PERFORMANCE OF FOUR MUNGBEAN CULTIVARS UNDER DIFFERENT SOWING DATE IN KHARIF II SEASON

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CERTIFICATE

This is to certify that the thesis entitled "**Performance of Four Mungbean Cultivars under Different Sowing date in Kharif-2 Season**" 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 **Shefath Jahan Sukhi**, Registration number: **09-03709** 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.

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ABSTRACT

A field experiment was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during the period from August, 2010 to February 2011to evaluate the performance of four mungbean cultivars under different sowing date on kharif II season. The experiment comprised four mungbean cultivars viz., BARI mung-3, BARI mung-4, BARI mung-5 and BINA mung-2, and four sowing dates viz., 23 August, 23 September, 23 October and 23 November. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Results showed that cultivar and sowing date significantly influenced all the parameters studied. Plant height, number of branches per plant, number of pods per plant, pod length, seed and stover yield were found highest in BINA mung-2 and lowest in BARI mung-3, while these parameters were found highest and lowest on sowing 23 October and 23 November, respectively. Sowing BINA mung-2 on 23 October and 23 November gave the highest seed yield (2.60 t/ha) and stover yield (3.42 t/ha) and the lowest seed yield (1.80 t/ha) and stover yield (1.87 t/ha), respectively. Results suggested that sowing all the four cultivars studied on 23 October is desirable for higher seed yield under AEZ 28 condition.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

The farmers of Bangladesh cultivate various types of pulse crops namely grasspea, lentil, mungbean, blackgram, chickpea, fieldpea and cowpea. Mungbean (*Vigna radiata* L.) is one of the most important pulse crops of Bangladesh (Anon., 2010). It ranks the fifth considering both acreage and production. 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, 2009). 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, 2009).

Pulse plays an important role in human nutrition and it is called poor man's meat because it is the cheapest source of protein for the poor people. It is an important food crop because it provides a cheap source of easily digestible dietary protein. According to FAO (1999), per capita requirement of pulse by human should be 80.0 g, whereas it is only about 10.0 g in Bangladesh (BBS, 2009), thus the ideal ratio of cereal to pulse (10:1) is not maintained, which is now 30:1. This is the fact that national production of the pulses is not adequate to meet the population demand. Pulses, being leguminous crops, are capable of fixing atmospheric nitrogen in the soil and enrich soil fertility. Thus they are considered as soil fertility building crops.

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, 2009). However, it is one of the less cared crop. 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). Adjustment of sowing date on mungbean variety is the important factor that greatly affects the reproductive behavior and yield attributes of this crop. A good number of high yielding mungbean varieties are available now in Bangladesh but, farmers generally grow the local varieties using almost no fertilizer and they rarely maintain the proper sowing time.

A number of agronomic practices have been found to influence the yield of pulse crops. Sowing date had a marked effect on growth and development of crops (Mittel and Srivastava, 1964). Optimum sowing date provides more time for the growth and development of plant, which is favorable for higher yield where as both early and late sowing hinder the growth and development with lowest yield potential (Gurung *et al*., 1996). Generally, mungbean are grown in kharif I season in our country but it may be easily growon in khraif II season easily before boro rice cultivation which aslo add additional benefit for the farmers of our country. But it is necessary to sowing in optimum sowing date for better growth, yield and also highest economic benefit.

Optimum times of sowing for specific cultivar are also two major limiting factors hindering the productivity of Mungbean. Therefore, experimental evidences indicate that there are enough scopes to increase the productivity of mungbean under proper management. In this study, an attempt was made to maximize the reproductive behavior and yield attributes of four mungbean varieties in different sowing time. Considering the above factors the present experiment was conducted with the following objectives:

i. To observe the yield performance of different mungbean cultivars in kharif II season,

ii. To observe the effect of sowing date on yield performance of mungbean in kharif II season, and

iii. To find out the best combination of mungbean cultivar and sowing date in kharif II season.

CHAPTER II

REVIEW OF LITERATURE

In many countries of the world including Bangladesh, mungbean is an important pulse crop. 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. Cultivar and sowing date play an important role in improving mungbean yield. But research works related to variety and sowing date are limited in Bangladesh context. However, some of the important and informative works and research findings related to the variety and sowing date so far been done at home and abroad have been reviewed in this chapter under the following headings-

2.1. Effects of cultivars

Quaderi *et al*. (2006) carried out an experiment in the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from October 2000 to February 2001 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, 2003. Both the strains in association with NM-92 had higher nodule dry weight, which was 13% greater than other strains x 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 during the period from March 2002 to June 2002 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 irrespective of seed treatment.

Mungbean cultivars Pusa 105 and Pusa Vishal were sown at 22.5 and 30 cm spacing and supplied with 36-46 N and 58-46 kg P per hectare in a field experiment conducted in Delhi, India during the kharif season of 2000 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 irrespective of NP doses.

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) conducted an experiment with mungbean in Jamalpur, Bangladesh, from February to June 1999, 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; and 5 sowing dates. 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) from 2000 to 2003 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 (0 and 20 kg/ha) and phosphorus levels (0, 20 and 40 kg ha^{-1}) 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) of 2001, in Mymensingh, Bangladesh, under no irrigation and 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, during the summer season of 2002 to study the effect of sowing dates on the agronomic traits and yield of two mungbean cultivars namely, 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 of 2003 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.

The effect of sowing rates on the growth and yield of mungbean cultivars NM-92, NARC mung-1 and NM-98 was investigated in Faisalabad, Pakistan during 2002-03 by Riaz *et al*. (2004). NM-98 produced the maximum pod number of 17.30, 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%.

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 on 15 June 2001 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 of 1998. 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 in 1999 and 2000 to investigate the response of mungbean 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, during May-July 1997. 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 of 1993-94 and 1995-96. 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. Effect of sowing time

Inderjit *et al*. (2005) conducted a field experiment on sandy-loam soil of Gurdaspur, Punjab, India, during the 1998-2000 winter season (rabi) to study the effect of different sowing dates, row spacings and seed rates on the productivity of lentil (*Lens culinaris* cv. LG 308) and reported significant effect for emergence of seedling for different sowing date. Turk *et al*. (2003) reported significant effect regarding seedling emergence for different sowing time. The sowing time and rate optimum for the growth and yield of the large-seeded lentil cv. Diskiai and the small-seeded cv. Smelinukai were investigated by Kazemekas (2001) on a light loamy soil in Lithuania from 1998 to 2000 and reported that sowing time significantly influenced seedling germination. Gurung *et al*. (1996) carried out a field experiment in 1991-94 at Dhankuta, Nepal to determine the appropriate sowing date for lentils and reported that October sowings were associated with early good crop vigour with highest percentage of seedling germination.

Sowing date effects on plant height of pulse crop were reported by the different researchers. Hanlan *et al*. (2006) reported that sowing date influenced overall plant height. Hossain *et al*. (2006) reported that lentil sown in November received less aphid infestation with tallest plant. Turk *et al*. (2003) reported tallest plant for early sowing (1 January). Allam (2002) reported that sowing on 1 November gave taller plants. The sowing time and rate optimum for the growth and yield of the large-seeded lentil were investigated by Kazemekas (2001) and found that the earliest sowing date were optimum for plant height. Andrews *et al*. (2001) reported that maximum plant height was closely positively related to monthly mean values for mean daily air temperature. Gurung *et al*. (1996) observed that longest plant from October sowings were associated with early good crop vigour which was mainly due to warmer air temperatures during the early vegetative growth. Bukhtiar *et al*. (1991) reported that the last week of October proved the better sowing date at which AARIL344 produced the tallest plant and the last week of October was found better with an optimum range from the end of September to 2nd week of November.

Number of branches per plant of pulse crop varied significantly for different sowing time. Hanlan *et al*. (2006) observed that highest canopy traits such as rapid growth, light interception. Lal *et al*. (2006) also reported similar observation. Turk *et al*. (2003) recorded high yields were obtained for early sowing (1 January), high plant density (120 plants m^{-2}) for highest number of branches per plant. Al-Hussien *et al*. (2002) reported that different sowing dates (early and late) significantly affect number of branches per plant of lentil. Allam (2002) found under various sowing dates (1 November, 15 November, and 1 December) that the sowing on 1 November gave taller plants with higher number of branches. Siddique *et al*. (1998) observed sowing in late April or early May allowed a longer period for vegetative and reproductive growth, rapid canopy development, more water use, and, hence, greater vegetative growth and number of branches. Gurung *et al*. (1996) reported reduced number of branches per plant from November and December sowings were mainly due to the adverse effect of low air temperatures at the early vegetative growth period and shorter total crop growth period. Mishra *et al*. (1996) also reported similar findings. Brand *et al*. (2003) reported that the optimum sowing dates for all cultivars in 2000 were mid June to early July and in 2001 mid May to mid June. Rahman and Sarker (1997) reported that high-yielding cultivars also had more leaves and petioles at both vegetative and reproductive phases, and number of branches per plant. Bukhtiar *et al*. (1991) reported that the last week of October was found better with an optimum range from the end of September to 2nd week of November.

Kazemekas (2001) reported dry matter content increased in the earliest sowing date were optimum for the growth and yield of both lentil cultivars. Andrews *et al*. (2001) in Canterbury, New Zealand were used to assess the potential of lentil and found 1 October sowing get maximum total dry matter. Siddique *et al*. (1998) reported that sowing in late April or early May allowed a longer period for vegetative and reproductive growth, rapid canopy development, more water use, and, hence, greater dry matter production. Early-sown lentils began flowering and filling seeds earlier in the growing season, at a time when vapour pressure deficits and air temperatures were lower. The values of water use efficiency for dry matter production, and transpiration efficiency, for early-sown lentil were comparable to those reported for cereal and other grain legume crops in similar environments.

Inderjit *et al*. (2005) reported that mungbean sown on 10 November produced flowering and attain maturity the crop sown on 25 November and 10 December by a margin of 8.85 and 11.5%, respectively. Kazemekas (2001) found that the earliest sowing date were optimum for the optimum flowering and maturity. Andrews *et al*. (2001) in Canterbury, New Zealand carried out an experiment to assess the potential of mungbean as a grain legume crop in the UK. The model was validated using five sowing dates (21 April, 28 April, 5 May, 12 May and 26 May) at Durham, UK, in 1999. Predicted time to flowering was within 7 days of actual time to flowering and predicted seed yields were within 9% of actual yields. Time to flowering generally decreased along the transect from North West to South East UK ranging from 28 June to 9 July and from 20 May to 14 June with the May and October sowings, respectively. Siddique *et al*. (1998) reported that sowing in late September or early October allowed a longer period for vegetative and reproductive growth. Early-sown lentils began flowering earlier in the growing season, at a time when vapour pressure deficits and air temperatures were lower, and used more water in the post-flowering period when compared with those treatments where sowing was delayed. El-Nagar and Galal (1997) in 1993-95 at Assiut, Egypt, lentils were sown 1 or 15 November, or 1 December and were harvested at physiological maturity or one or two weeks later and reported that delaying harvesting by one or two weeks after physiological maturity decreased seed yield by 19.7% and 33.6%, respectively.

Brand *et al*. (2003) found that the optimum sowing dates for mungbean cultivars in 2000 were mid June to early July and in 2001 mid May to mid June. Turk *et al*. (2003) reported that early sowing (1 January) ensured high plant density (120 plants m^{-2}). The performance of lentil cv. Giza 9 were investigated by Allam (2002) under various sowing dates (1 November, 15 November, and 1 December and reported that sowing on 1 November gave higher number of pods per plant, number of seeds per pod and seed yield per plant. Harvest index was higher when sowing was conducted on 1 and 15 November. Rahman and Sarker (1997) reported that higher seed yields were achieved through the contribution of more pods per plant and bigger seeds. Gurung *et al*. (1996) reported that warmer air temperatures during vegetative growth period and longer total growth period, seed yield from September sowing was low. This was mainly due to excess rainfall during early vegetative growth stage which had adverse effects on crop establishment. Bukhtiar *et al*. (1991) observed that the higher harvest index (HI) of 42.3% in AARIL344 and 41.4% in AARIL337 was obtained from 23 November sowing. The lower HI (25.1%) was recorded in AARIL355 sown on 26 September. The last week of October was found better with an optimum range from the end of September to 2nd week of November.

Lal *et al*. (2006) found maximum disease intensity (51%) which was recorded from 15 October-sown crop, while maximum grain yield (730 kg/ha) was obtained in crop sown on 5 November. Hossain *et al*. (2006) reported that lentil aphid appeared in the field in the first week of January. The crop sown in November received less aphid infestation and consequently produced higher yield than the crop sown in December. Inderjit *et al*. (2005) found that lentil sown on 10 November (14.6 q/ha) out yielded the crop sown on 25 November and 10 December by a margin of 12.8 and 90.1%, respectively. Significantly higher mean seed yield was obtained in lentil sown on 10 November at 20 cm row spacing (15.7 q/ha) and that sown on 10 November using 37.5 kg seed/ha (15.9 q/ha). Brand *et al*. (2003) reported that the optimum sowing dates for all cultivars in 2000 were mid June to early July and in 2001 mid May to mid June. The effects of sowing date (1 January, 15 January and 2 February), plant density phosphorus level and ethephon application were investigated in the semiarid region in the north of Jordan by Turk *et al*. (2003) and observed that high yields were obtained for early sowing (1 January). Field experiments were conducted by Ahmed *et al*. (2002) found that the control options were sowing dates (mid-November, mid-December and mid-January), host plant resistance (cultivars ILL 5883 (highly resistant), ILL 5722 (moderately resistant) and ILL 2130 (highly susceptible) and fungicide seed treatment.

Al-Hussien *et al*. (2002) reported that delaying the sowing date and applying imazapic and imazethapyr resulted in the most promising results, recording 97-98% weed control in Idleb and Tel Hadya and producing 221 and 40% more seed yield in Idleb and Tel Hadya, respectively. Muhammad *et al*. (2002) reported sowing in November significantly enhanced seed yield by 113.2% in 1993-94 and 102.1% in 1994-95 compared to sowing in December. This positive response to early sowing, higher density or fully irrigated crop was the direct consequence of improvement in all the yield components. The sowing time and rate optimum for the growth and yield of the large-seeded lentil were investigated by Kazemekas (2001) and found that based on the different parameters evaluated, i.e. seed yield, the earliest sowing date were optimum for the growth and yield of both lentil cultivars.

Andrews *et al*. (2001) predicted time to flowering was within 7 days of actual time i.e. 15 September to flowering and predicted seed yields were within 9% of actual yields and actual yields ranged from 1.40 to 1.65 t ha^{-1}. El-Nagar and Galal (1997) reported that delaying sowing decreased seed yield. Rahman and Sarker (1997) reported the highest (1.85 t/ha) and the lowest (0.75 t/ha) seed yields were obtained from cultivars ILX 87052 and Utfala, respectively. Higher seed yields were achieved through the contribution of higher total dry matter, more pods per plant and bigger seeds. Gurung *et al*. (1996) found that average seed yields of crops sown on 10 and 25 October were 1274 and 1591 kg/ha, respectively, which were significantly higher than other sowing dates. Seed yield was greatly reduced if sowing was advanced from 10 October to 25 September (533 kg/ha) or delayed from 25 October to 9 November (597 kg/ha). The straw yields of lentil were also higher from October sowings. Mishra *et al*. (1996) reported that seed yield decreased with delay in sowing date after 23 October and the weed-free control gave the highest seed yield. Sekhon *et al*. (1994) reported that sowing rates had no significant effect on seed yields and seed yields ranged from 1.04 t at the lowest rate to 1.20 t at 60 kg seed/ha. Bukhtiar *et al*. (1991) found that the last week of October proved the better sowing date at which AARIL344 produced the highest yield of 1686 kg/ha followed by 9-6 and AARIL496 (1649 and 1625 kg/ha, respectively). With sowing in the 2nd week of November AARIL496 yielded better (1446 kg/ha) followed by 9-6 and AARIL344 (1427 and 1365 kg/ha, respectively). The overall mean seed yield for cultivars was higher (1236.5 kg/ha) in 9-6 followed by AARIL496 (1225.4 kg/ha) and AARIL344 (1222.4 kg/ha). The lowest mean yield (493.2 kg/ha) was recorded in AARIL355.

From the above reviewed literature it was revealed that there is a scope of research works related to variety and sowing date in our environmental condition and crop pattern.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University during the period from August, 2010 to February 2011 to study the performance of four mungbean cultivars under different sowing date in kharif II season. This chapter includes materials and methods that were used in conducting the experiment. The details materials and methods of this 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. 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 monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Meteorological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from the Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar and presented in Appendix II.

3.4. Planting material

The variety BARI mung-3, BARI mung-4, BARI mung-5 and BINA mung-2 was used as the test crops. The seeds were collected from the Pulses Research Centre of Bangladesh Agricultural Research Institute, Joydevpur, Gajipur and Bangladesh Institute of Nuclear Agriculture, Mymnsingh. BARI mung-3, BARI mung-4, BARI mung-5 and BINA mung-2 were the released varieties of mungbean, which was recommended by the national seed board.

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 stubbles and weeds were removed. The first ploughing and the final land preparation were done on 12 and 20 August 2010, respectively. Experimental land was divided into unit plots following the design of experiment.

3.6. Fertilizer application

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous, and potassium respectively. Manures and fertilizers that were applied to the experimental plot presented in Table 1. The total amount of cowdung, TSP and MP was applied as basal dose at the time of land preparation. The total amount of Urea was applied in two installments at 15 and 30 day after seed sowing.

Table 1. Dose and method of application of fertilizers in mungbean field (Afzal *et al*., 1998)

Fertilizers and Manures	Dose/ha (Basal)
Urea	45 kg
TSP	100 kg
MP	58 kg

3.7. Treatment

The experiment was consisted of two factors:

Factor A: Varity (4 levels)

V_1: BARI mung-3

V_2: BARI mung-4

V_3: BARI mung-5

V_4: BINA mung-2

Factor B: Sowing date (4 levels)

S_1: Sowing on 23 August

S_2: Sowing on 23 September

S_3: Sowing on 23 October

S_4: Sowing on 23 November

There were on the whole 16 treatment combinations for the experiment, which were V_1S_1, V_1S_2, V_1S_3, V_1S_4, V_2S_1, V_2S_2, V_2S_3, V_2S_4, V_3S_1, V_3S_2, V_3S_3, V_3S_4, V_4S_1, V_4S_2, V_4S_3 and V_4S_4.

3.8. Experimental design and layout

The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experimental area was divided into three equal blocks. Each block was divided into 16 plots, where 16 treatment combinations were allocated at random. There were 48 unit plots altogether in the experiment. The size of the each unit plot was 2.0 m × 1.5 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.

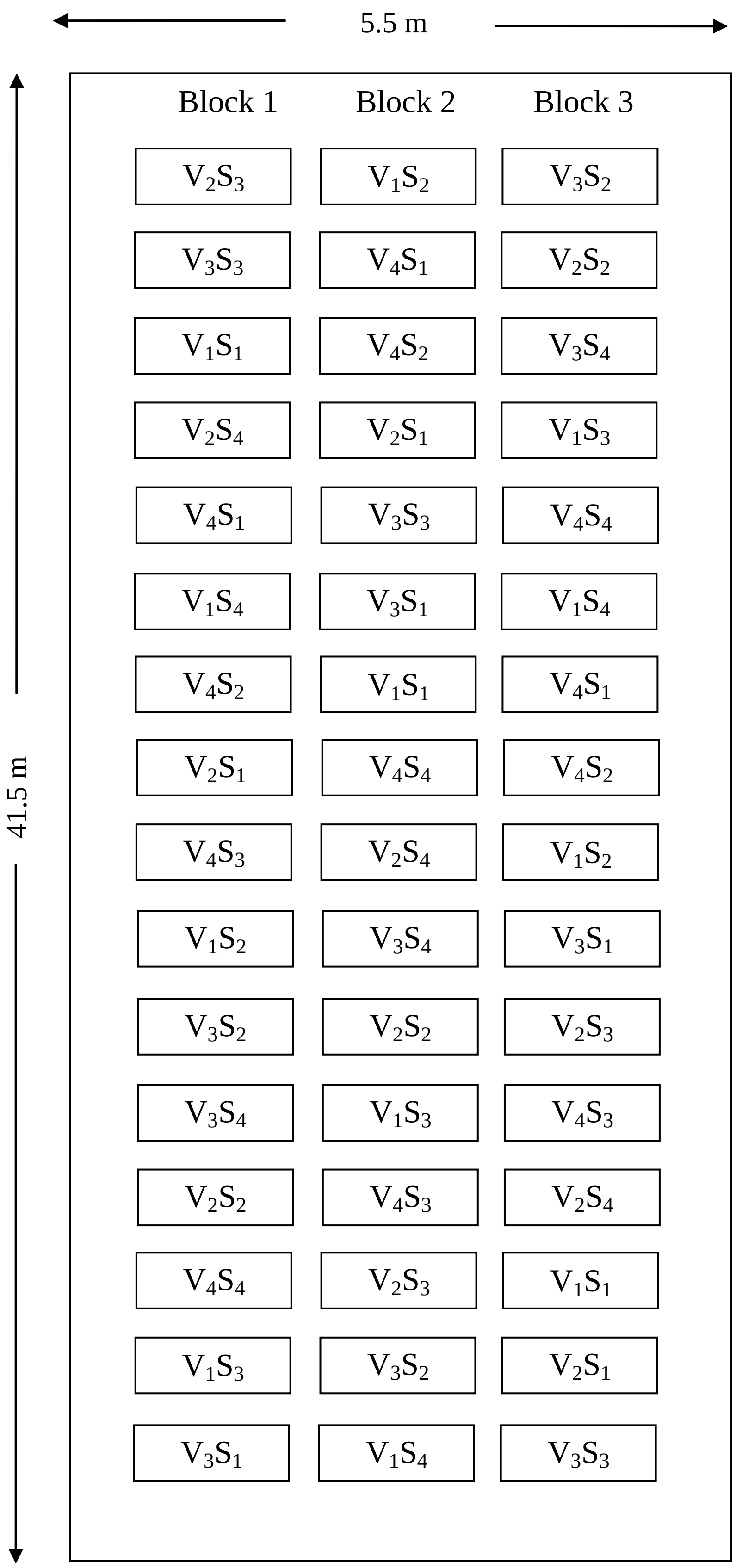
3.9. Sowing of seeds in the field

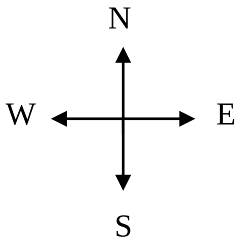
The seeds of mungbean were sown as per the sowing date of treatment i.e. August 23, September, 23, October, 23 and November 23 2010. Seeds were treated with Bavistin before sowing the seeds to control the seed borne disease. The seeds were sown in the furrows having a depth of 3 cm maintaining line to line distance 30 cm and plant to plant distance 8 cm.

3.10. Intercultural operations

3.10.1. Thinning

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





Plot size = 2.0 m ×1.5 m

Plot to plot: 0.5 m

Replication to replication: 1.0 m

Factor A:

V_1: BARI mung-3

V_2: BARI mung-4

V_3: BARI mung-5

V_4: BINA mung-2

Factor B:

S_1: Sowing on 23 August

S_2: Sowing on 23 September

S_3: Sowing on 23 October

S_4: Sowing on 23 November

Figure 1. Field layout of two factorial experiment in the Randomized Complete Block Design (RCBD)

3.10.2. Irrigation and weeding

The crop was cultivated under residual soil moisture condition without irrigation. The crop field was weeded twice at 20 and 35 DAS.

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 50 EC was sprayed for 2 times at the rate of 1 litre/ha to control the insects.

3.11. Plant sampling and data collection

Ten plants from each treatment were randomly selected and marked with sample card. Plant height, branches per plant were recorded from selected plants at an interval of 10 days started from 20 DAS to 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 pre demarcated area at the center of each plot.

3.13. Data collection

The following data were recorded

i. Days to seedling emergence

ii. Plant height (cm)

iii. Branches per plant (no.)

iv. Total dry matter content per plant (%)

v. Days to 1st flowering

vi. Days to 80% pod maturity

vii. Pods per plant (no.)

viii. Pod length (cm)

ix. Weight of 1000 seeds (g)

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

xi. Stover yield (t ha^{-1})

3.14. Procedure of data collection

3.14.1. Days to seedling emergence

Days to seedling emergence were measured by counting the number of days required to start seed germination.

3.14.2. Plant height

The heights of plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in centimeter. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot starting from 20 to 60 DAS at 10 days interval and at harvest.

3.14.3. Branches per plant

The branches were counted from selected plants starting from 20 DAS to 60 DAS at 10 days interval and at harvest. The total average number of branches per plant were counted.

3.14.4. Total dry matter

Plant samples were collected from each plot at 10 days interval from 20 DAS to 60 DAS and their fresh weight were taken. Plants including roots, stem (with pods) and leaves was oven dried at 70^0C for 72 hours than transferred into desiccators and allowed to cool down to the room temperature and final weight 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 measured by counting the number of days required to start flower initiation in each plot.

3.14.6. Days to 80% pod maturity

Days to 80% pod maturity were measured by counting the number of days required to attain 80% pods of third flash of mungbean plants blackish in color.

3.14.7. Pods per plant

Number of total pods of selected plants from each plot was counted and the mean number was expressed on per plant basis. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.14.8. Pod length

Pod length of ten randomly selected pods from each selected ten plants was counted and the mean length was expressed on per pod basis.

3.14.9. Weight of 1000-seed

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

3.14.10. Seed yield per hectare

The seeds collected from 3.0 m^2 of each plot were sun dried properly. The weight of seeds was taken and converted the yield into t/ha.

3.14.11. Stover yield per hectare

The stover collected from 3.0 m^2 of each plot was sun dried properly. The weight of stover was taken and converted the yield into t/ha.

3.15. Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different mungbean variety and sowing date on yield and yield contributing characters of mungbean. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to determine the effect of different cultivar and sowing date on growth and yield of mungbean. Data on different yield contributing characters and yield were recorded to find out the suitable cultivar and optimum sowing date for mungbean cultivation. The analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendix III-VI. The results have been presented and discussed, and possible interpretations given under the following headings:

4.1. Days to 1st emergence of seedling

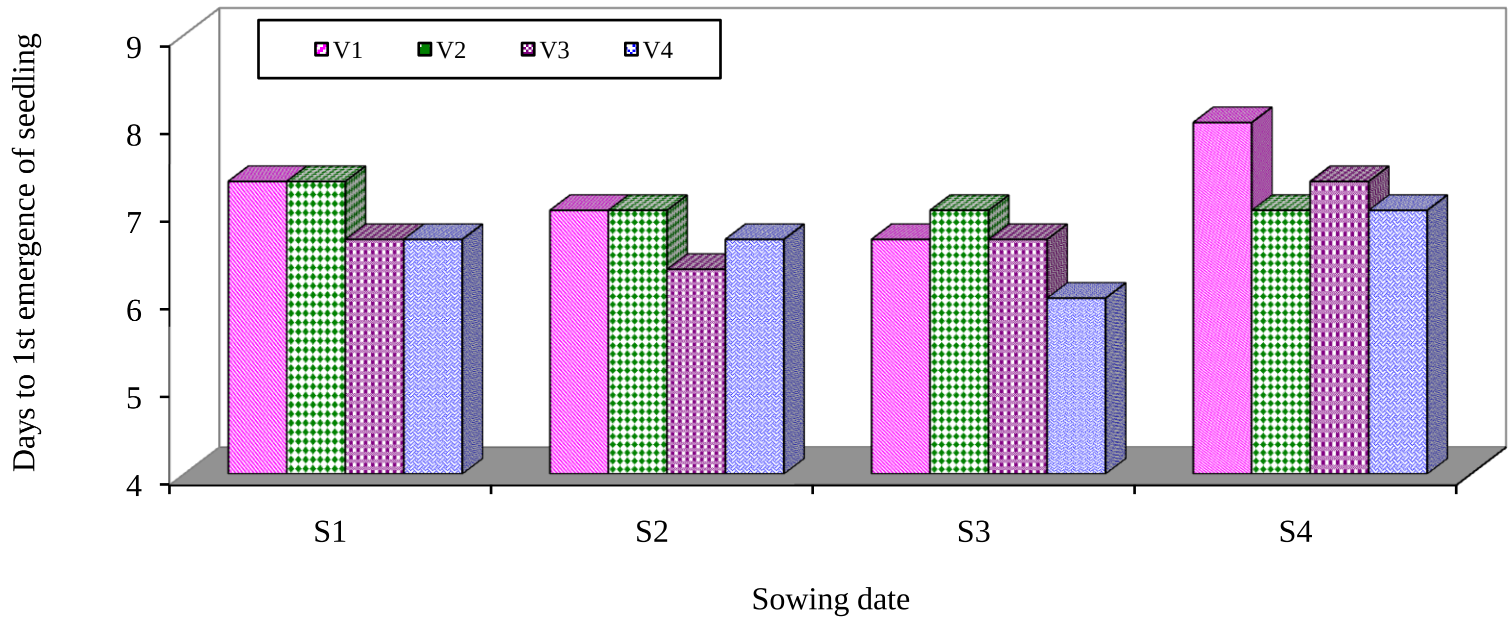
A statistically significant variation was recorded for days to 1st emergence of mungbean seedlings due to different cultivar (Appendix III). Days to emergence of seedling varied from 5.65 t0 7.72 days. The minimum days required for 1st emergence of seedling (5.65 days) was recorded from V_1 (BARI mung-3) which was closely followed (6.41 days) by V_2 (BARI mung-4), while the maximum days to 1st emergence of seedling (7.72 days) was found from V_4 (BINA mung-2), which was statistically identical (7.62 days) with V_3 (BARI mung-5) (Figure 2). Seedling emergence varied for different cultivar due to genetical and environmental influences as well as management practices. Ezzat *et al*. (2005) reported in their earlier study that different variety take different times for seedling emergence.

Days to 1st emergence of seedling of mungbean varied significantly due to different sowing date (Appendix III). The minimum days required for 1st emergence of seedling (5.73 days) was found from S_1 (Sowing on 23 August) while, the maximum days to 1st emergence of seedling (7.47 days) was recorded from S_4 (Sowing on 23 November) which was statistically identical (7.18 days) with S_3 (Sowing on 23 October) and closely followed (7.02 days) by S_2 (Sowing on 23 September) (Figure 3).

Interaction effect of cultivar and sowing date showed statistically significant differences for days to 1st emergence of mungbean seedling (Appendix III). The minimum days to 1st emergence of seedling (6 days) was observed from V_4S_3 (BINA mung-2 and Sowing on 23 October) and the maximum (8.00 days) was recorded from V_1S_4 (BARI mung-3 and Sowing on 23 November) (Figure 4).

4.2. Plant height

Significant variation was recorded for plant height of mungbean for different cultivars at 20, 30, 40, 50, 60 DAS and harvest (Appendix III). The tallest plant (10.84 cm, 22.66 cm, 33.49 cm, 39.47 cm, 41.32 cm and 39.49 cm) were found in V_4 (BINA mung-2) at all the stage studied, which were statistically similar (10.32 cm, 21.92 cm, 32.12 cm, 39.44 cm, 40.92 cm and 38.32 cm) with V_3 (BARI mung-5), while the shortest plant (9.63 cm, 21.36 cm, 31.53 cm, 37.40 cm, 39.03 cm and 37.21 cm) in V_1 (BARI mung-3) at 20, 30, 40, 50, 60 DAS and harvest, respectively, which was followed (9.96 cm, 21.79 cm, 31.91 cm, 38.00 cm, 39.76 cm and 38.67 cm) by V_2 (BARI mung-4) for same DAS (Figure 5). Hanlan *et al*. (2006) reported 0.3 to 0.44 m plant height for different cultivars of mungbean.



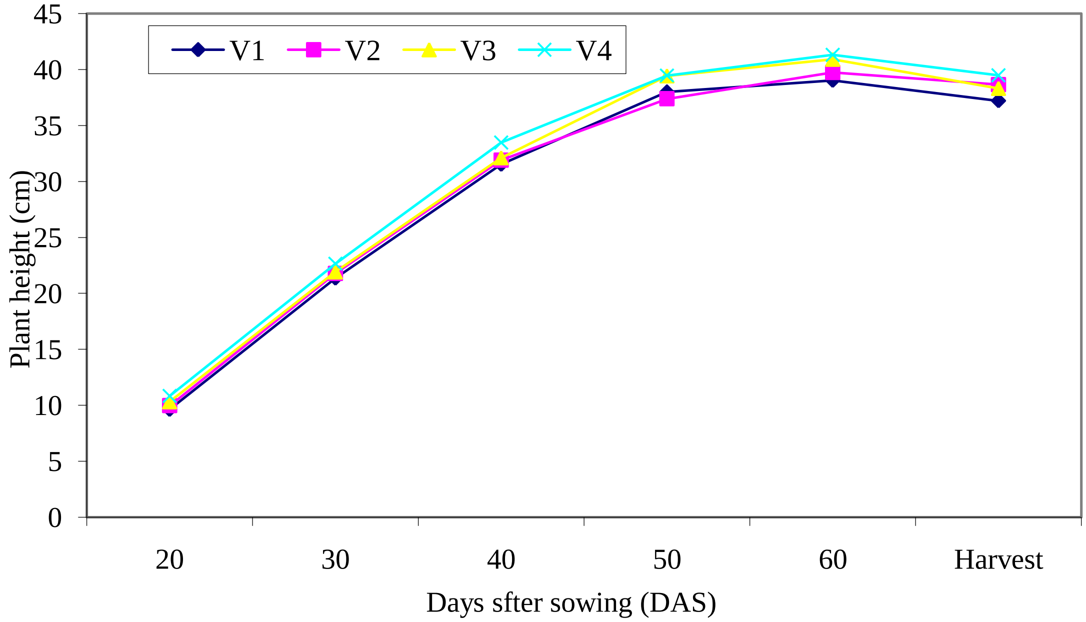
V_1: BARI mung-3 V_2: BARI mung-4 S_1: Sowing on 23, August S_2: Sowing on 23, September

V_3: BARI mung-5 V_4: BINA mung-2 S_3: Sowing on 23, October S_4: Sowing on 23, November

Figure 4. Interaction effect of cultivar and sowing date on days to 1st emergence of seedling of mungbean [LSD(0.05) = 1.143].

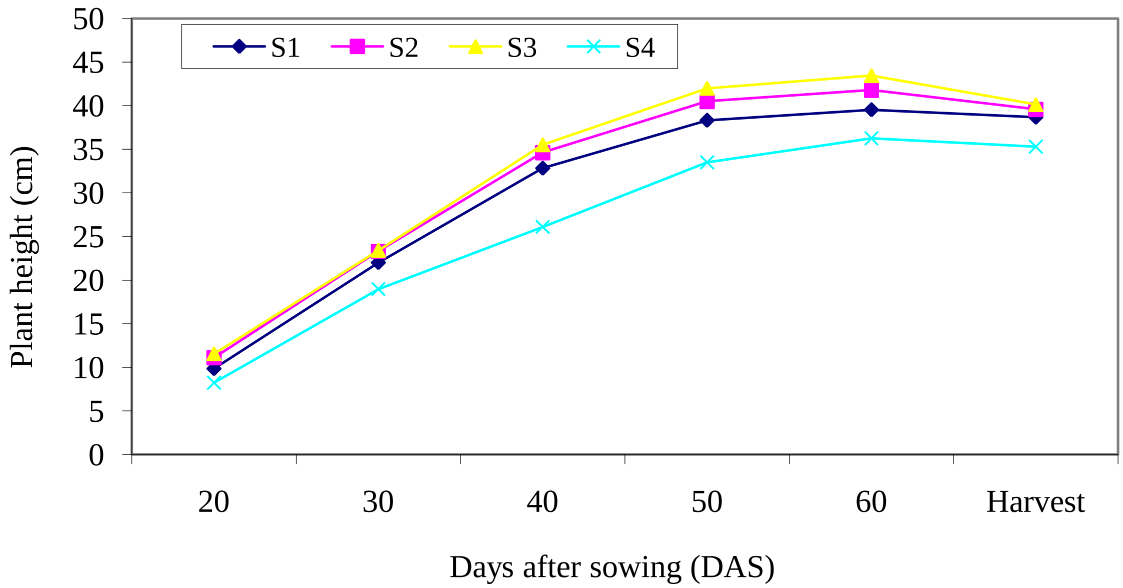
Plant height of mungbean at 20, 30, 40, 50, 60 DAS and harvest varied significantly due to sowing date (Appendix III). At 20, 30, 40, 50, 60 DAS and harvest the tallest plant (11.56 cm, 23.43 cm, 35.52 cm, 42.00 cm, 43.45cm and 40.13 cm) was recorded in S_3 (Sowing on 23 October), which was statistically identical (11.09 cm, 23.30 cm, 34.61 cm, 40.48 cm, 41.78 cm and 39.57 cm) with S_2 (Sowing on 23 September) and closely followed (9.85 cm, 22.01 cm, 32.83 cm, 38.32 cm, 39.53 cm and 38.67 cm) by S_1 (Sowing on 23 August) and the shortest plant (8.25 cm, 18.99 cm, 26.11 cm, 33.51 cm, 36.27 cm and 35.32 cm) was obtained from S_4 (Sowing on 23 November), respectively for same days after sowing (Figure 6). Allam (2002) reported that mungbean sowing on 1 November gave taller plants than sowing on 15 November and 01 December.

Statistically significant differences were recorded due to the interaction effect of cultivar and sowing date for plant height at 20, 30, 40, 50, 60 DAS and harvest (Appendix III). The tallest plant (13.32 cm, 25.66 cm, 38.71 cm, 45.20 cm, 46.80 cm and 42.60 cm) was recorded from V_4S_3 (BINA mung-2 and Sowing on 23 October) and the shortest plant (6.79 cm, 17.16 cm, 23.38 cm, 28.83 cm, 33.13 cm and 33.38 cm) was recorded from V_4S_4 (BINA mung-2 and Sowing on 23 November) (Table 2).



V_1: BARI mung-3 V_2: BARI mung-4
V_3: BARI mung-5 V_4: BINA mung-2

Figure 5. Effect of cultivar on plant height of mungbean [LSD (0.05) = 0.838, 0.895, 1.440, 1.686, 1.510 and 1.507 for 20, 30, 40, 50, 60 DAS and harvest, respectively]



S_1: Sowing on 23, August S_2: Sowing on 23, September
S_3: Sowing on 23, October S_4: Sowing on 23, November

Table 2. Interaction effect of cultivar and sowing date on plant height of mungbean

Treatment	Plant height (cm) at					
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
V_1S_1	9.31 ef	21.59 de	32.35 cd	38.00 c-e	38.57 c-f	37.82 cd
V_1S_2	9.91 d-f	22.41 c-e	33.33 cd	38.89 cd	39.24 c-f	38.04 b-d
V_1S_3	11.01 b-e	23.08 b-d	34.97 bc	40.86 bc	41.91 bc	39.38 a-d
V_1S_4	8.27 fg	18.36 gh	25.48 gh	34.25 f	36.39 ef	33.60 e
V_2S_1	9.30 ef	21.22 d-f	30.63 de	34.56 ef	38.17 d-f	38.12 b-d
V_2S_2	11.83 a-c	24.07 a-c	34.10 bc	39.36 b-d	43.39 b	40.27 a-d
V_2S_3	10.49 b-e	22.27 c-e	33.96 bc	40.63 bc	41.41 b-d	38.82 b-d
V_2S_4	8.23 fg	19.59 fg	28.96 ef	35.07 ef	36.07 fg	37.49 cd
V_3S_1	9.88 d-f	21.92 de	33.46 cd	40.05 bc	39.93 cd	38.15 b-d
V_3S_2	10.27 c-e	22.20 c-e	34.00 bc	40.47 bc	40.59 b-d	38.60 b-d
V_3S_3	11.42 b-d	22.73 b-e	34.42 bc	41.32 bc	43.70 ab	39.71 a-d
V_3S_4	9.70 d-f	20.83 ef	26.61 fg	35.91 d-f	39.48 c-e	36.82 d
V_4S_1	10.91 b-e	23.30 b-d	34.89 bc	40.67 bc	41.47 b-d	40.60 a-c
V_4S_2	12.36 ab	24.51 ab	37.00 ab	43.19 ab	43.89 ab	41.38 ab
V_4S_3	13.32 a	25.66 a	38.71 a	45.20 a	46.80 a	42.60 a
V_4S_4	6.79 g	17.16 h	23.38 h	28.83 g	33.13 g	33.38 e
$LSD_{(0.05)}$	1.675	1.791	2.881	3.373	3.019	3.015
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	9.86	6.90	5.35	8.24	6.50	9.71

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

V_1: BARI mung-3 — S_1: Sowing on 23 August

V_2: BARI mung-4 — S_2: Sowing on 23 September

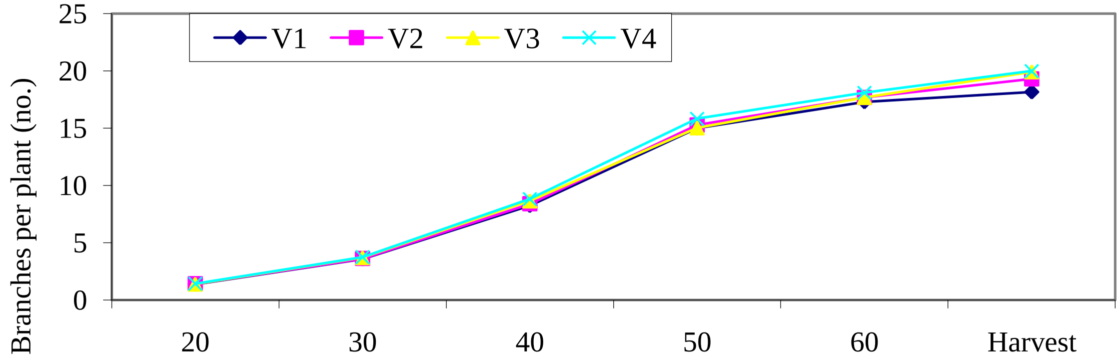
V_3: BARI mung-5 — S_3: Sowing on 23 October

V_4: BINA mung-2 — S_4: Sowing on 23 November

4.3. Branches per plant (no.)

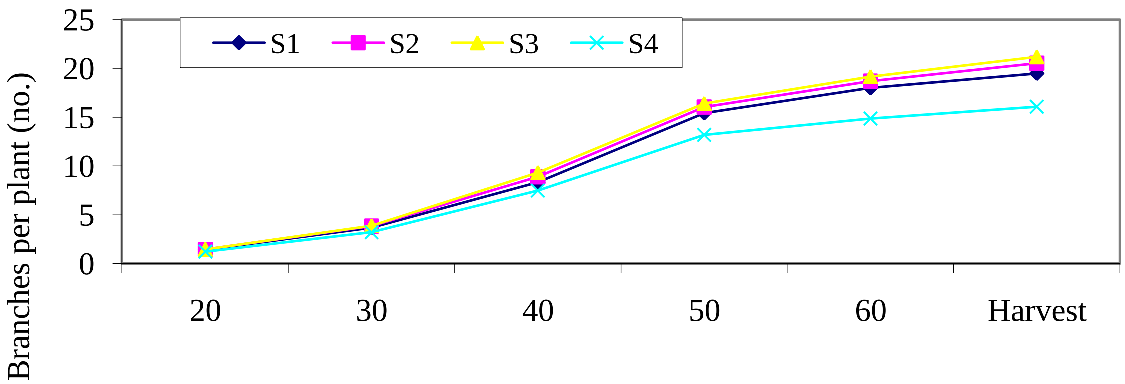
Number of branches per mungbean plant varied significantly due to cultivar at 20, 30, 40, 50, 60 DAS and harvest (Appendix IV). The highest number of branches per plant (1.42, 3.74, 8.81, 15.82, 18.09 and 19.98) was obtained from V_4 (BINA mung-2), which was statistically similar (1.40, 3.70, 8.65, 15.27, 17.68 and 19.92) with V_3 (BARI mung-5), while the lowest number of branches per plant (1.35, 3.57, 8.24, 14.99, 17.30 and 18.16) was found in V_1 (BARI mung-3) at 20, 30, 40, 50, 60 DAS and harvest, respectively which was followed (1.39, 3.62, 8.39, 15.03, 17.68 and 19.30) by V_2 (BARI mung-4) for same days after sowing (Figure 7).

Statistically significant variation was recorded for number of branches per plant of mungbean at 20, 30, 40, 50, 60 DAS and harvest due to different sowing date (Appendix IV). At 20, 30, 40, 50, 60 DAS and harvest the highest number of branches per plant (1.47, 3.89, 9.33, 16.41, 19.17 and 21.21) was found from S_3 (Sowing on 23 October), which was statistically identical (1.44, 3.83, 8.90, 16.04, 18.70 and 20.54) to S_2 (Sowing on 23 September) and closely followed (1.42, 3.69, 8.35, 15.45, 18.02 and 19.51) by S_1 (Sowing on 23 August) and the lowest number of branches per plant (1.23, 3.22, 7.51, 13.21, 14.87 and 16.10) was obtained from S_4 (Sowing on 23 November), respectively for same days after sowing (Figure 8). Allam (2002) reported that mungbean sowing on 1 November gave higher number of branches than that sowing on 15 November and 1 December.



V_1: BARI mung-3 V_2: BARI mung-4
V_3: BARI mung-5 V_4: BINA mung-2

Figure 7. Effect of cultivar on number of branches per plant of mungbean [LSD (0.05) = 0.046, 0.121, 0.379, 0.537, 0.526 and 0.988 for 20, 30, 40, 50, 60 DAS and harvest, respectively]



S_1: Sowing on 23, August S_2: Sowing on 23, September
S_3: Sowing on 23, October S_4: Sowing on 23, November

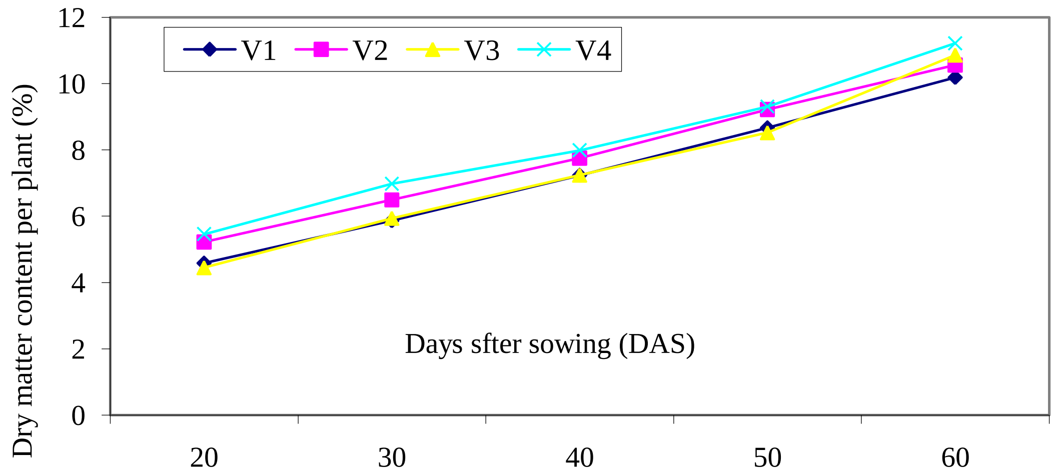
Figure 8. Effect of sowing date on number of branches per plant of mungbean [LSD (0.05) = 0.046, 0.121, 0.379, 0.537,

Cultivar and sowing date showed significant interaction effect for number of branches per plant at 20, 30, 40, 50, 60 DAS and harvest (Appendix IV). The highest number of branches per plant (1.53, 4.03, 10.20, 17.93, 20.50 and 22.57) was recorded from V_4S_3 (BINA mung-2 and Sowing on 23 October) and the lowest number (1.17, 3.10, 6.73, 11.73, 13.03 and 14.90) was found from V_4S_4 (BINA mung-2 and Sowing on 23 November) (Table 3). It was also found that sowing on 23 August to 23 September all the varieties showed statistically identical results but sowing on 23 November showed significantly lowest results.

4.4. Total dry matter content in plant

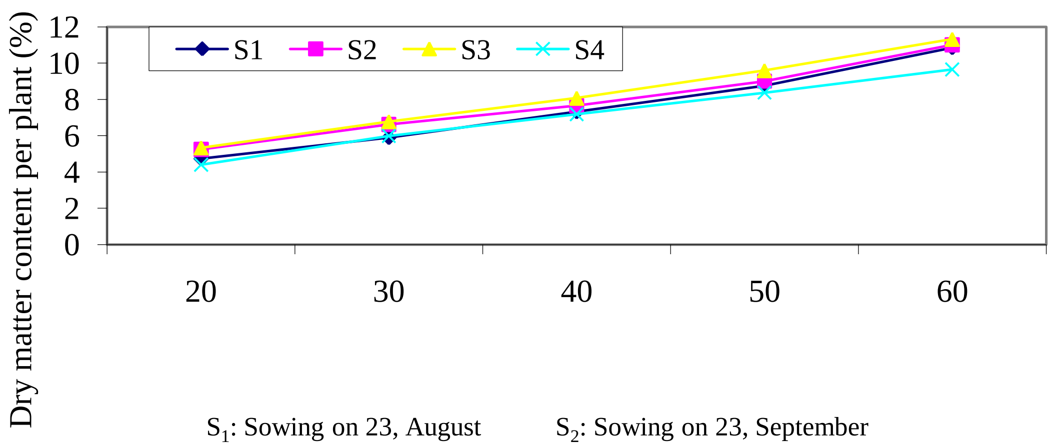
Significant differences was recorded for dry matter content in plant of mungbean due to different cultivar at 20, 30, 40, 50 and 60 DAS (Appendix V). The highest dry matter content in plant (5.46%, 6.98%, 7.99%, 9.31% and 11.22%) was found in V_4 (BINA mung-2), which was statistically similar (5.22%, 6.49%, 7.75%, 9.22% and 10.86%) with V_2 (BARI mung-4), while the lowest dry matter content in plant (4.45%, 5.94%, 7.23%, 8.52% and 10.19%) was found in V_3 (BARI mung-5) at 20, 30, 40, 50 and 60 DAS, respectively and were followed (4.59%, 5.87%, 7.24%, 8.67% and 10.56) by V_1 (BARI mung-3) for same DAS (Figure 9).

Dry matter content in plant of mungbean varied significantly for different sowing date at 20, 30, 40, 50, 60 DAS and harvest (Appendix V). At 20, 30, 40, 50 and 60 DAS the highest dry matter content in plant (5.33%, 6.77%, 8.07%, 9.59% and 11.32%) was obtained in S_3 (Sowing on 23 October) which was identical (5.25%, 6.63%, 7.66%, 9.01% and 11.01%) to S_2 (Sowing on 23 September) and



V_1: BARI mung-3 V_2: BARI mung-4
V_3: BARI mung-5 V_4: BINA mung-2

Figure 9. Effect of cultivar on dry matter content per plant of mungbean [Lsd (0.05) = 0.838, 0.895, 1.440, 1.686, 1.510 and 1.507 for 20, 30, 40, 50, 60 DAS and harvest, respectively]



S_1: Sowing on 23, August S_2: Sowing on 23, September
S_3: Sowing on 23, October S_4: Sowing on 23, November

Figure 10. Effect of sowing date on dry matter content per plant (%) of mungbean [Lsd (0.05) = 0.838, 0.895, 1.440, 1.686, 1.510 and 1.507 for 20, 30, 40, 50, 60 DAS

Table 3. Interaction effect of cultivar and sowing date on number of branches per plant of mungbean

Treatment	Branches plant^{-1} (No.) at					
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
V_1S_1	1.40 bc	3.70 cd	8.17 d-f	15.40 c-f	17.90 cd	18.90 d-f
V_1S_2	1.40 bc	3.67 cd	8.30 d-f	15.57 c-f	18.03 c	18.57 d-f
V_1S_3	1.43 a-c	3.77 a-d	8.93 b-d	16.43 b-d	18.73 bc	19.47 c-f
V_1S_4	1.17 e	3.13 g	7.57 f	12.57 h	14.53 e	15.70 gh
V_2S_1	1.40 bc	3.50 de	7.97 ef	14.90 e-g	16.90 d	18.20 ef
V_2S_2	1.43 a-c	3.70 cd	9.30 bc	16.33 b-d	18.47 c	20.07 b-e
V_2S_3	1.43 a-c	3.87 a-c	8.80 b-e	15.33 d-f	18.57 c	21.20 a-c
V_2S_4	1.33 cd	3.40 ef	7.50 f	14.50 fg	16.80 d	17.73 fg
V_3S_1	1.40 bc	3.73 b-d	8.43 de	14.93 e-g	18.27 c	20.40 a-e
V_3S_2	1.43 a-c	3.93 a-c	8.53 c-e	15.23 d-f	18.47 c	21.60 a-c
V_3S_3	1.47 ab	3.90 a-c	9.40 b	15.93 b-e	18.90 bc	21.60 a-c
V_3S_4	1.27 d	3.23 fg	8.23 d-f	14.03 g	15.10 e	16.07 gh
V_4S_1	1.50 ab	3.83 a-c	8.83 b-e	16.57 bc	19.00 bc	20.53 a-d
V_4S_2	1.50 ab	4.00 ab	9.47 ab	17.03 ab	19.83 ab	21.93 ab
V_4S_3	1.53 a	4.03 a	10.20 a	17.93 a	20.50 a	22.57 a
V_4S_4	1.17 e	3.10 g	6.73 g	11.73 h	13.03 f	14.90 h
$LSD_{(0.05)}$	0.091	0.242	0.759	1.074	1.052	1.976
Level of significance	0.01	0.05	0.01	0.01	0.01	0.05
CV(%)	6.87	8.01	5.34	7.22	9.57	6.13

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

V_1: BARI mung-3 — S_1: Sowing on 23 August
V_2: BARI mung-4 — S_2: Sowing on 23 September
V_3: BARI mung-5 — S_3: Sowing on 23 October
V_4: BINA mung-2 — S_4: Sowing on 23 November

the lowest dry matter content in plant (4.40%, 5.90%, 7.18%, 8.37% and 9.65%) was found in S_4 (Sowing on 23 November), which was closely followed (4.74%, 5.99%, 7.32%, 8.76% and 10.85%) by S_1 (Sowing on 23 August), respectively for same days after sowing (Figure 10).

Interaction effect of cultivar and sowing date on plant dry matter at 20, 30, 40, 50 and 60 DAS and harvest were significant (Appendix V). The highest dry matter content in plant (6.46%, 8.55%, 9.61%, 10.71% and 12.08%) was recorded in V_4S_3 (BINA mung-2 and Sowing on 23 October) and the lowest (3.85%, 5.14%, 6.02%, 6.87% and 9.40%) in V_4S_4 (BINA mung-2 and Sowing on 23 November) (Table 4).

4.5. Days to 1st flowering

Days to 1st flowering of mungbean showed significant variations due to cultivar (Appendix VI). The minimum days to 1st flowering (30 days) was recorded from V_4 (BINA mung-2), while the maximum days to 1st flowering (35 days) was found in V_1 (BARI mung-3) which was statistically similar (34 days and 33 days) to V_2 (BARI mung-4) and V_3 (BARI mung-5), respectively (Table 5).

Days to 1st flowering of mungbean sowed significant differences due to sowing date (Appendix VI). The minimum days to 1st flowering (31 days) was recorded in S_3 (Sowing on 23 October), which was statistically identical (32 days) to S_2 (Sowing on 23 September), while the maximum days to 1st flowering (36 days) was obtained in S_4 (Sowing on 23 November), which was statistically identical (34 days) to S_1 (Sowing on 23 August) (Table 5).

Table 4. Effect of cultivar and sowing date on dry mater content of plant of mungbean

Treatment	Dry matter content in plant (%) at				
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS
V_1S_1	4.26 e-g	5.51 cd	7.12 d-f	8.60 de	9.79 e
V_1S_2	4.62 d-g	5.79 cd	7.03 d-g	8.10 ef	9.49 e
V_1S_3	5.18 cd	6.61 bc	7.95 b-e	9.39 cd	12.19 a
V_1S_4	4.31 e-g	5.57 cd	6.85 e-g	8.60 de	9.30 e
V_2S_1	4.84 c-f	5.85 cd	7.34 b-f	8.83 de	10.50 b-e
V_2S_2	6.22 a	7.70 ab	8.37 bc	10.00 a-c	11.33 a-d
V_2S_3	4.82 c-f	5.80 cd	7.27 c-f	8.71 de	10.50 b-e
V_2S_4	5.00 c-e	6.63 bc	8.03 b-d	9.33 cd	9.90 de
V_3S_1	4.40 d-g	5.56 cd	6.91 e-g	8.24 ef	11.50 ab
V_3S_2	4.08 fg	5.47 cd	6.81 fg	7.65 fg	11.42 a-c
V_3S_3	4.87 c-f	6.11 cd	7.44 b-f	9.53 b-d	10.53 b-e
V_3S_4	4.44 d-g	6.63 bc	7.80 b-f	8.67 de	10.00 c-e
V_4S_1	5.45 bc	6.67 bc	7.91 b-f	9.37 cd	11.60 ab
V_4S_2	6.07 ab	7.57 ab	8.43 b	10.30 ab	11.80 ab
V_4S_3	6.46 a	8.55 a	9.61 a	10.71 a	12.08 a
V_4S_4	3.85 g	5.14 d	6.02 g	6.87 g	9.40 e
$LSD_{(0.05)}$	0.723	1.020	0.964	0.827	1.291
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	8.79	9.67	7.65	5.56	7.23

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

V_1: BARI mung-3 — S_1: Sowing on 23 August

V_2: BARI mung-4 — S_2: Sowing on 23 September

V_3: BARI mung-5 — S_3: Sowing on 23 October

V_4: BINA mung-2 — S_4: Sowing on 23 November

Table 5. Effect of cultivar and sowing date on plant characters, yield contributing characters and yield of mungbean

Treatment	Days to 1st flowering	Days to 80% pod maturity	Pod length (cm)	Weight of 1000 seeds (g)	Seed yield (t/ha)	Stover yield (t/ha)
Cultivar						
V_1	35 a	78 b	2.66 b	23.83 a	2.03 b	2.64 c
V_2	34 a	83 a	2.74 b	19.77 b	2.06 b	2.69 bc
V_3	33 a	81 a	2.88 ab	19.57 b	2.11 b	2.84 ab
V_4	30 b	79 b	3.06 a	19.87 b	2.39 a	2.87 a
$LSD_{(0.05)}$	2.521	2.735	0.249	1.214	0.126	0.154
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
Sowing date						
S_1	34 a	85 a	2.74 b	21.04 a	2.24 a	2.82 b
S_2	32 b	79 b	3.04 a	21.87 a	2.27 a	3.05 a
S_3	31 b	77 b	3.25 a	22.29 a	2.32 a	3.17 a
S_4	36 a	70 b	2.32 c	17.84 b	1.76 b	2.01 c
$LSD_{(0.05)}$	2.521	2.735	0.249	1.214	0.126	0.154
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	5.69	12.98	10.52	7.01	7.11	6.67

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

V_1: BARI mung-3 S_1: Sowing on 23 August

V_2: BARI mung-4 S_2: Sowing on 23 September

V_3: BARI mung-5 S_3: Sowing on 23 October

V_4: BINA mung-2 S_4: Sowing on 23 November

Significant variation was recorded for interaction effect of cultivar and sowing date in terms of days required for 1st flowering (Appendix VI). The maximum days required for 1st flowering (39 days) was obtained from V_1S_1 (BARI mung-3 and Sowing on 23 August) and the minimum (26 days) was recorded from V_4S_1 (BINA mung-2 and Sowing on 23 August) (Table 6).

4.6. Days to 80% pod maturity

Statistically significant differences were recorded for days to 80% pod maturity of mungbean due to cultivar (Appendix VI). The maximum days to 80% pod maturity (83 days) was found in V_2 (BARI mung-4) which was statistically similar (81 days) to V_3 (BARI mung-5), while the minimum days to 80% pod maturity (78 days) was recorded in V_1 (BARI mung-3) which was statistically identical (79 days) to V_4 (BINA mung-2) (Table 5).

Days to 80% pod maturity of mungbean differed significantly due to different sowing date (Appendix VI). The maximum days to 80% pod maturity (85 days) was recorded from S_1 (Sowing on 23 August), while the minimum days to 80% pod maturity (70 days) was found in S_4 (Sowing on 23 November) which was statistically identical (77 days and 79 days) with S_3 (Sowing on 23 October) and S_2 (Sowing on 23 September), respectively (Table 5).

Interaction effect of cultivar and sowing date showed significant variation for days to 80% pod maturity (Appendix VI). The maximum days to 80% pod maturity (88 days) was obtained from V_3S_1 (BARI mung-5 and Sowing on 23 August) and the minimum (73 days) was recorded in V_1S_3 (BARI mung-3 and Sowing on 23 October) (Table 6).

Table 6. Interaction effect of cultivar and sowing date on plant characters, yield contributing characters and yield of mungbean

Treatment	Days to 1st flowering	Days to 80% pod maturity	Pod length (cm)	Weight of 1000 seeds (g)	Seed yield (t/ha)	Stover yield (t/ha)
V_1S_1	39 a	83 a-d	2.57 de	24.52 ab	2.16 b	2.86 cd
V_1S_2	33 b-e	76 ef	2.74 c-e	24.87 ab	2.19 b	2.82 d
V_1S_3	33 b-e	73 f	3.04 b-d	25.97 a	2.23 b	2.98 b-d
V_1S_4	37 a-c	79 b-e	2.31 ef	19.97 c-f	1.53 d	1.90 g
V_2S_1	35 a-d	85 ab	2.55 d-f	19.32 d-f	1.98 bc	2.48 e
V_2S_2	33 a-e	83 a-d	3.21 bc	21.20 c-e	2.10 b	2.89 cd
V_2S_3	30 d-f	82 a-e	2.95 b-d	19.99 c-f	2.23 b	3.10 a-d
V_2S_4	38 ab	82 a-e	2.26 ef	18.56 ef	1.94 bc	2.30 ef
V_3S_1	36 a-c	88 a	2.77 c-e	19.43 d-f	2.22 b	2.96 b-d
V_3S_2	28 ef	79 c-f	2.83 b-e	19.87 c-f	2.21 b	3.18 a-c
V_3S_3	29 ef	77 d-f	3.24 a-c	20.66 c-f	2.24 b	3.16 a-d
V_3S_4	39 a	82 a-e	2.70 c-e	18.33 f	1.76 cd	2.05 fg
V_4S_1	26 f	84 a-c	3.09 b-d	20.90 c-f	2.59 a	2.98 b-d
V_4S_2	32 c-f	77 d-f	3.38 ab	21.55 cd	2.57 a	3.30 ab
V_4S_3	32 c-f	77 d-f	3.76 a	22.53 bc	2.60 a	3.42 a
V_4S_4	30 d-f	76 ef	2.01 f	14.52 g	1.80 cd	1.87 g
$LSD_{(0.05)}$	5.041	5.471	0.498	2.429	0.253	0.308
Level of significance	0.01	0.05	0.01	0.05	0.05	0.01
CV(%)	5.69	12.98	10.52	7.01	7.11	6.67

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

V_1: BARI mung-3 — S_1: Sowing on 23 August

V_2: BARI mung-4 — S_2: Sowing on 23 September

V_3: BARI mung-5 — S_3: Sowing on 23 October

V_4: BINA mung-2 — S_4: Sowing on 23 November

4.7. Pod length

Pod length of mungbean showed statistically significant variation due to cultivar (Appendix VI). The highest pod length (3.06 cm) was recorded in V_4 (BINA mung-2), which was statistically similar (2.88 cm) to V_3 (BARI mung-5), while the lowest pod length (2.66 cm) was observed from V_1 (BARI mung-3), which was statistically similar (2.74 cm) to V_2 (BARI mung-4) (Table 5).

Different sowing date showed significant differences in terms of pod length of mungbean (Appendix VI). The highest pod length (3.25 cm) was recorded from S_3 (Sowing on 23 October) which was statistically identical (3.04 cm) to S_2 (Sowing on 23 September), while the lowest (2.32 cm) in S_4 (Sowing on 23 November), which was significantly different from all other treatments (Table 5).

Interaction effect of cultivar and sowing date on pod length varied significantly (Appendix VI). The highest pod length (3.76 cm) was recorded in V_4S_3 (BINA mung-2 and Sowing on 23 October) and the lowest (2.01 cm) was recorded in V_4S_4 (BINA mung-2 and Sowing on 23 November) (Table 6).

4.8. Pods per plant (no.)

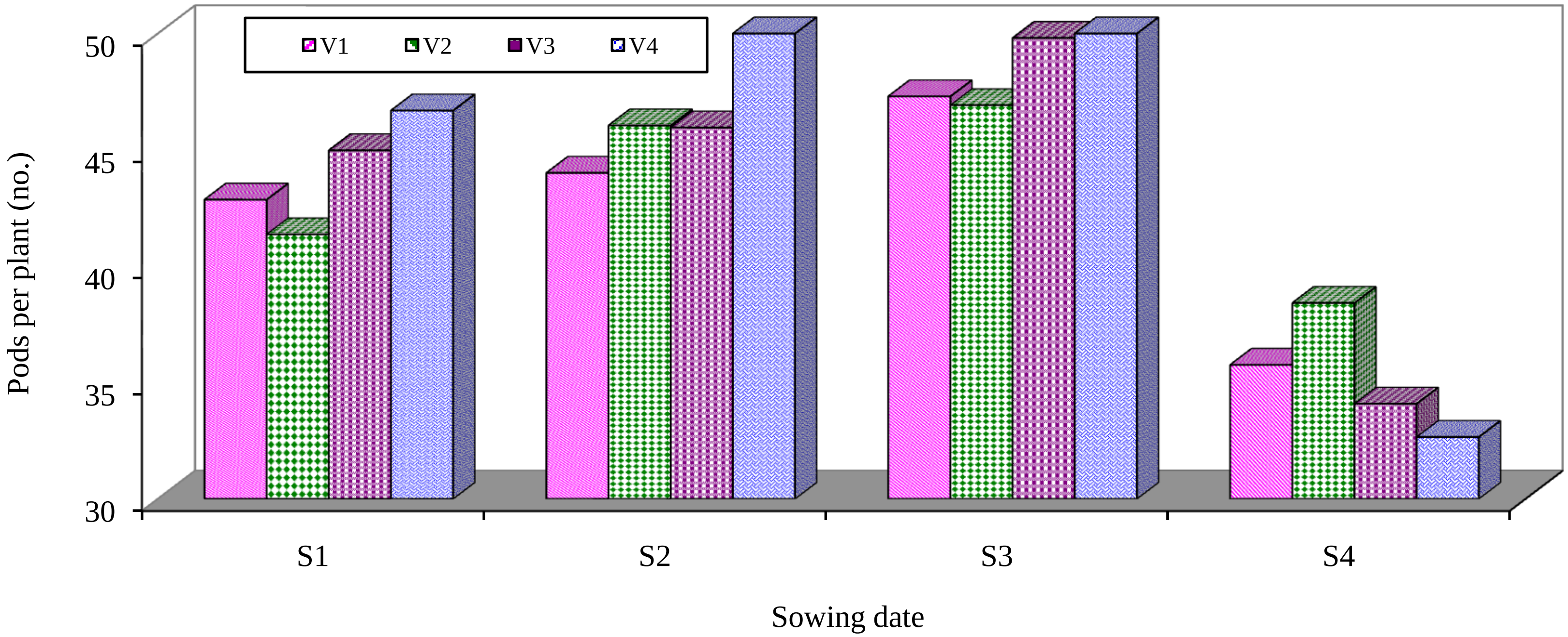
A statistically significant variation was recorded for number of pods per plant of mungbean due to different cultivar (Appendix VI). The highest number of pods per plant (45.86) was found in V_4 (BINA mung-2) which was statistically similar (43.71) to V_3 (BARI mung-5), while the lowest number of pods per plant (42.48) was found in V_1 (BARI mung-3) which was statistically similar (43.19) with V_2 (BARI mung-4) (Figure 11).

Number of pods per plant of mungbean varied significantly due to sowing date (Appendix VI). The highest number of pods per plant (49.50) was found in S_3 (Sowing on 23 October) which was closely followed (46.53) by S_2 (Sowing on 23 September), while the lowest number of pods per plant (35.23) was found in S_4 (Sowing on 23 November), which was significantly different from that of all other treatments (Figure 12). Allam (2002) reported that mungbean sowing on 1 November gave higher number of pods per plant than sowing on 15 November and 1 December.

Interaction effect of cultivar and sowing date showed statistically significant differences for number of pods per plant (Appendix VI). The highest number of pods per plant (53.98) was recorded from V_4S_3 (BINA mung-2 and Sowing on 23 October) and the lowest (32.66) was found in V_4S_4 (BINA mung-2 and Sowing on 23 November) (Figure 13). It was also found that sowing on 23 October and on 23 November produced respectively the highest and lowest number of pods by all the varieties studied.

4.9. Weight of 1000 seeds

Due to different cultivar, weight of 1000 seeds of mungbean showed significant differences (Appendix VI). The highest weight of 1000 seeds (23.83 g) was found in V_1 (BARI mung-3), while the lowest weight of 1000 seeds (19.57 g) was found in V_3 (BARI mung-5) which was statistically similar (19.77 g and 19.87 g) to V_2 (BARI mung-4) and V_4 (BINA mung-2), respectively and significantly different from V_1 (BARI mung-3) (Table 5).



V_1: BARI mung-3 V_2: BARI mung-4 S_1: Sowing on 23, August S_2: Sowing on 23, September
V_3: BARI mung-5 V_4: BINA mung-2 S_3: Sowing on 23, October S_4: Sowing on 23, November

Figure 13. Interaction effect of cultivar and sowing date on number of pods per plant of mungbean [LSD(0.05) = 4.871].

Weight of 1000 seeds of mungbean differs significantly due to sowing date (Appendix VI). The highest weight of 1000 seeds (22.29 g) was recorded in S_3 (Sowing on 23 October), which was statistically identical (21.87 g and 21.04 g) to S_2 (Sowing on 23 September) and S_1 (Sowing on 23 August), respectively, while the lowest weight of 1000 seeds (17.84 g) was obtained in S_4 (Sowing on 23 November) (Table 5).

Interaction effect of cultivar and sowing date showed statistically significant differences in weight of 1000 seeds (Appendix VI). The highest weight of 1000 seeds (25.97 g) was recorded in V_1S_3 (BARI mung-3 and Sowing on 23 October) and the lowest (14.52 g) was found in V_4S_4 (BINA mung-2 and Sowing on 23 November) (Table 6).

4.10. Seed yield

Seed yield of mungbean varied significantly due to different cultivar (Appendix VI). The highest seed yield (2.39 t/ha) was obtained in V_4 (BINA mung-2), while the lowest seed yield (2.03 t/ha) was recorded in V_1 (BARI mung-3) and was statistically similar (2.06 t/ha and 2.11 t/ha) with V_2 (BARI mung-4) and V_3 (BARI mung-5), respectively (Table 5).

Due to different sowing date significant variation was recorded in terms of seed yield of mungbean (Appendix VI). The highest seed yield (2.32 t/ha) was recorded in S_3 (Sowing on 23 October) which was statistically identical (2.27 t/ha and 2.24 t/ha) to S_2 (Sowing on 23 September) and S_1 (Sowing on 23 August), while the lowest seed yield (1.76 t/ha) was found in S_4 (Sowing on 23 November) (Table 5). Inderjit *et al*. (2005) reported that there was a significant reduction in seed yield with delay in sowing from 10 November to 10 December. Mungbean sown on 10 November (14.6 q/ha) out yielded the crop sown on 25 November and 10 December by a margin of 12.8 and 90.1%, respectively. Muhammad *et al*. (2002) reported that sowing in November significantly enhanced seed yield by 113.2% in 1993-94 and 102.1% in 1994-95 compared to sowing in December.

Interaction effect of cultivar and sowing date showed statistically significant differences for seed yield under the present trial (Appendix VI). The highest seed yield (2.60 t/ha) was recorded in V_4S_3 (BINA mung-2 and Sowing on 23 October) treatment and the lowest (1.80 t/ha) in V_4S_4 (BINA mung-2 and Sowing on 23 November) (Table 6). It was recorded that sowing on 23 August (S_1), 23 September (S_2) and 23 October (S_3) showed statistically similar yield but were significantly different from that of sowing on 23 November (S_4) in V_1 (BARI mung-3), V_3 (BARI mung-5) and V_4 (BINA mung-2), whereas, V_2 (BARI mung-3) showed the statistically similar yield sowing on all the sowing date studied. Turk *et al*. (2003) and observed that highest seed yields were obtained for early sowing for different mungbean variety. Gurung *et al*. (1996) found that average seed yields of crops sown on 10 and 25 October were 1274 and 1591 kg/ha, respectively, which were significantly higher than other sowing dates. Seed yield was greatly reduced if sowing was advanced from 10 October to 25 September (533 kg/ha) or delayed from 25 October to 9 November (597 kg/ha).

4.11. Stover yield

A statistically significant variation was recorded for stover yield of mungbean due to cultivar (Appendix VI). The highest stover yield (2.87 t/ha) was recorded in V_4 (BINA mung-2), which was statistically similar (2.84 t/ha) to V_3 (BARI mung-5), while the lowest stover yield (2.64 t/ha) was recorded in V_1 (BARI mung-3), which was statistically similar (2.69 t/ha) to V_2 (BARI mung-4) (Table 5).

Stover yield of mungbean varied significantly due to different sowing date (Appendix VI). The highest stover yield (3.17 t/ha) was found in S_3 (Sowing on 23 October), which was statistically identical (3.05 t/ha) with S_2 (Sowing on 23 September), while the lowest stover yield (2.01 t/ha) was recorded in S_4 (Sowing on 23 November) and significantly different from that of all other treatments (Table 5).

Statistically significant differences for stover yield were recorded due to interaction of cultivar and sowing date (Appendix VI). The highest stover yield (3.42 t/ha) was observed in V_4S_3 (BINA mung-2 and Sowing on 23 October) and the lowest (1.87 t/ha) was recorded in V_4S_4 (BINA mung-2 and Sowing on 23 November) (Table 6). Turk *et al.* (2003) and observed that highest stover yields were obtained for early sowing for different mungbean variety.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to study the performance of four mungbean cultivars under different sowing date on kharif II season. The field duration of the experiment was August, 2010 to February 2011. The experiment was consisted of two factors. Factor A: Varity (4 levels)- V_1: BARI mung-3; V_2: BARI mung-4; V_3: BARI mung-5 and V_4: BINA mung-2, Factor B: Sowing date (4 levels)- S_1: Sowing on 23 August; S_2: Sowing on 23 September; S_3: Sowing on 23 October and S_4: Sowing on 23 November. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth parameter, yield attributes and yield were recorded.

The minimum days to 1st emergence of seedling (5.65 days) was recorded in V_1 (BARI mung-3), while the maximum days to 1st emergence of seedling (7.72 days) was found in V_4 (BINA mung-2). At 20, 30, 40, 50, 60 DAS and harvest the tallest plant (10.84 cm, 22.66 cm, 33.49 cm, 39.47 cm, 41.32 cm and 39.49 cm) was observed in V_4 while the shortest plant (9.63 cm, 21.36 cm, 31.53 cm, 37.40 cm, 39.03 cm and 37.21 cm) was found in V_1. The highest number of branches per plant (1.42, 3.74, 8.81, 15.82, 18.09 and 19.98) was obtained in V_4 while the lowest (1.35, 3.57, 8.24, 14.99, 17.30 and 18.16) was found in V_1 as same days after sowing. The highest dry matter content in plant (5.46%, 6.98%, 7.99%, 9.31% and 11.22%) was observed in V_4 and the lowest (4.45%, 5.94%, 7.23%, 8.52% and 10.19%) was found in V_3. The minimum days required for 1st flowering (30 days) was recorded in V_4, while the maximum to 1st flowering (35 days) was found in V_1. The maximum days to 80% pod maturity (83 days) was found in V_2 and the minimum days to 80% pod maturity (78 days) was observed in V_1. The highest number of pods per plant (45.86) was observed in V_4 while the lowest (42.48) was found in V_1. The highest pod length (3.06 cm) was recorded in V_4 while the lowest (2.66 cm) was observed in V_1. The highest weight of 1000 seeds (23.83 g) was observed in V_1 and the lowest (19.57 g) was found in V_3. The highest seed yield (2.39 t/ha) was obtained in V_4 and the lowest (2.03 t/ha) was recorded in V_1. The highest stover yield (2.87 t/ha) was recorded in V_4 while the lowest (2.64 t/ha) in V_1.

The minimum days to 1st emergence of seedling (5.73 days) was found in S_1 (Sowing on 23 August) while, the maximum days to 1st emergence of seedling (7.47 days) was recorded in S_4 (Sowing on 23 November). At 20, 30, 40, 50, 60 DAS and harvest the tallest plant (11.56 cm, 23.43 cm, 35.52 cm, 42.00 cm, 43.45cm and 40.13 cm) was recorded in S_3 and the shortest plant (8.25 cm, 18.99 cm, 26.11 cm, 33.51 cm, 36.27 cm and 35.32 cm) was obtained in S_4. At 20, 30, 40, 50, 60 DAS and harvest the highest number of branches per plant (1.47, 3.89, 9.33, 16.41, 19.17 and 21.21) was found in S_3 and the lowest (1.23, 3.22, 7.51, 13.21, 14.87 and 16.10) was obtained in S_4 at same days after sowing. At 20, 30, 40, 50 and 60 DAS the highest dry matter content in plant (5.33%, 6.77%, 8.07%, 9.59% and 11.32%) was obtained in S_3 and the lowest (4.40%, 5.90%, 7.18%, 8.37% and 9.65%) was found in S_4. The minimum to 1st flowering (31 days) was recorded in S_3 while the maximum days to 1^{st} flowering (36 days) was obtained in S_4. The maximum days to 80% pod maturity (85 days) was recorded in S_1 and the minimum days to 80% pod maturity (77 days) was found in S_3. The highest number of pods per plant (49.50) was found in S_3 while the lowest (35.23) was observed in S_4. The highest pod length (3.25 cm) was recorded in S_3 while the lowest pod length (2.32 cm) was obtained in S_4. The highest weight of 1000 seeds (22.29 g) was recorded in S_3 while the lowest (17.84 g) was obtained in S_4. The highest seed yield (2.32 t/ha) was recorded in S_3 and the lowest seed yield (1.76 t/ha) was found in S_4. The highest stover yield (3.17 t/ha) was found in S_3 while the lowest (2.01 t/ha) was recorded in S_4.

The minimum days to 1^{st} emergence of seedling (6 days) was observed in V_4S_3 and the minimum (8.00 days) was recorded in V_1S_4. At 20, 30, 40, 50, 60 DAS and harvest the tallest plant (13.32 cm, 25.66 cm, 38.71 cm, 45.20 cm, 46.80 cm and 42.60 cm) was recorded in V_4S_3 and the shortest plant (6.79 cm, 17.16 cm, 23.38 cm, 28.83 cm, 33.13 cm and 33.38 cm) was recorded in V_4S_4. The highest number of branches per plant (1.53, 4.03, 10.20, 17.93, 20.50 and 22.57) was recorded in V_4S_3 and the lowest (1.17, 3.10, 6.73, 11.73, 13.03 and 14.90) was found in V_4S_4. The highest dry matter content in plant (6.46%, 8.55%, 9.61%, 10.71% and 12.08%) was recorded in V_4S_3 and the lowest (3.85%, 5.14%, 6.02%, 6.87% and 9.40%) was recorded in V_4S_4. The maximum days required for 1^{st} flowering (39 days) was obtained in V_1S_1 and the minimum (26 days) was recorded in V_4S_1. The maximum day to 80% pod maturity (88 days) was obtained in V_3S_1 and the minimum (73 days) was recorded in V_1S_3. The highest number of pods per plant (53.98) was recorded in V_4S_3 and the lowest (32.66) was found in V_4S_4. The highest pod length (3.76 cm) was recorded in V_4S_3 and the lowest (2.01 cm) was recorded in V_4S_4. The highest weight of 1000 seeds (25.97 g) was recorded in V_1S_3 and the lowest (14.52 g) was found in V_4S_4. The highest seed yield (2.60 t/ha) was recorded in V_4S_3 was obtained in V_4S_4. The highest stover yield (3.42 t/ha) was observed in V_4S_3 and the lowest (1.87 t/ha) in V_4S_4

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

1. Such study is needed to be repeated in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of regional adaptability,
2. Other cultivars and genotypes may be used for further study, and
3. Other sowing dates may be used for further study to specify the specific date of sowing.

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APPENDICES

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

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy 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

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 matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from August 2010 to Fubruary, 2011

Month	*Air temperature (^oC)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
August, 2010	32.22	27.60	89	39
September, 2010	31.20	22.75	84	15
October, 2009	29.18	18.26	81	39
November, 2009	25.82	16.04	78	00
December, 2009	22.40	13.50	74	00
January, 2011	24.50	12.40	68	00
February, 2011	27.10	16.70	67	30

* Monthly average,

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

Appendix III. Analysis of variance of the data on days to first flowering and plant height of mungbean as influenced by different cultivar, sowing date and their interaction

Source of variation	Degrees of freedom	Mean square						
		Days to 1st emergence	Plant height (cm) at					
			20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.083	0.477	0.031	1.293	3.136	2.566	1.058
Factor A (Cultivar)	3	1.111**	3.260*	3.491*	8.767*	12.983*	13.342*	10.711*
Factor B (Sowing date)	3	1.278**	26.337**	51.217**	217.063**	164.124**	115.873**	55.589**
Interaction (A×B)	9	1.371*	3.820**	5.811**	13.072**	21.774**	15.437**	7.859*
Error	30	0.194	1.009	1.153	2.985	4.091	3.278	3.269

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

Appendix IV. Analysis of variance of the data on number of branches per plant of mungbean as influenced by different cultivar, sowing date and their interaction

Source of variation	Degrees of freedom	Mean square					
		Number of branches per plant					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.0001	0.008	0.141	0.075	0.023	0.014
Factor A (Cultivar)	3	0.012*	0.075*	0.776*	1.729**	1.254*	8.577**
Factor B (Sowing date)	3	0.411**	1.113**	7.440**	24.696**	45.312**	61.842**
Interaction (A×B)	9	0.009**	0.052*	0.984**	3.561**	4.178**	3.945*
Error	30	0.003	0.021	0.207	0.415	0.398	1.404

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

Appendix V. Analysis of variance of the data on dry matter content of mungbean plant as influenced by different cultivar, sowing date and their interaction

Source of variation	Degrees of freedom	Mean square				
		Dry matter content in plant (%) at				
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	0.087	0.058	0.378	0.576	0.089
Factor A (Cultivar)	3	2.854**	3.266**	1.718**	1.842**	2.290*
Factor B (Sowing date)	3	2.317**	2.334**	1.905*8	3.130**	6.442**
Interaction (A×B)	9	1.286**	2.659**	2.347**	3.182**	2.043**
Error	30	0.188	0.374	0.334	0.246	0.599

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

Appendix VI. Analysis of variance of the data on plant characters, yield contributing characters and yield of mungbean as influenced by different cultivar, sowing date and their interaction

Source of variation	Degrees of freedom	Mean square						
		Days to 1st flowering	Days to 80% pod maturity	Pod length (cm)	Number of pods plant^{-1}	Weight of 1000 seeds (g)	Seed yield (t/ha)	Stover yield (t/ha)
Replication	2	5.250	5.896	0.002	0.741	0.732	0.014	0.0001
Factor A (Cultivar)	3	62.250**	73.639**	0.367**	25.389*	50.438**	0.326**	0.152**
Factor B (Sowing date)	3	62.306**	139.250**	1.950**	453.779**	48.649**	0.820**	3.285**
Interaction (A×B)	9	34.324**	19.065*	0.246**	20.247*	6.210*	0.063*	0.146**
Error	30	9.139	10.763	0.089	7.849	2.121	0.023	0.034

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