raceme of mungbean. *Australian J. Crop Sci*., **5**(8): 987-992.

Mondal, M.M.A., Fakir, M.S.A., Prodhan, A.K.M.A., Ismail, M.R. and Ashrafuzzaman, M. (2011a). Effect of nodal position on rachis morphology and yield attributes in raceme of mungbean. *Australian J. Crop Sci*., **5**(11): 1339-1344.

Mondal, M.M.A., Rahman, M.A., Akter, M.B. and Fakir, M.S.A. (2011c). Effect of foliar application of nitrogen and micronutrients on growth and yield in mungbean. *Legume Res*., **34**: 166-171.

Muhammad, A., Abdul, R., Muhammad, A. and Zafar, M.I. (2006). Association among Rhizobium phaseoli strains and mungbean genotypes under rainfed conditions. *Sarhad J. Agric*., **22**(3): 453-457.

Navarrete, M. and Jeannequin, B. (2000). Effect of frequency of auxiliary bud pruning on vegetable growth and fruit yield in greenhouse tomato crops. *Scientia Hort*., **86**(3): 197-210.

Navgire, K.D., Datar, V.V., Asewar, B.V. and Dahiwal, A.L. (2001). Response of mungbean cultivars to different Rhizobium strains under rainfed conditions. *Ann. Plant Physio*., **15**(2): 134-137

Pessarakli M.M., Dris R. (2003). Effects of pruning and spacing on the yield and quality of eggplant. *J. Food Agric. Environ*., **1**(2): 215-216.

Potter, Y.K. and Hotchkiss, M.P. (1997). Nutrient content in mungbean. *Ann. Agril. Sci*., **35**(2): 23-28.

Quaderi, R.S., Islam, S.M.A., Hossain, A.F.M.G.F., Hoque, M.M. and Haque, M.S. (2006). Influence of seed treatment with indole acetic acid on mungbean cultivation. *Intl. J. Bot*., **2**(1): 42-47.

Rahman, M.S., Eunus, M. and Awal, M.A. (2005). Dry matter production and partitioning of mungbean (*Vigna radiata* I.) varieties as influenced by sowing date and planting method in summer. *Bangladesh J. Training and Dev.*, **15**(1/2): 193-199.

Raj, S. and Tripathi, K.P. (2005). Productivity and economics of mungbean (*Vigna radiata* L.) as influenced by varieties and nutrient management. *J. Arid Leg*., **2**(2): 223-226.

Riaz, A., Imran, M., Javed, K. and Bukhari, S.A.H. (2004). Growth and yield response of three mungbean (*Vigna radiata* L.) cultivars to varying seeding rates. *Intl. J. Agric. Bio*., **6**(3): 538-540.

Satish, K., Singh, R.C. and Kadian, V.S. (2003). Response of mungbean genotypes to phosphorus application. *Indian J. Pulses Res*., **16**(1): 65-66.

Shamsuzzaman, A.M.M., Alam, M.S., Mondal, G. and Ahamed, K.U. (2004). Growth and yield response of summer mungbean to irrigation frequency. *J. Agric. Rural Dev.*, **2**(1): 95-100.

Sultana, M., Ahmed, B., Rahman, M.M., Sultana, S. and Haque, M.M. (2013). Growth and seed yield of mungbean as influenced by leaf clipping and fertilizer doses. *Bangladesh Res. Pub. J*., **9**(2): 79-86.

Taj, F.H., Muhammad, A. and Kakar, K.M. (2003). Effect of seed rates on mungbean varieties under dryland conditions. *Intl. J. Agric. Biol.*, **5**(2): 160-161.

Tickoo, J.L., Naresh, C., Gangaiah, B. and Dikshit, H.K. (2006). Performance of mungbean (*Vigna radiata*) varieties at different row spacings and nitrogen-phosphorus fertilizer levels. *Indian J. Agric. Sci.*, **76**(9): 564-565.

UNDP. (1988). Land resources appraisal of Bangladesh for agricultural development report 2: Agro-ecological Regions of Bangladesh, FAO, Rome. p. 212.

Yadav, D.S., Panwar, K.S. and Singh, V.K. (1994). Management of pulse crops in sequential cropping. 27p. *In* Abstract. Proc. Intecropping Symp. on Pulses Rws. 2-6 April, 1994, New Delhi, India.

Yasari, E., Mozafari, S., Shafiee, E. and Foroutan, A. (2009). Evaluation of sink-source relationship of soybean cultivars at different dates of sowing. *Res. J. Agric. Biol. Sci*., **5**: 786-793.

APPENDICES

Appendix I. Characteristics of the soil of experimental field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the soil of experimental field

Morphological features	Characteristics
Location	Expeimental Field , SAU, Dhaka
AEZ	Madhupur 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

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI, 2012

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from March to June 2013

Month (2013)	Air temperature (^{0}C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
March	23.2	16.5	64	12
April	26.2	18.1	61	88
May	27.0	19.2	63	54
June	27.1	16.7	67	145

Source: Bangladesh Meteorological Department (Climate & weather division), Agargoan, Dhaka – 1212

Appendix III. Analysis of variance of the data on plant height, number of branches per plant and number of leaves per plant of mungbean as influenced by variety and flower removal

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm) at harvest	Number of branches per plant at harvest	Number of leaves per plant at harvest	Dry matter content in plant (%)
Replication	2	2.751	0.003	0.790	0.089
Factor A (Variety)	3	257.015**	0.793**	29.166**	2.290*
Factor B (Flower removal)	3	35.918**	1.182**	53.148**	6.442**
Interaction (A×B)	9	18.899**	0.104*	3.929*	2.043**
Error	30	6.736	0.055	1.537	0.599

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix IV. Analysis of variance of the data on yield contributing characters of mungbean as influenced by variety and flower removal

Source of variation	Degrees of freedom	Mean square			
		Days to 1st flowering	Number of Pods per plant	Number of seeds per pods	Pod length (cm)
Replication	2	5.250	0.014	0.141	0.058
Factor A (Variety)	3	62.250**	8.577**	0.776*	3.266**
Factor B (Flower removal)	3	42.306	61.842**	7.440**	2.334**
Interaction (A×B)	9	34.324*	3.945*	0.984**	2.659**
Error	30	9.139	1.404	0.207	0.374

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix V. Analysis of variance of the data on yield contributing characters and yield of mungbean as influenced by variety and flower removal

Source of variation	Degrees of freedom	Mean square			
		Weight of 1000 seeds (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
Replication	2	0.031	0.014	0.0001	0.056
Factor A (Variety)	3	3.491*	0.326**	0.152**	4.563**
Factor B (Flower removal)	3	51.217**	0.820**	3.285**	6.851**
Interaction (A×B)	9	5.811**	0.063*	0.146**	3.096**
Error	30	1.153	0.023	0.034	0.562

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance