EFFECT OF SOWING DATE ON GROWTH AND YIELD OF MUNG BEAN (*Vigna radiata* L.)

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EFFECT OF SOWING DATE ON GROWTH AND YIELD OF MUNG BEAN (*Vigna radiata* L.)

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*This is to certify that thesis entitled, **"EFFECT OF SOWING DATE ON GROWTH AND YIELD OF MUNG BEAN (Vigna radiata L.)"** was submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in AGRICULTURAL BOTANY** embodies the result of a piece of bona fide research work carried out by **RESHMA KHATUN**, Registration no. **19-10361** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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DEDICATED TO

MY BELOVED PARENTS

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ABSTRACT

Sowing time is an important agronomic factors that significantly affects plant growth development and final production. Similarly, suitable cultivar also plays an appreciable rate in final productivity. Therefore, the experiment was conducted in the research field of the Sher-e-Bangla Agricultural University, Dhaka from March 2020 to June 2020 to study the effect of sowing date on growth and yield of Mung bean (*Vigna radiata* L). This experiment consisted of three Mung bean varieties viz. V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3 = BARI Mung-7 sown on three different dates termed as treatments i. e. T_1= 15 March 2020, T_2= 30 March 2020, and T_3= 15 April 2020 and different parameters were recorded. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experimental plot was fertilized at the rate of 40 kg/ha (Urea), 80 kg/ha (TSP), 30 kg/ha (MoP) and necessary intercultural operations were done. The data regarding plant height, number of leaves and number of branches were recorded at both 30 Days after sowing (DAS) and harvest, and the other parameters were recorded at the time of harvest only. At 30 DAS, the highest plant height (22.67 cm) was observed in V_2 when sown on T_1 and during harvest plant height was found highest (55.17 cm) in the same variety with the same treatment. At 30 DAS and harvest, the highest number of leaves (average 4.33 and 15 respectively) were obtained in V_2 when sown on T_1. In case of number of branches, at 30 DAS and harvest, the highest number (average 2.67 and 7.67) were observed in V_2 when sown on T_1 and T_3 respectively. The variety V_3 takes longer time for maturity (66 days) and V_1 variety takes less time for maturity (55.67 days). In terms of yield and yield attributes, the highest number of pods per plant (39) were recorded in V_2 when sown onT_1 and the number of fertile seeds per pod were recorded highest (14) in V_2 when sown onT_1. The maximum pod length (14.67 cm) was recorded in V_2 when sown on T_1. In case of 1000- seed weight the highest value (53.18 g) was recorded in V_2 when sown on T_1. The maximum SPAD value (55), the highest yield (1.68 t ha^{-1}), maximum biological yield (3.5 t ha^{-1}), the highest Stover yield (1.88 t ha^{-1}) was recorded in V_2 when sown on T_1. Finally, the maximum Harvest Index (53.33 %) was calculated in V_2 when sown on T_1. The results in this study indicated that the variety performed better in respect of growth, yield and others yield contributing characters' is V_2 (BARI Mung -6) on the sowing time T_1 (15 March 2020).

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LIST OF ABBREVIATION AND ACRONYMS

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

CHAPTER I

INTRODUCTION

Mung bean (*Vigna radiata* (L.) R.Wilczek var. radiata) is one of the most food legume crops in South, East and Southeast Asia, where 90% of global production currently takes place. Mung bean is a relatively drought tolerant and low input crop that can provide green manure as well as livestock feed and thus is favoured by small holder farmers. Pulses play a crucial role in Bangladesh's agricultural economy. They have three times as much protein in them than grains do. Pulses contain vitamin B, minerals, and high-quality fibers, all of which are beneficial for human health. Pulse crops use symbiotic nitrogen fixation from the atmosphere to enrich the soil. They are an important part of sustainable agriculture since they are a great source of protein and maintain soil fertility through biological nitrogen fixation in the soil.

The main pulse crops in Bangladesh include Mung bean, grass pea, lentil, black gram, chick pea, field pea, and cow pea. One of the most significant pulse crops in Bangladesh is the Mung bean (*Vigna radiata* L.), which is a member of the subfamily papillionaceae of the family leguminosae. This widely cultivated pulse crop is a member of the leguminosae family. It is a significant pulse crop known as Mung bean (*Vigna radiata* L. wilczek). When dehusked, it is yellow with green husk. The beans are tiny, ovoid-shaped, and green (Anonymous, 2016). In Bangladesh, it ranks third in terms of protein content and fourth in terms of production and acreage (Sarkar *et al*., 1982).

The World Health Organization (WHO) states that each person needs 45g of pulse per day. However, the daily availability of pulse in Bangladesh is barely 12g per person. To meet the current per capita needs of our country, 6.01 million tons of pulse are needed (BARI, 1998). In the fiscal year of 2020-2021, the area of mung bean cultivation was 109304.77 (acre) and the production was 41189.26 metric ton (BBS, 2022).

Bangladesh's agro ecological conditions are ideal for cultivating this crop. The native Mung bean may be grown in both the summer and the winter in Bangladesh due to its favorable winter climate (Bose, 1982 and Miah et al., 2009). The Mung bean has a brief life cycle. Cereals have mostly taken the place of Mung beans (Abedin et al., 1991). Nowadays, it is grown following the harvest of Rabi crops (wheat, mustard, lentil, etc.).

Among different reasons for the lower production of pulses in Pakistan, seeding time and plant population have special importance. In the changing scenario of different abiotic and biotic stress, the managerial practices must be optimized for ensuring the better crop production (Hassan *et al*., 2020a, b). Agro-ecological conditions play a vital role in the determination of planting time. Similarly, optimum sowing time in mung bean may vary from variety to variety (Sarkar *et al*., 2004). Planting time is of paramount importance and it has a significant effect on growth, development and yield (Asghar *et al*., 2006; Aslam *et al*., 2015; Hassan *et al*., 2020c; Mohsin *et al*., 2021). The planting time significantly varies among cultivars, therefore proper planting times should be adopted in order to get higher productivity (Aslam *et al*., 2000.)

The early sowing enhances final yield and biomass production owing to an increase in grain weight and other production traits (Barros *et al*., 2004; Hassan *et al*., 2020). The decrease in the growth cycle due to late sowing reduced the interception of radiations that decreases the accumulation of total dry matter and consequently leads to poor yield (Vega and Hall, 2002). Selection of the cultivar and appropriate sowing date is very essential to attain yield (Jan *et al*., 2002). Various varieties of mung bean respond differently to sowing dates and growing season. Thus, for different varieties of mung bean there should be varied optimum sowing dates (Reddy, 2009). After identifying high yielding cultivars, sowing at optimum dates can result in higher yields (Ali and Gupta, 2012). The variable authors reported the significant differences in the seed yield of mung bean with variable planting times.

Temperate environments with high radiation with an average daily temperature of 27˚C, a daily precipitation between 3.2 and 5 mm/day and a soil with a soil moisture level of 50% and a pH of 6.5 are most suitable for growing Mung bean. Mung bean has an average photoperiod between 46 to 63 days and will flower between 12 and 13 hours. The deleterious effect of high temperature stress on plant photosynthetic processes is well known and has been studied comprehensively (Berry and

Bjorkman,1980; Weis and Berry, 1988; Karim *et al*., 1999). The optimum average temperature for Mung bean cultivation has been reported to be 28-30°C (Poehlman, 1991).

Mung bean (*Vigna radiata* L.), one of the pulse crops, is a significant cash crop that may be cultivated well in the summer in hot and arid climates (Sekhon, 2008). On the other hand, the timing of seeding had a notable impact on the growth and productivity of summer Mung beans. One of the key input variables influencing the growth and yield of the field crops is the sowing timing. It has an impact on the length of the Mung bean's vegetative, reproductive, and maturation periods (Soomro & Khan 2003). Because agro-ecological circumstances differ from region to region, the best time to sow Mung beans varies depending on the variety (Sarkar *et al*., 2004). The sowing date assists to realize potential yield by ensuring total harmony between the vegetative and reproductive phases and the meteorological rhythm (Singh *et al*., 2010). In Bangladesh, attempts to plant Mung beans in the heat have had some degree of success (FAO, 1984).

In order for different types to produce their highest yield, there must be a set of planting dates, particularly throughout the summer. Summer Mung bean production is decreased by delayed seeding after March and early sowing before February (Chovatia *et al*., 1993). The best time to plant summer Mung beans may be in February, and planting beyond March may expose plants to rain damage during the maturation period (Dharmalingam & Basu, 1993).

Early sowing encourages a lot of insect pests and diseases, while late sowing yields less grain because of the short growth season and ultimately less photosynthetic accumulation (Quresh &Rahim, 1987). To get the best yield from Mung beans, the most crucial non-monetary input is sowing time (Samanta *et al*., 1999). Therefore, it is vital to determine the ideal sowing period for Mung beans. Because agro-ecological conditions can change from variety to variety and season to season, the best time to sow Mung beans may vary.

Mung bean plants use photosynthesis, which makes use of solar energy, to produce energy. Among other things, the effectiveness of radiation use affects how quickly plants develop. Better photosynthesis efficiency leads to more robust plant development. So it was looked at which photosynthetic pathway the Mung bean used and what kind of environment promoted photosynthesis.

Additionally, it can tolerate drought and requires little in the way of nutrients to grow. Mung beans increase the physical, chemical, and biological qualities of soil by symbiotically fixing nitrogen from the atmosphere. In addition to these, two other critical elements in preserving soil fertility are the soil's capacity to fix nitrogen and the addition of organic matter (Senanayake *et al*., 1987; Zapata *et al*., 1987). Rhizobia nodulate Mung bean, a leguminous plant, causing the development of nodules and forming a nitrogen-fixing symbiosis (Dudeja *et al*., 2012). Being a legume, the plant can use symbiotic N fixation to fix atmospheric N and can also be used as hay or feed (Oplinger *et al*., 1990). Poor crop management techniques, abiotic and biotic restrictions, and the lack of high-quality seeds of better kinds for farmers all contribute to the low yield (Chauhan *et al*., 2010; Pratap *et al*., 2019a). We also noted that the average values for Mung bean seed production, seed size, protein, sugar, and oil concentrations were 1.31 mg ha-1, 7.08 g seed-100, 24.3%, 4.91%, and 1.59%, respectively. The typical Mung bean yield in farmer fields is far lower than the amount of potential production kg/ha. Poor soil fertility, insufficient fertilizer application, weed infestation, insect and disease attack, and low yield are possible causes. Our farmers are mistaken in thinking that because Mung beans are legumes, they do not require fertilizers, even though nitrogen and phosphorus alone, when combined, may significantly increase yield and improve Mung bean quality. A beginning dose of nitrogen application has a positive impact on crop output and quality (Sandhu *et al*., 1978). The production and transport of carbohydrates, the development of roots, the maturity of crops, and disease resistance are all important functions of phosphorus. Therefore, the current analysis was conducted to determine the best Mung bean variety(s) to use and the best time to seed them.

OBJECTIVES:

1) To know the effect of sowing date on growth and yield of Mung bean

2) To find out appropriate sowing date for better Mung bean production

CHAPTER II

REVIEW OF LITERATURE

This chapter includes research findings of different researchers in home and abroad regarding the effect of sowing dates on growth and grain yields of Mung bean. Since the work on the influence of plant growth and yields on Mung bean is scanty, an attempt has therefore been made to review the work on Mung bean and other crops. A good number of research works on different aspects of mung bean production have been done by research workers in and outside of the country, especially in the South East Asia for the improvement of mung bean production. Recently Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have started research on varietal development and improvement of this crop. Research work related to the study of performance of different varieties of mung bean is reviewed and presented in this chapter. The information has been reviewed and cited under the following headings.

Mung bean (Mung) a common pulse crop (*Vigna radiata* L) of the family *Fabaceae*. It is a short duration crop. It is widely cultivated in Natore, Barishal, Bhola, Patuakhali. February-March is the best time for sowing and most popular variety is BARI Mung-6. Mung beans used as forage or hay, used as cheap crop, improve physical chemical and biological properties of soil and fixing nitrogen from atmosphere through symbiosis process. Mung beans contains 51% carbohydrate, 26% protein, 4% mineral and 3% vitamin. Mung bean (*Vigna radiata* L*)* is widely grown in Bangladesh. It contains 19.5% to 28.5% protein. It provides grain for human consumption and the plant fix nitrogen to the soil. It supplies a substantial amount of nitrogen to the succeeding non-legume crops (i.e., rice) grown in rotation (Sharma and Prasad, 1999). Major area of Mung bean is replaced by cereals (Abedin *et al*., 1991). Now a day, it is being cultivated after harvesting of Rabi crops such as wheat, mustard, lentil, etc. As Mung bean is a short duration crop, it can well fit as a cash crop between major cropping seasons. It is grown three times in a year covering 23264 ha with an average yield of 0.77 t/ha (BBS, 2009).

2.1 Effect of sowing date

Sowing time is the most important factor to obtain optimum yield from Mung bean (Samanta *et al*., 1999). High yielding varieties and suitable sowing time are the most important factors affecting the yield.

The findings of Gebolghu *et al*. (1996), who reported higher number of pods per plant in late sowing as compared to early sowing.

Too early sowing may not successfully emergence, while yield from too late sown crop may be low due to unfavorable condition for growth and development of Mung bean (Hussain *et al*., 2004). There must be a specific sowing date, especially in the summer season for different varieties to obtain maximum yield.

Mung bean cultivars varied significantly in yield and yield components (Rahman *et al*., 2002).

Quresh and Rahim (1987), who found that earlier planting gave significantly higher mean biological yield. The probable reason for this might be the less plant population in early sowing and heavy rains, which adversely affected the Mung bean production.

For maximum Mung bean production, optimum sowing time may vary from variety to variety and season to season due to variation in agro-ecological conditions as it determines the vegetative, reproductive and maturity periods (Soomro and Khan, 2003).

In Bangladesh, research had been done on growth, yield contributing characteristics and yield of different varieties of Mung bean in relation to variation of sowing time (Ahmed *et al*., 1978; Miah *et a1*., 2009; Nag *et al*., 2000).

Several research efforts on planting date effects on Mung bean production have already been done in different regions of the world. However, little information is available regarding its effects under rain-fed environments as moisture utilization at proper time is necessary for good crop production (Hussain *et al.,* 2004; Miah *et al.,* 2009).

Sangakkara (1998) reported from Sri Lanka that late sowing of Mung bean produced the lowest yields of low-quality seeds.

Different scientists suggested that majority of crops can utilize the factors of favorable environment which ultimately influences plant to have more growth and development in Mung bean plants (Miah *et al.,* 2009; Quresh and Rahim, 1987; Soomro, 2003; Sarkar *et al.,* 2004).

Rehman *et al*. (2009) conducted a field experiment to study the effect of sowing dates (30 March, 15 April, 15 May, 15 June, and I5 July). They revealed that significant differences were observed among various sowing dates for all the parameters except grains per pod. Sowing date of 30 March took more days to emergence, flowering, and physiological maturity. Maximum emergence was recorded for 15 April sowing. The crop attained maximum plant height under I5 May sowing. Highest grain yield was recorded for early planting of 30 March.

Delayed planting generally shifts reproductive growth into less favorable conditions with shorter days and lower radiation and temperature. Early or late sown crop may not emerge properly followed by lower growth and development producing lower yield (Hussain *et al.,* 2004). Earlier 50% flowering with delayed sowings have been observed in Mung bean (Singh *et al*., 2010).

Fraz *et al*. (2006), who suggested higher number of pods/plants in late sowing (3rd week of July) as compared to early sowing (3rd week of June) at Faisalahad (Pakistan).

Sadeghipour (2008) and Sarkar *et al.* (2004) reported that number of seeds per pod affected by sowing date. Early sowing faces a large number of insect pests and diseases, while late sowing fetches lesser grain yield due to short growing season and ultimately lesser accumulation of photosynthates (Quresh & Rahim. 1987).

Sarkar *et al*. (2004) showed that pod length of Mung bean was significantly influenced by planting time. He also reported that higher number of pods per plant in late sowing as compared to early sowing.

Mung bean crop sown in first week of July grown taller plants, higher yield and yield components (Ramzan *et al*., 1992). Seed yield, days to emergence and days to maturity of Mung bean cultivars decreased with delay in sowing time (Thakar and Dhingra, 1993).

Farrag (1995) reported in a field study conducted on Mung bean *(Vigna radiata)* at El- Mania. Egypt that 1st May sowing showed earliest maturity and a significant increase in total grain yield, number of pods plant^{-1}, number of grains plant $^{-1}$ and 1000 grain weight compared to 15th March and 15th June sowings.

Rakesh *et al.* (2000) indicated that Mung bean crop sown on 15th March had higher number of pods plant^{-1}, seeds pod^{-1} and higher grain yield.

Singh and Sekhon (2002) indicated that at Ludhiana (Punjab), the crop sown on 12 July produced significantly higher grain yield than 2 August sowing due to taller plants, more branches per plant, more pods per plant and higher number of seeds per pod. Late sown crop could not attain proper growth, which resulted in drastic reduction in yield.

Raza and Hasanzada (1995) showed that Mung bean yield was higher in crop sown in June and July. There was a linear relationship between appearance of leaves and accumulation of heat in comparison between two Mung bean varieties in different planting dates. Delay in planting date caused decrease in length of main stems, sub stems and the number of pods and as a result, decrease in grain yield. Planting date was effective on seed yield and delayed planting caused the weakness of performance so that the highest on the first planting and the third seeding date had lowest performance.

Soomro and Khan (2003) at lslamabad (Pakistan) found that the early sowing (5 July) showed maximum (9.2 cm) pod length. followed by 15 July sown crop (8.5 cm) and least pod length (5.1 cm) was observed in last sowing (5 August) so it was concluded that first week of July was the ideal time of sowing.

Muhammad *et al*. (2005) guided a field experiment at Dera Ismail Khan (Pakistan), with seven sowing dates (15 April, 1 May, 15 May, 1 June, 15 June, 1 July and 1 August) of Mung bean and found that sowing on 1 May resulted in the highest number of branches per plant, pods per plant, 1000- grain weight and grain yield.

In Hazipur (Bangladesh), Razzaque *et al*. (2005) tested sowing of Mung bean from January to May and reported that I5 February gave highest grain yield.

Singh *et al.* (2012b) conducted a field experiment at Ludhiana (Punjab) during kharif season for evaluation of date of sowing for Mung bean. The crop was sown on two different dates (last week of July and first week of August). The plant height, number of pods per plant, seeds per plant and 1000-seed weight was significantly higher when Mung bean sown in last week of July as compared to first week of August and resulted higher grain yield.

Among the various agronomic practices, planting time is the most important factor influencing the yield of Mung bean Asghar *et al.* (2006). Patel *et al*. (1992) reported that the grain yield of two varieties of Mung bean was considerably more at the first date of sowing as compared to second date of sowing.

Singh *et al.* (2012a) conducted a field experiment at Varanasi (kittar Pradesh) which was sown on 1 July, 16 July, 1 August and 16 August. The results revealed the higher disease (Web blight) severity on the crop sown on 1 July (63.3%) and 16 July (56.0%) than that on sown on 16 August (24.81/6). However, crop sown on 1 August (683 kg/ha) recorded maximum grain yield compared to those which were sown on 1 July (557 kg/ha) and had comparatively lower disease (48.9/0) than crop sown on 16 July (56.0%).

Delayed sowing after March and early sowing before February reduce yield of summer Mung bean Chovatia *et al*. (1993). Yield of non-primed Mung bean declined linearly with date of sowing.

Miah *et al.* (2009) reported that early sowing before 2 March, summer Mung bean caused a substantial decrease in growth and yield of Mung bean. The highest seed yield obtained from 2 March sowing might be due to suitable temperature prevailing accompanied by higher soil moisture content due to sufficient rainfall in April, which enhanced the vegetative as well as reproductive growth of the crop. This finding closely resembles to those reported by Sinha *et a.* (1989) and Miah *et al.* (2009) who opined that Mung bean being a warm season plant produced higher yield at the optimum mean temperature range of 25-30°C.

Sadeghipour (2008) reported from Tehran (Iran) that crop sown on 29 June gave maximum grain yield because number of pods per plant and 1000-seed weight were increased, while crop sown on 30 May produced minimum grain yield due to decreased number of pods per plant.

Hanlan *et al*. (2006) reported that sowing date influenced overall plant height.

Singh *et al.* (2010) at Ludhiana tested Mung bean sowing on 5, 15, 25 July or 5 August and reported higher grain yield with 15 and 25 July sowings than with 5 July and 5 August sowing dates.

Hossain *et al.* (2006) reported that lentil sown in November received less aphid infestation with tallest plant.

Sangakkara (1998) reported from Sri Lanka that late sowing of Mung bean produced the lowest yields of low-quality seeds.

Differences in harvest index under different sowing dates of Mung bean have also been reported by other researchers (Kabir and Sarkar, 2008; Miah *et al*., 2009; Jahan and Adam, 2012).

Choi *et al.* (1991) tested three sowing dates (21 May, 15 June and 10 July) and reported that 15 June gave the highest number of pods per plant and highest grain yield.

Fraz *et al.* (2006) reported maximum grain yield in late sowing date (3rd week of July) as compared to early sowing (3rd week of June and 1st week of July) due to higher number of pods per plant, number of grains per pod, 1000-grain weight and harvest index. This might be due to decreased vegetative growth and increased reproductive growth, which favored these characters.

Farghali and Hussein (1995) in an experiment on 23 accessions of Mung bean grown under different sowing time (15 February, 15 May and 15 August) at Assuit. Egypt observed that 15 May sown crop was superior to 15 February and 15 August sowings with respect to number of clusters per plant, number of seeds per pod and 1000- grain weight. The highest number of pods per plant and total grain yield were obtained from the I5 August sowing date.

Seijoon *et al.* (2000) also found similar results and opined that the increased harvest index with late sowing could be related to high assimilate use efficiency due to increased sink capacity.

Kazemekas (2001) reported dry matter content increased in the earliest sowing date were optimum for the growth and yield of both lentil cultivars.

Chahal (1998) at Ludhiana (Punjab) conducted an experiment with four sowing dates and the grain yield of the Mung bean sown on 25 June, 7 July, 22 July and 6 August was 764, 905, 623 and 481 kg ha^{-1} respectively. The crop sown on 7 July provided significantly higher grain yield, recording 18, 45 and 88 percent increase as compared to yield under 25 June, 22 July and 6 August sown crops. Total dry matter accumulation, number of pods per plant, number of grains per pod and 1000- grain weight in case of 7 July sown crop were significantly higher than those of other three planting dates tried.

Sekhon *et al*. (2002) conducted a field experiment at Ludhiana (Punjab) with four sowing dates of 8, 16, 24 July and 1 August. They reported that 8 and 16 July sowings gave significantly higher grain yield. In another trial by these researchers 10 and 25 July sowings gave more yield than 10 August sowing.

Al-Hussien *et al.* (2002) reported that delaying the sowing date and applying imazapic and imazethapyr resulted in the most promising results, recording 98% weed control in Idleb and Tel Hadya and producing 221 and 40% more seed yield in Idleb and Tel Hadya, respectively.

Sharma *et al.* (2007) from Ludhiana reported maximum grain yield in early sowing (10 July) as compared to late sowings (26 July and 10 August) due to favourable temperature, which resulted in better plant height, increased number of branches per plant, higher number of pods per plant and higher 1000-seed weight. The late planting affected the growth and yield attributing characters.

Monem *et al.* (2012) conducted a field experiment at Varamin (Iran) on Mung bean which was sown on 5 May, 20 May and 6 June and found that sowing on 5 May was significantly superior to 20 May and 6 June sowings due to higher number of seeds per pod, harvest index and grain yield.

Singh *et al.* (2003) compared the performance of Mung bean under four sowing dates (1 July, 12 July, 24 July and 5 August) and reported the lowest grain yield of 5 August sown crop.

A field experiment was carried out at Dhaka (Bangladesh) to study the effect of time of sowing (15 March, 15 April and 15 May) on the growth and yield of Mung bean and found that 15 April sown crop had maximum plant height (68.4 cm), leaves per plant (29.33), total dry matter per plant (17.99 g), branches per plant (8.17), pods per plant (11.33), pod length (8.78 cm), seeds per pod (11.17), 1000-seed weight (46.52 g), grain yield per plant (5.33 g), grain yield per ha (1.77 tons) and harvest index (29.58%). The grain yield decreased by 36.8 and 49.9% when the crop was sown early (15 March) or late (15 May) due to production of lower yield components (Jahan and Adam, 2012).

The early sowing enhances final yield and biomass production owing to an increase in grain weight and other production traits (Barrors *et al.*,2004; Hasan *et al.*, 2020).

2.2 Effect of varieties on growth and yields attributes

Ali *et al*. (2014) investigated the effect of sowing time on yield and yield components of different Mung bean varieties, a field experiment was conducted during 2012 at agronomic research area, University of Agriculture, Faisalabad, Pakistan.

Ahmad *et al.* (2003) conducted a pot experiment in Bangladesh on the growth and yield of Mung bean cultivars viz., BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5, BU Mung-1, BU Mung-2 and BINA Mung-5 and found that BARI Mung-2 produced the highest seed yield while BARI Mung-3 produced the lowest.

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

Two summer Mung bean 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 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). 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.

Kabir and Sarkar (2008) carried out to study the effect of variety and planting density on the yield of Mung bean in Kharif-I season (February to June) of 2003. The experiment comprised five varieties viz. BARI Mung-2, BARI Mung-3, BARI Mung-

4, BARI Mung-5 and BINA Mung-2. The experiment was laid out in a Randomized Complete Block Design with three replications. It was observed that BARI Mung-2 produced the highest seed yield and BINA Moog-2 did the lowest.

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 (Mung bean, mothbean and clusterbean) in the arid region of Rajasthan, India. The experiment with Mung bean variety K-851 gave better yield than Asha and the local cultivar. In another experiment, Mung bean cv. PDM-54 showed 56.9% higher seed yield and 13.7% higher fodder yield than the local cultivar.

Salah Uddin *et al.* (2009) carried out in experimental field of the department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to investigate the interaction effect of variety and fertilizers on the growth and yield of summer Mung bean during the summer season of 2007. Five levels of fertilizer viz. control, N + P +K, Biofertilizer, Biofertilizer + N + P + K and Biofertilizer + P + K. and three varieties BARI Mung 5, BARI Mung 6 and BINA MOOG5 were also used as experimental variables. The experiment was laid out in Randomized Block Design with fifteen treatments where each treatment was replicated three times. BARI Mung-6 obtained highest number of nodule plant $^{-1}$ and higher dry weight of nodule. It also obtained highest number of pod plant $^{-1}$, seed plant $^{-1}$, 1000 seed weight and seed yield.

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 Mung bean (Vigna radiata L.). Among the Mung bean varieties, BINA moog 5 performed better than that of BINA moog 2 and BINA moog 4.

The performance of 20 Mung bean cultivars was evaluated by Madriz-Isturiz and Luciani-Marcano (2004) in a field experiment conducted in Venezuela during the rainy season of 1994-95 and dry season of 1995. Significant differences in the values of the parameters measured due to cultivar were recorded. The cultivars VC 1973C, Creole VC 1973A, VC 2768A, VC 1178B and Mililiter 267 were the most promising cultivars for cultivation in the area with the average yield was 1342.58 kg/ha.

Bhuiyan *et al.* (2008) Field studies with and without Bradyrhizobium was carried out with five Mung bean varieties to observe the yield and yield attributes of Mung bean. Five Mungbean varieties viz. BARI Mung-2, BARI Mung-4, BARI Mung-5, BINA moog-2 and Barisal local, and the rhizobial inoculum (Bradyrhizobium strain BAUR-604) were used. The seeds and stover were dried and weighed adjusting at 14% moisture content and yields were converted to t/ha. The yield attributing data were recorded from 10 randomly selected plants. BARI Mung-2 produced the highest seed yield (1.03 t/ha in 2001 and 0.78 t/ha in 2002) and stover yield (2.24 t/ha in 2001 and 2.01 t/ha in 2002). Higher number of pods/plants was also recorded in BARI Mung-2, while BARI Mung-5 produced the highest 1000-seed weight. Application of Bradyrhizobium inoculant produced significant effect on seed and stover yields in both trials conducted in two consecutive years. Seed inoculation significantly increased seed (0.98 t/ha in 2001, 27% increase over control and 0.75 t/ha in 2002, 29% increase over control) and stover (2.31 t/ha in 2001 and 2.04 t/ha in 2002) yields of Mung bean. Bradyrhizobium inoculation also significantly increased pods/plant, seeds/pod and 1000-seed weight. Inoculated BARI Mung-2 produced the highest seed and stover yields as well as yield attributes, such as pods/plant and seeds/pod.

Rasul *et al.* (2012) led to establish the proper inter-row spacing and suitable variety evaluation in Faisalabad, Pakistan. Three Mung bean varieties V_1, V_2, V_3 (NM-92, NM-98, and M-1) were grown at three inter-rows spacing (S_1- 30 cm, S_2- 60 cm and S_3- 90 cm) respectively. Experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement randomizing varieties in the main and inter-row spacing in the sub-plots. The data recorded were analyzed statistically using Fisher's analysis of variance technique and Least Significant Difference (LSD) test at 5% probability level. Highest seed yield was obtained for variety V_2 at 30 cm spacing. Among varieties V_2 exhibited the highest yield 727.02 kg ha^{-1} while the lowest seed yield 484.79 kg ha^{-1} was obtained with V_3. The spacing 30 cm showed highest seed yield 675.84 kg ha^{-1} as compared to other spacing treatments. Low potential varieties and improper agronomic practices may be a serious cause of low productivity in pulses. The interaction of V_2S_1 exhibited significantly higher yield than other treatments. The lowest seed yield was obtained at V_3S_1 (462.8 kg ha^{-1}). The higher yield in V_2S_1 was characterized by more number of plants in narrow spacing of 30 cm (37 plants m^{-2}), plant height of 51.4 cm, higher number of fruit bearing branches (7 per plant), the highest number of pods per plant (18.86), number of seeds per pod (10.06), 1000 grain weight (4.8 g), the highest biological yield (4894.2 kg ha^{-1}) with a harvest index of (17.75) and the highest number of nodules per plant (15) were the components of high yield formation for Mung bean variety V_2 under the inter-row spacing of 30 cm. So, it can be concluded that Mung bean variety Nm-98 should be grown at inter row spacing of 30 cm under the agro-climatic conditions of Faisalabad.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out at the Agronomy research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from March 2020 to June 2020 to study of effect of sowing date on growth and grain yields of Mung bean. The sowing time of Mung bean was March 2020 and harvesting time of Mung bean was June 2020. The details of the materials and methods i.e., experimental period, location, soil and climatic condition of the experimental area, materials that were used for the experiment, treatment, and design of the experiment, growing of crops, data collection procedure and procedure of data analysis that followed in this experiment has been presented under the following headings:

3.1 Location

The experiment, which examined the impact of sowing date on Mung bean growth and grain yields, was conducted at the agronomy research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, between March 2020 and June 2020.

3.2 Site selection

The trial site was situated 8.6 meters above sea level at 90°22 E longitude and 23°41 N latitude. The area was located in the Madhupur Tract's 28th Agro Ecological Zone (AEZ-28) (Appendix I). It belonged to the "Nodda" cultivated series and was a dark reddish brown terrace soil.

3.3 Soil

0 to 15 cm of soil was sampled from the experimental site. The majority of the soil sample was loamy soil, which ranged in texture from sandy soil to silty soil. Soil Resources and Development Institute (SRDI), Dhaka, conducted the soil analyses. In Appendix III, the physio-chemical characteristics of the soil are listed.

3.4 Climate and weather

The area's subtropical climate has three distinct seasons: winter (November to February), hot season (pre-monsoon) (March to April), and monsoon (May to October). High temperatures and heavy rainfall occur during the Kharif season (April to September), while scant rainfall and moderately low temperatures occur during the Rabi season (October to March). The climatic conditions during the study period were included in Appendix VII.

3.5 Planting materials

The variety BARI Mung-5, BARI Mung-6, BARI Mung-7 was used as planting materials in this experiment. The high yielding variety of Mung bean developed by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

BARI Mung-5:

Planting material was BARI Mung-5. In 1997, BARI finished developing it and launched it. The cultivar's plant height ranges from 40 to 45 cm. It is tolerant of yellow mosaic virus and resistant to Cercospora leaf spot. After emergence, its life cycle lasts for around 55–60 days. Synchronization of pod ripening is one of this cultivar's key traits. This cultivar has an average yield of around 1700 kg/ha. The seeds were huge, deeply green, and free of any other types of seeds, weed seeds, or other foreign objects.

BARI Mung-6:

Planting material was BARI Mung-6. In 2003, BARI finished developing it and launched it. The cultivar's plant height ranges from 40 to 45 cm. It is tolerant of yellow mosaic virus and resistant to Cercospora leaf spot. After emergence, it has a life cycle of roughly 55–58 days. Synchronization of pod ripening is one of this cultivar's key traits. This cultivar typically yields 1800 kg/ha. The seeds were huge, deep green, and free of any other seeds, weed seeds, or other foreign objects**.**

BARI Mung -7:

Plant height 50-55cm, seed color green, smooth, 1000-seed weight 28-32 g, day neutral, for this reason it is cultivated in kharif-1 and kharif-2. It is more suitable for southern part of Bangladesh.

3.6 Seed collection

The pulse seed center at the Bangladesh Agricultural Research Institute (BARI), located in Gazipur, Bangladesh, is where the Mung bean variety's seeds were procured. Before planting, the seeds were examined in the lab for germination, and the Mung bean variety had a germination rate of above 90%.

3.7 Experimental treatments

The experiment had three treatments of different sowing date of Mung bean. The treatments were as follows.

1. T_1= sowing date 15 March 2020
2. T_2= sowing date 30 March 2020
3. T_3= sowing date 15 April 2020

3.8 Experimental Design and Layout

Three replications of the experiment were set up using a Randomized Complete Block Design (RCBD). Three blocks, one for each replication, were placed in the experimental field. Nine plots were created out of each block, and treatments were distributed among them at random. The spacing between blocks was 1m, and 0.5m separated two plots. The plot was 3 m by 2 m in size. The experiment's layout is depicted in Appendix II.

3.9 Details of the field operations

The cultural operations that were carried out during the experiment are presented below

3.9.1 Land preparation

A disc plough was used to plow the ground initially. After that, it was harrowed once more to improve the tilt of the soil. The soil was broken up into tiny fragments by hammering the land's clods. The field was cleared of weeds, stubble, and agricultural remains. Finally, the land was properly prepared by using a power tiller, followed by laddering to achieve a desired tilt.

3.9.2 Fertilizer application

Following the Bangladesh Agricultural Research Institute's (BARI) advice, urea, TSP, and Mop were administered at rates of 40, 80, and 30 kg per hectare, respectively, during the process of final land preparation.

3.9.3 Sowing of seeds

The BARI Mung-5, BARI Mung-6, and BARI Mung-7 seeds were sowed on March 15, March 30, and April 15, 2020, respectively, in accordance with the treatment's recommended sowing dates. Mung bean seeds were manually planted at a depth of about 3 cm, 25 cm apart from lines with constant spacing**.**

3.9.4 Germination of seeds

Seed germination occurred from 3rd day of sowing. On the 4th day the percentage of germination was more than 80% in case of different time of sowing.

3.10 Intercultural operations

3.10.1 Thinning

The plots were thinned out on 15 days after sowing (DAS) to maintain a uniform plant stand.

3.10.2 Gap filling

To fill in the spaces where seeds failed to germinate, seedlings were transplanted. After the seeds germinated, the spaces were filled in within two weeks.

3.10.3 Weeding

Weeds were controlled through two weeding's at 15 and 25 days after sowing (DAS). Demarcation boundaries and drainage channels were also kept weed free.

3.10.4 Irrigation

Irrigation water was added to each plot.

3.11 Harvesting and sampling

The crop was considered mature when 80–90% of the pods turned a dark shade of black. There were three harvests. Hand picking was used to harvest the food. Each plot's unique bag of gathered pods was sorted before being taken to the threshing floor. Spreading the harvested pods out on the threshing floor allowed them to dry in the sun. For the seeds to be at a safe moisture level, they were separated, cleaned, and dried in the sun for three days.

3.12 Threshing

The crop was spread out on the open threshing floor for three days to be sun dried. The bundles were beaten with bamboo sticks to extract the seeds from the plants.

3.13 Drying, cleaning, and weighing.

The sun was used to dry the collected seeds, bringing the moisture content down to a safe level. We cleaned and weighed the dry seeds and straw.

3.14 Recording of data

The data were recorded on the following parameters

3.14.1. Growth parameters

a. Plant height (cm)

b. No. of leaf per plant

c. No. of branch per plant

d. Days to flowering

e. Days to maturity

3.14.2. Yield contributing parameters

a. Pods plant^{-1} (no.)

b. Pod length (cm)

c. Seeds pod^{-1} (no.)

d. 1000 seeds weight (g)

3.14.3. Yields parameter

a. Seed yield (ton ha^{-1})

b. Stover yield (ton ha^{-1})

c. Biological yield (ton ha^{-1})

d. Harvest index (%)

3.14.4. Physiological parameter

a. SPAD value

3.15 Procedures of Data Collection

a. Plant height (cm)

Five plants were collected randomly from each plot. The height of the plants was measured from the ground level to the tip of the plant at days after sowing (DAS) and harvested stage to observe the growth rate of the plants.

b. No. of leaf per plant

The number of leaves per plant was counted at 30 DAS and harvested from selected plants. The average number of leaves per plant was determined and recorded.

c. No. of branch per plant

The number of branches per plant was counted at harvest from selected plants. The average number of branches per plant was determined and recorded.

d. No. of pods per plant

Number of pods plant^{-1} was counted from the five plant sample and then the average pod number was calculated.

e. Pod length (cm)

The length of pods was measured from ten randomly selected pods, collected from five randomly selected plants plot^{-1} at harvest and then the average value was recorded.

f. No. of seeds per pod

The pods from each of five plants plot^{-1} were separated from which ten pods were selected randomly. The number of seeds pod^{-1} was counted and average number of seeds per pod was determined.

g. Weight of 1000 seed (g)

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

h. Seed yield (ton ha^{-1})

Seed yield was recorded on the basis of total harvested seeds plot^{-1} (1m^2) and was expressed in terms of yield (ton ha^{-1}). Seed yield was adjusted to 12% moisture content.

i. Stover yield (ton ha^{-1})

After separation of seeds from plant, the straw and shell of harvested area was sun dried and the weight was recorded and then converted to t ha^{-1}.

j. Biological yield (ton ha^{-1})

The summation of seed yield and above ground Stover yield was the biological yield.

Biological yield = Grain yield + Stover yield.

k. Harvest index (%)

The harvest index denotes the ratio of economic yield (seed yield) to biological yield and was calculated with the following formula.

Harvest index (%) = Seed yield/Biological yield x 100

l. SPAD value

The measurement was conducted five times for each leaf and the mean was calculated as the SPAD value of the given leaf. SPAD value is measurement of chlorophyll content in leaf.

3.16 Data analysis technique

The data collected on different parameters under the experiment were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program STATISTIX- 10 and the differences between pairs of means were compared by Least Significant Difference (LSD).

CHAPTER IV

RESULTS AND DISCUSSION

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

4.1 Plant height

The plant height was varied significantly influenced by different sowing dates in case of all three varieties (V_1=BARI Mung-5, V_2=BARI Mung-6, V_3=BARI Mung-7) at 30 DAS and harvest. Data on plant height were recorded periodically at 30 days after sowing (DAS) and harvest time. The plant height was significantly affected due to the different varieties at different days after sowing. In case of V_1, the highest plant height of 16.5 cm was observed at 30 DAS and 44.33 cm at harvest on T_3 (15 April 2020). In case of V_2, the highest plant height was 22.67 cm at 30 DAS and 51 cm at harvest on T_1 (15 March 2020). In case of V_3, the highest plant height was 20.67 cm at 30 DAS and 55.17 cm at harvest on T_1. Overall, the highest plant height was observed in V_2 when sown on 15 March 2020 (T_1). Plant height increased gradually with delay in sowing due to increased temperature as reported by Poehlman (1993). This variation in plant height might be attributed to the genetic characters. Usually harvesting of fruits are done when the maximum fruits are ripening at the first time. But if the plants are kept in the field for longer period the life span of plants is extended further giving new flowers and fruits. Similar findings of plant heights were obtained by Farghali and Hossein (1995).

Table 1. Interaction effect of different varieties and sowing dates on plant height on Mung bean

Treatment	Plant height (cm)	
	30 DAS	Harvest
V_1T_1	12.50 e	41.67 e
V_1T_2	14.67 de	42.33 de
V_1T_3	16.50 cd	44.33 d
V_2T_1	22.67 a	51.00 b
V_2T_2	20.50 ab	48.33 c
V_2T_3	17.8 bcd	46.83 c
V_3T_1	20.67 ab	55.17 a
V_3T_2	20.00 ab	54.83 a
V_3T_3	18.67 bc	53.33 ab
$LSD_{(0.05)}$	3.5	2.44
CV (%)	11.8	12.9

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

4.2 Number of leaves per plant

The number of leaves per plant counted at different days were significantly influenced by varieties. Data on number of leaves were recorded at periodically. From the observation we could see that the in case of V_1 the maximum number of leaves were 4.33 cm at 30 DAS and 12.6 cm at harvest which were observed on T_1. In case of V_2 the maximum number of leaves were 4.66 cm at 30 DAS and 15 cm at harvest on T_1. In case of another variety V_3, the maximum number of leaves were 4 cm at 30 days after sowing and 11.33 cm at harvest on T_1. Overall, the highest number of leaves per plant was observed in V_2 when sown on 15 March 2020 (T_1).

Table 2. Interaction effect of different varieties and sowing dates on number of leaves on Mung bean

Treatment	Number of leaves	
	30 DAS	Harvest
V_1T_1	4.33 ab	12.66 b
V_1T_2	3.66 abc	11.00 bcd
V_1T_3	3.00 c	9.00 d
V_2T_1	4.66 a	15.00 a
V_2T_2	3.66 abc	11.66 bc
V_2T_3	3.33 bc	10.00 cd
V_3T_1	4.00 abc	11.33 bc
V_3T_2	3.66 abc	10.66 bcd
V_3T_3	3.33 bc	9.66 d
$LSD_{(0.05)}$	1.18	2.05
CV (%)	18.28	10.55

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

4.3 Days to first flowering

There was a marked difference among the varieties in the days to first flowering. The earliest of days to first flowering (29) was found in V_1 when sown on T_3 and the longest time (36.67) were recorded in V_2 when sown on T_2 (fig 1). Number of days required for first flowering were reduced with delay in sowing; the resultant effect might be due to increased temperature. Singh *et al*. (2010) observed by earlier 50% flowering with delayed sowings have been observed in Mung bean.

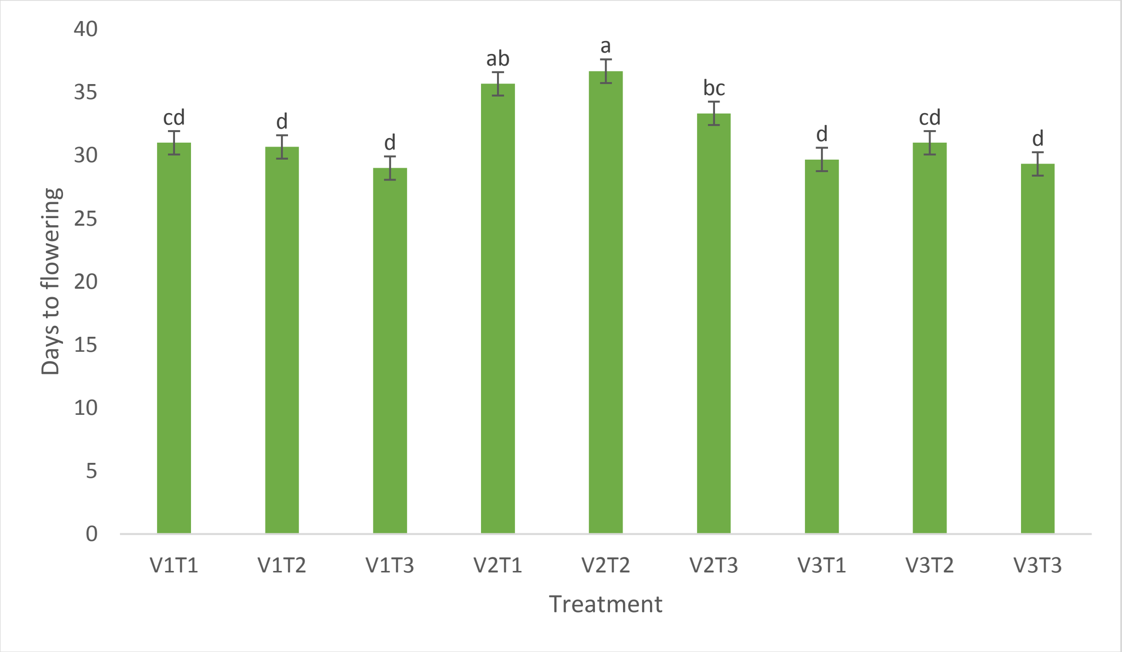


Fig 1: Effect of varieties and sowing dates on days to first flowering on Mung bean.

4.4 Days to Maturity

The maturity of plant was varied significantly influenced by different varieties on Mung bean. From the observation we can assume that the highest days required for the maturity of the plant were 66 days, and the lowest were 55.67 days. High temperature delayed flowering as well as maturity.

Table 3. Interaction effect of different varieties and sowing dates on maturity on Mung bean

Treatment	Maturity
V_1T_1	57.33 b
V_1T_2	57.33 b
V_1T_3	55.67 b
V_2T_1	58.00 b
V_2T_2	58.00 b
V_2T_3	58.33 b
V_3T_1	66.00 a
V_3T_2	66.00 a
V_3T_3	65.67 a
$LSD_{(0.05)}$	4.26
CV (%)	4.09

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

4.5 Number of branches per plant

There was a significant difference among the varieties in the number of branches per plant. In case of V_1, the maximum number of branches per plant that was 1.67 in number were observed at 30 DAS and 4.67 at harvest when sown on T_1. In case of V_2, the maximum number of branches per plant were observed at 30 DAS (2.67) and 7.67 at harvest when sown on T_3. In case of V_3, the maximum number of branches per plant were observed 2.33 at 30 DAS and 7.67 at harvest when sown on T_3. The number of branches showed significant variation due to the different sowing time. Minimum number of branches per plant were mainly responsible for the lowest dry matter production. Mehmet (2008) who stated that as spacing gets wider, there will be more interception of sunlight for photosynthesis, which results in the production of more nutrients for partitioning toward the development of more branches.

Table 4. Effect of different varieties and sowing dates on number of branch per plant on Mung bean

Treatment	Number of branches/plant	
	30 DAS	Harvest
V_1T_1	1.67 a	4.67 cd
V_1T_2	2.00 a	4.00 d
V_1T_3	2.00 a	4.00 d
V_2T_1	2.67 a	5.67 bcd
V_2T_2	2.00 a	7.33 ab
V_2T_3	2.00 a	7.67 a
V_3T_1	2.33 a	5.33 cd
V_3T_2	2.00 a	6.00 abc
V_3T_3	2.00 a	7.67 a
LSD $_{(0.05)}$	1.61	1.71
CV (%)	44.98	17.04

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

4.6 Number of pods per plant

Data on number of pods per plant were recorded at harvest. The number of pods per plant were significantly affected due to the different varieties at different days after sowing. The highest number of pods per plant (39) was recorded in V_2 when sown onT_1. The lowest number of pods plant^{-1} (28.33) were recorded in V_1 when sown on T_2. Genotypic variations in effective pods plant^{-1} were observed by Mondal *et al.* (2004) in Mung bean.

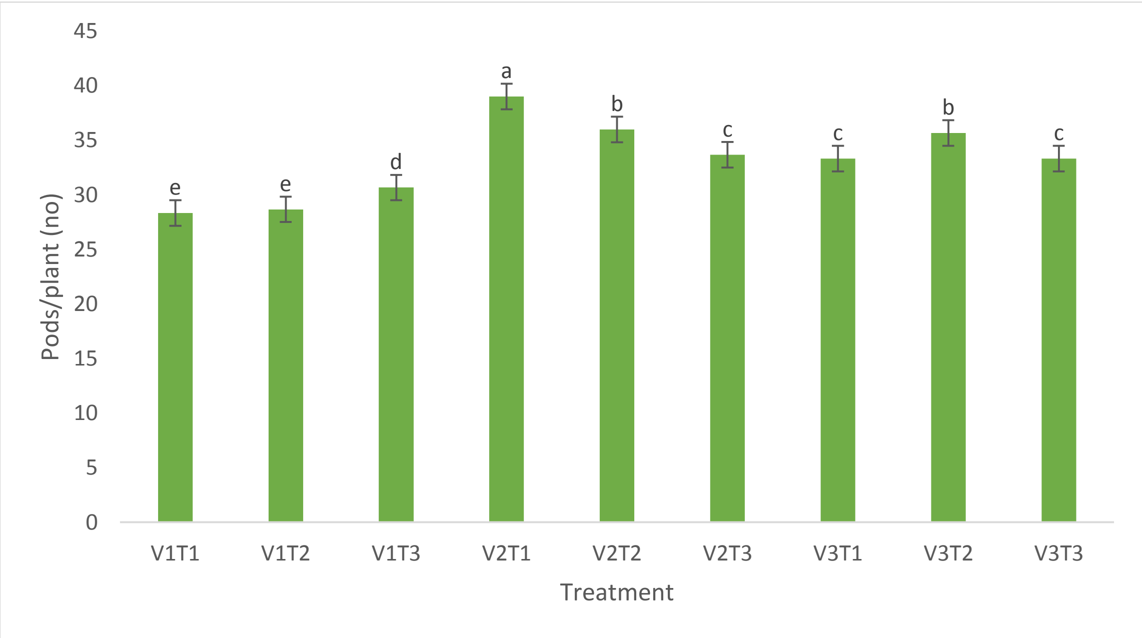


Fig 2: Combined effect of different variety and different sowing dates on number of pods per plant on Mung bean.

4.7 Number of seeds per pod

The number of seeds per pod was significantly affected by varieties. The maximum number of fertile seeds per pod (14) was recorded in V_2 when sown on T_1. The minimum number of fertile seeds per pod (11.03) was observed in V_1 when sown on T_1. A result was found by Infante *et al*. (2003) which was similar with this study. They found significant difference on number of seeds per pod among the varieties. Genotypic variations in seeds pod^{-1} was also observed by Thakuria and Saharia (1990) in Mung bean.

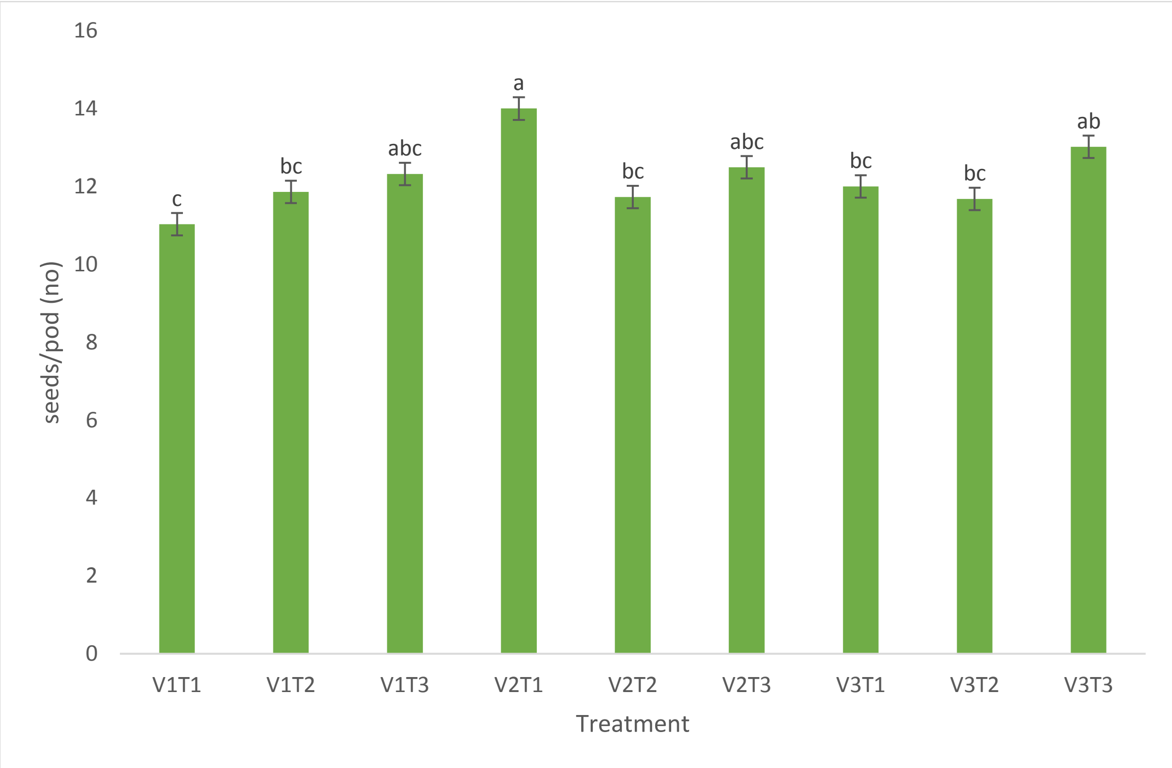


Fig 3: Combined effect of different variety and different sowing dates on number of seeds per pod on Mung bean.

4.8 Pod Length

Pod length is one of the most important yield contributing characters in Mung bean. The maximum pod length (14.67 cm) was recorded on V_2 (BARI Mung- 6). The minimum pod length (11.1 cm) was observed on V_1 (BARI Mung- 5). Pod length varies from variety to variety which also findings of Parvez *et al*. (2013) and Mahbub *et al*. (2016). The probable reason of this difference could be the genetic make-up of the varieties.

Table 5. Interaction effect of different varieties and different sowing dates on pod length on Mung bean

Treatment	Pod length (cm)
V_1T_1	11.10 b
V_1T_2	11.84 b
V_1T_3	12.27 ab
V_2T_1	14.67 a
V_2T_2	12.99 ab
V_2T_3	12.87 ab
V_3T_1	12.35 ab
V_3T_2	12.43 ab
V_3T_3	13.35 ab
$LSD_{(0.05)}$	2.59
CV (%)	12.85

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

4.9 1000-seed weight

Variety had a significant effect in 1000-seed weight, and it was also observed in studied varieties of Mung bean. Results showed that weight of 1000 seeds influenced by different sowing dates were statistically significant. The highest 1000- seed weight was recorded in BARI Mung- 6 (53.18 g). In contrast, the lowest 1000-seed weight was recorded in BARI Mung- 5 (44.7 g) in fig 4. The result was not corroborating with the findings of Farghali and Hussein (1995). They observed that Mung bean grown under different sowing time, 2nd sown crop was superior to 1st and 3rd sowings with respect to number of cluster per plant, number of seeds per pod and 1000 grain weight. Optimum sowing time gave the earliest maturity and a significant increase in number of pods plant^{-1}, number of grains plant^{-1} and 1000 grain weight compared to early and late sowing. Genotypic variation in 1000-seed weight was also observed by Tomar *et al*. (1996) in Mung bean that also supported the present experimental results.

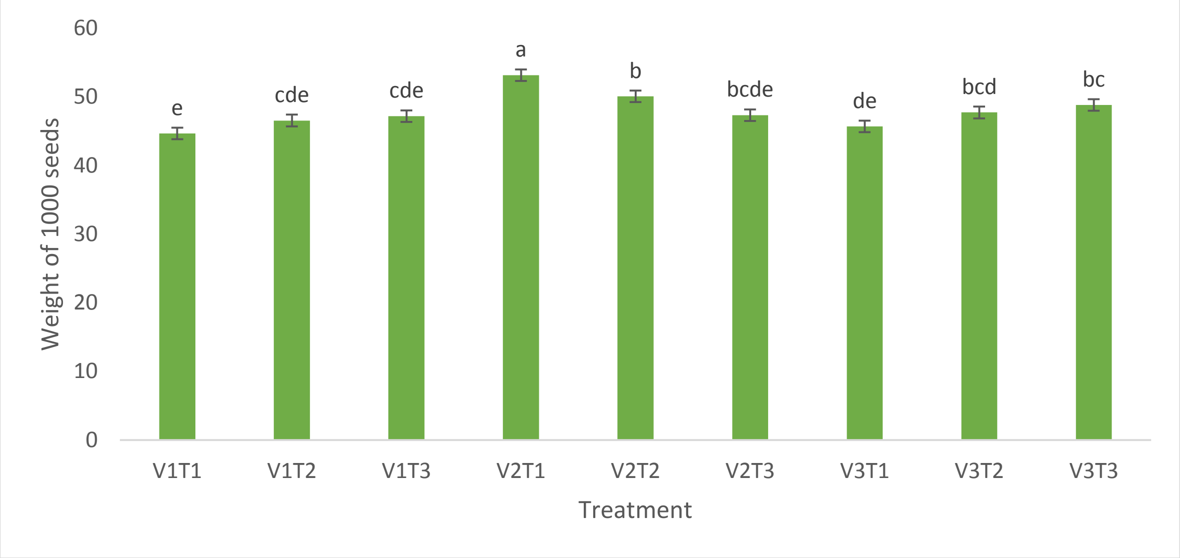


Fig 4: Effect of sowing dates on different varieties on 1000 seed weight on Mung bean.

4.10 SPAD value

There was a significant variation in SPAD value on different sowing dates on Mung bean. In case of V_1, the highest SPAD value was observed on T_2 and lowest value on T_3. In case of V_2, the highest value was observed on T_1 and lowest value was on T_2. In case of V_3, the highest value was observed on T_3 and lowest value on T_2. Overall, the maximum SPAD value was recorded in V_2 when sown on T_1 and the minimum value was recorded in V_1 when sown on T_3 (fig 5).

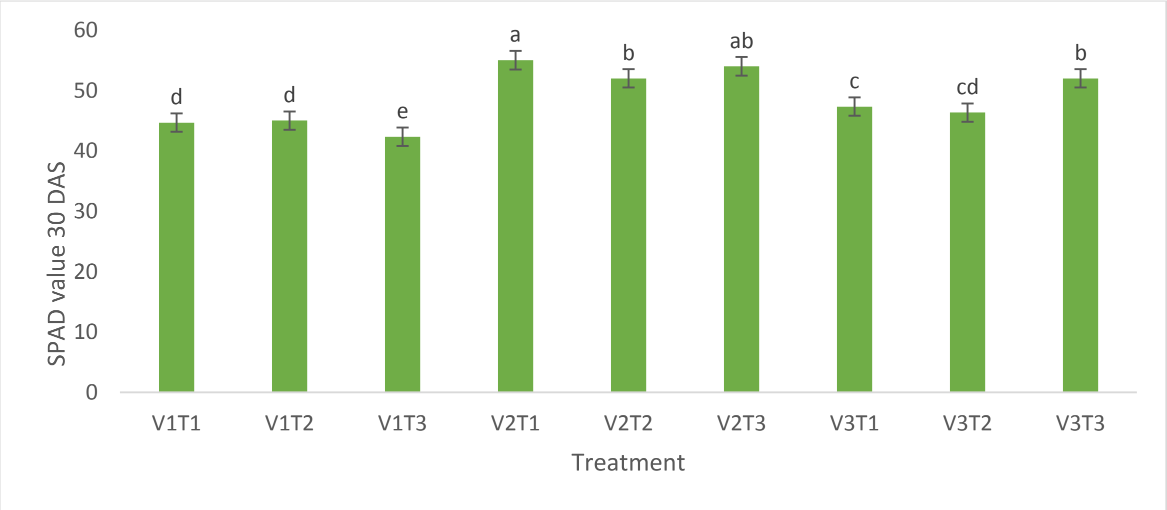


Fig 5: Effect of sowing date on SPAD value on Mung bean.

4.11 Seed Yield

The seed yield was significantly affected by varieties. Seed yield ton per ha is a function of various yield components such as number of pods per plant, seeds per pod and 1000-grain weight. The maximum yield ton per ha (1.68 g) was recorded in V_2 and the minimum (1.34 g) in V_1 (Table 6 and Appendix VI). The probable reason of this difference might be due to higher number of pod length, seeds per pod. The performance of other varieties was as intermediate yielder. Genotypic variation in seed yield was also observed by Borah (1994). This finding was not closely resembling to those reported by Sinha *et al*. (1989), Poehlman (1991) and Miah *et al.* (2009) who opined that Mung bean being a warm season plant produced higher yield at the optimum mean temperature range of 25-30°C. The highest seed yield obtained due to suitable temperature prevailing accompanied by higher soil moisture content due to sufficient rainfall, which enhanced the vegetative as well as reproductive growth of the crop and the lowest yields of low-quality seeds are produced in late sowing of Mung bean. Late sown crop could not attain proper growth which resulted in drastic reduction in yield. This results also resembles to Rakesh *et al.* (2000) indicated that Mung bean crop sown on 15th March had higher number of pods plant^{-1}, seeds pod^{-1} and higher grain yield. Sangakkara (1998) reported from Sri Lanka that late sowing of Mung bean produced the lowest yields of low-quality seeds. For better production we can sow the seed proper time.

Table 6. Combined effect of different varieties and different sowing date on seed yield on Mung bean crop

Treatment	Seed yield (tonha^{-1})
V_1T_1	1.34 d
V_1T_2	1.48 bc
V_1T_3	1.46 cd
V_2T_1	1.68 a
V_2T_2	1.59 ab
V_2T_3	1.48 bc
V_3T_1	1.48 bc
V_3T_2	1.58 abc
V_3T_3	1.48 bc
$LSD_{(0.05)}$	0.12
CV(%)	4.60

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

4.12 Stover yield

Stover yield of Mung bean varied significantly due to different sowing dates (fig 6). The highest stover yield (1.88-ton ha^{-1}) was recorded on V_2T_1 (Sowing on 19 March) treatment while the lowest stover yield (1.29-ton ha^{-1}) was recorded on V_1T_2 (Sowing on 27 March). This result was not similar with the findings of Mohsina (2014) where S_2 (13 September) produced the highest stover yield (1.78 t ha^{-1}) followed by S_1 (24 August) (1.59 t ha^{-1}) and lowest in S_4 (23 October) (0.25 t ha^{-1}). The highest yield was found on optimum sowing date and in late planting it affected the yield and yield attributing characters of crop.

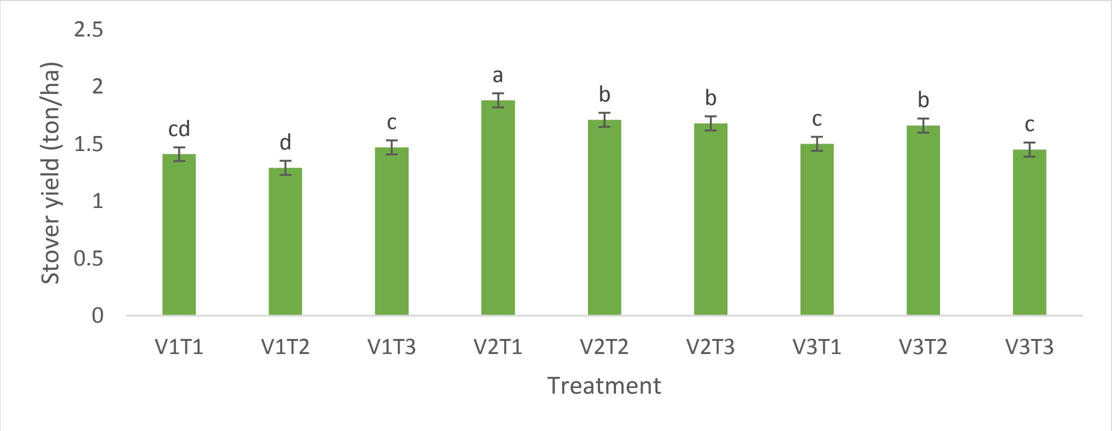


Fig 6: Combined effect of sowing dates and different varieties on stover yield on Mung bean.

4.13 Biological yield

Biological yield was significantly influenced by different sowing dates. The maximum biological yield (3.5 t ha^{-1}) was recorded on V_2T_1 treatment while the minimum biological yield (2.7 t ha^{-1}) was recorded on V_1T_1(fig 7). Suitable sowing time is the most important factors affecting the yield. Majority of crops can utilize the factors of favorable environment which ultimately influences plant to have more growth and development. Lower yield under delayed sowing was the result of reduction in biological yield. Quresh and Rahim (1987), who found that earlier planting gave significantly higher mean biological yield. The probable reason for this might be the less plant population in early sowing and heavy rains, which adversely affected the Mung bean production.

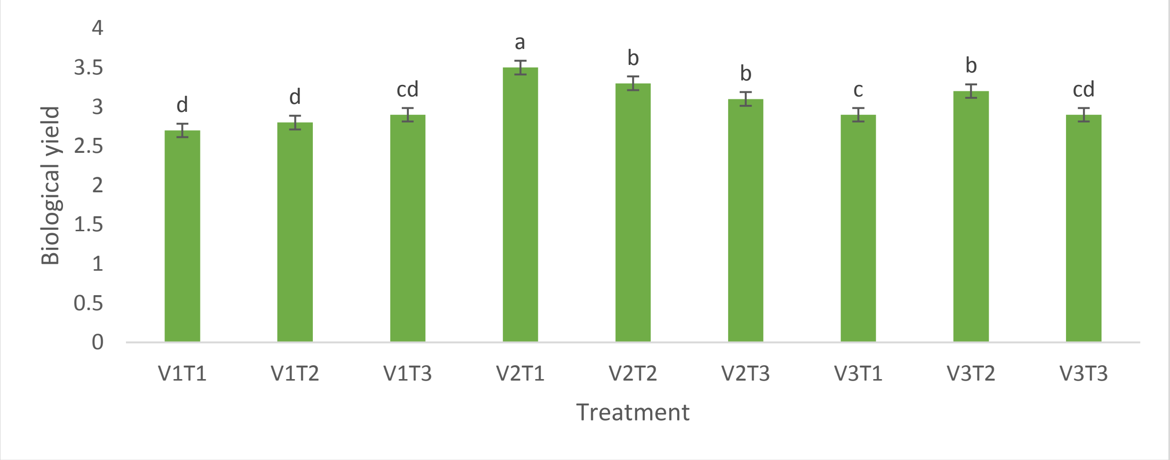


Fig 7: Effect of sowing dates and different varieties on biological yield on Mung bean.

4.14 Harvest index

There was a significant variation in Harvest index in terms of different sowing dates. The maximum Harvest index (53.33 %) was recorded on V_2T_1 treatment while the minimum Harvest index (46.6%) was recorded on V_2T_3 (fig 8). The dissimilar result was reported by Seijoon *et al.* (2000) who found that the increased harvest index with late sowing could be related to high assimilate use efficiency due to increased sink capacity. The lowest harvest index was calculated from the last sowing (11 April), which might be due to elevated ambient temperature and higher cumulative rainfall that enhanced vegetative growth of the crop resulting in larger canopy but few pods, as reported by Gaaster (1993). Hussain (2003), who found that sowing methods affected the harvest index and maximum harvest index was recorded with bed sowing.

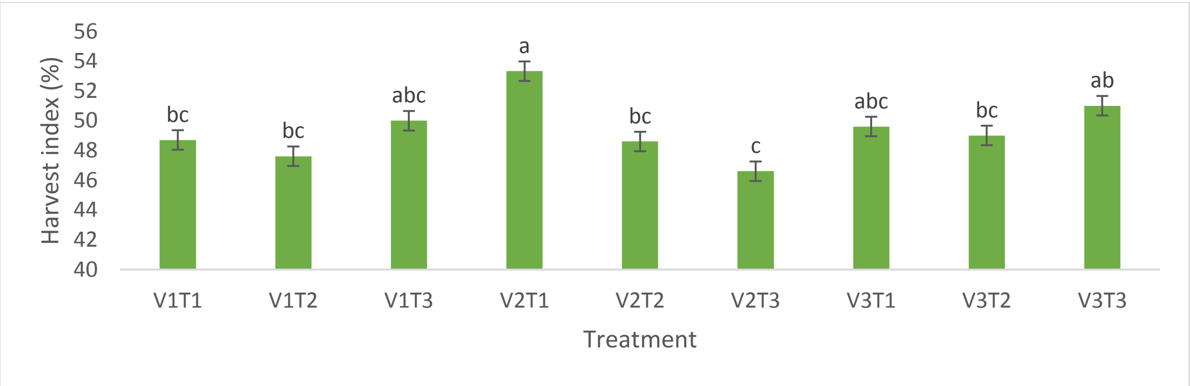


Fig 8: Effect of sowing dates and different varieties on harvest index on Mung bean

CHAPTER V

SUMMARY AND CONCLUSION

The present experiment was carried out at the farm of Sher-e-Bangla Agricultural university, Dhaka-1207 to find out the effect of sowing date on growth and yield of Mung bean (*Vigna radiata* L.) during the period from March 2020 to June 2020. The experiment comprised of three varieties, viz., V_1=BARI Mung-5, V_2= BARI Mung-6, V_3= BARI Mung-7 and three treatment of sowing dates (T_1= 15 March 2020, T_2= 30 March 2020, T_3= 15April 2020).

The experiment was set up in Randomized Complete Block Design (RCBD) with three replications. In total, there were nine treatment combinations in this study. A unit plot was 3m x 2m and the treatments were distributed randomly in each block. The experimental plot was fertilized at the rate of 40 kg/ha (Urea), 80 kg/ha (TSP), 30 kg/ha (Mop). Necessary intercultural operations were done as and when necessary. Data on growth and yield parameters were recorded and analyzed statistically. The recorded data on various parameters were statistically analyzed. Following STATISTIX- 10 software package programme. Difference between treatment means were adjusted by Least Significant Difference (LSD). Data were taken on growth and yield contributing characters and the collected data were statistically analyzed for evaluation of the treatment effects. The summary of the results has been described in this chapter.

The plant height was significantly affected due to the different varieties at different days after sowing. The tallest plant height in case of V_1, the highest plant height of (16.5 cm) at 30 DAS and (44.33 cm) at harvest was observed on T_3(15 April 2020). In case of V_2, the highest plant height was (22.67 cm) at 30 DAS and (51 cm) at harvest on T_1 (15 March 2020). In case of V_3, the highest plant height was (20.67 cm) at 30 DAS and (55.17 cm) at harvest on T_1. The highest number of leaves was (4.66) at 30 DAS and (15) at harvest time.

The earliest of days to first flowering (29 DAS) was found in V_1 when sown on T_3 and the longest time (36.67 DAS) were recorded on T_2 treatment. In case of V_1, the highest number of branches per plant was observed in (1.67) at 30 DAS and (4.67) at harvest when sown on T_1. In case of V_2, the highest number of branches per plant was observed in (2.67) at 30 DAS and (7.67) at harvest when sown on T_3. In case of V_3, the highest number of branches per plant was observed in (2.33) at 30 DAS and (7.67) at harvest when sown on T_3. The number of branches showed significant variation due to the different sowing time. The number of pods per plant was significantly affected due to the different varieties at different days after sowing. The highest number of pods per plant (39 DAS respectively) was recorded in V_2 when sown on T_1. The lowest number of pods plant^{-1} (28.33 DAS respectively) was recorded in V_1 when sown on $T_{2.}$ The highest number of fertile seeds per pod (14) was recorded in V_2 when sown on T_1. The minimum number of fertile seeds per pod (11.03) was observed in V_1 when sown on T_1. The maximum pod length (14.67 cm) was recorded on V_2T_1. The highest 1000- seed weight was recorded in V_2 when sown on T_1(53.18 g). The maximum spad value was recorded on V_2T_1. The highest yield ton per ha (1.68 g) was recorded in V_2 and the minimum (1.34 g) in V_1. The highest Stover yield (1.88-t ha^{-1}) was recorded on V_2T_1 (Sowing on 15 March) treatment while the lowest Stover yield (1.29-t ha^{-1}) was recorded on V_1T_2 (Sowing on 30 March). The maximum biological yield (3.5 t ha^{-1}) was recorded on V_2T_1 treatment. Suitable sowing time is the most important factors affecting the yield. The maximum Harvest index (53.33 %) was recorded on V_2T_1 treatment while the lowest Harvest index (46.6%) was recorded on V_2T_3 due to elevated ambient temperature and higher cumulative rainfall that enhanced vegetative growth of the crop.

From the results of the study, it may be concluded as follows:

- Throughout the whole life cycle of the plant, the BARI Mung-6 Mung bean variety performed better in terms of growth, yield, and yield components. The lowest yield was produced by BARI Mung-5.
- According to the results of the current study, Mung bean sowing on March 15 may considered to produce a higher yield. Among variations, BARI Mung-6 seems to be suited to Bangladesh's agro-ecological conditions.
- From the present study it may be concluded that 15 March sowing may be adapted for obtaining higher yield in Mung bean. Among varieties, BARI Mung-6 appears to be well adapted to the agro-ecological conditions in Bangladesh. There are significant differences in the morphological and reproductive performances of different varieties of Mung bean.

- Further detailed study is needed to notice the reproductive behavior of Mung bean for better understanding. This kind of study has to be executed in different agro ecological zones of Bangladesh to have a concrete direction. However, to reach a specific conclusion and recommendation, the same experiment need to be repeated and more research work should be done over different agro ecological zones with different variety with sowing conditions.

CHAPTER VII

REFERENCES

Abedin, M.Z. and Anwarul, M. (1991). Prospects of Increasing Pulse Production Through Improved Cropping Systems. In: Proceedings of the 2nd National Workshop on Pulses. BARI, Joydebpur, Gazipur. 65-73.

Ahmad, A., Karim, F., Shamdane, G. and Maniruzzaman, A.F.M. (2003). Effect of time of weeding and plant density on the growth and yield of Mung bean. *Bangladesh J. Agric. Res.* 16 (2): 23-25.

Ahmed, Z.U., Shaikh, M. A., Khan, A.I. and Kaul, A.K. (1978). Evaluation of local exotic and mutant germplasm of Mung bean for varietal characters and yield in Bangladesh. *SABRAO J.* 10: 48-51.

Ahmed, Z.U., Shaikh, M.A.Q. and Razzaque, M.A. (1987). Bangladesh Assoc. Advan. Sci. Dhaka (Bangladesh) In: Proc. 12th Ann. Bangladesh Sci. Conf., Section 1, Dhaka (Bangladesh), BAAS. p.13.

Al-Hussien, N., Bayaa, B. and Erskine, W. (2002). Integrated Management of lentil broomrape, 1. Sowing date and chemical treatments. *Arab J. Plant Prot.* 20 (2):84-92.

Ali, M. and Gupta, S. (2012). Carrying capacity of Indian agriculture: Pulse crops. *Current Science,* 102: 874-881.

Ali, S., Khaliq, T., Ahmad, A., Rehman,M., Hussain,S., Rehman, K. and perve, A.W. (2014). Genotypic Variations in Mung Bean Yield and its Attributes in Response to Different Sowing Times. *Res. J. Agric. Environ. Manage*. 3(5), pp. 255-258.

Anonymous. (2016). Agronomy project coordinator report Mung bean and urdbean. All India coordinated research project on MULLaRPICAR. *Indian Institutes of Pulse Research.* 20: 80-84.

Asghar, A., Chaudhry, A.M., Tanveer, A. (2006). Response of mung bean (*Vagina radiate* L.) genotypes to rhizobia culture. *Pakistan Journal of Agriculture Science,* 37: 1-2.

Asghar, M., Saleeem, M. F., Ali, A. and lshaq, R. A. F. (2006). Effect of sowing date and planting patterns on growth and yield of Mung bean. *J. Agric. Res.* 44:139 -146.

Aslam, M., Mahmood, I.A., Sultan, T., Ahmad, S. (2000). Inoculation approach to legume crops and their production assessment in Pakistan-A Review. *Pakistan Journal of Biological Science,* 2: 193-195.

Aslam, M.M., Zeeshan, M., Irum, A., Hassan, M.U., Ali, S., Hussain, R., Ramzani, P.M.A. and Rashid, M.F. (2015). Influence of seedling age and nitrogen rates on productivity of rice (*Oryza sativa* L.): A Review. *American Journal of Plant Sciences*, 6: 1361-1369.

BARI (Bangladesh Agricultural Research Institute). (1997). Report of lentil, blackgram and Mung bean development pilot project. Pulse Res. Sta., Bangladesh Agril. Res. Inst., Joydebpur, Gazipur.1701, Bangladesh. pp. 24-25.

BARI (Bangladesh Agricultural Research Institute). (1998). Bangladesh-e Moog Daler Chash (in Bangla)-Mung Bean Cultivation in Bangladesh. Pulse Res. Sta., Bangladesh Agril. Res. Inst., Joydebpur, Gazipur-1701, Bangladesh. p. 45.

Barros, J.F., Carvalho, M., and Basch, G. (2004). Response of sunflower (*Helianthus annuus* L.) to sowing date and plant density under Mediterranean conditions. *European Journal of Agronomy*, 21: 347-356.

BBS. (2009). Bangladesh Bureau of Statistics, Statistical Yearbook of Bangladesh, Statistics Division, Ministry of Planning, GOB.

BBS. (2022). Bangladesh Bureau of Statistics, Statistical Yearbook of Bangladesh, Statistics Division, Ministry of Planning, GOB.

Berry, J. and Bjorkman,O. (1980). Photosynthetic response and adaptation to temperature in higher plants. *Annu. Rev. Plant Physiol*. 31: 491-543.

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.

Bhuiyan, M.A.H., Mian, M.H. and Islam, M.S. (2008). Studies on the effects of Bradyrhizobium inoculation on yield and yield attributes of Mung bean. *Bangladesh J. Agril. Res*. 33(3): 449-45.

Borah, U.K. (1994). Performance of green gram genotypes under different seed rates during summer season. *J. Agric. Sd. Soc. North East India*, 7: 79-81.

Bose, R.D. (1982). Studies in Indian pulses. *Indian J. Agric. Sci*. 52: 604-624.

Chahal, S.S. (1998). Effect of sowing date on the growth, yield and quality of Mung-bean (Vigna radiata (L.) Wilczek) cultivars under irrigated conditions. M.Sc. thesis, Punjab Agric. Univ. Ludhiana, India.

Chalanka De Silva, H.C. and Asaeda, T. (2017). Effects of heat stress on growth, photosynthetic pigments, oxidative damage and competitive capacity of three submerged macrophytes. *J. Plant Int*., 12: 228-236.

Chauhan, Y.S., Douglas, C., Rachaputi, R.C.N., Agius, P., Martin, W., King, K. (2010). "Physiology of Mung bean and development of the Mung bean crop model," in Proceedings of the 1st Australian Summer Grains Conference Australia, Gold Coast, QL. 21–24.

Choi, K.J., Lee, Y.S., Choi, H.K., Kim, T.S. and Lee, U. (1991). Study on varietal variation for some agronomic characters under different sowing dates. Res. Rep Rural Develop Admin. *Upland Ind. Crops*. 33: 15-22

Chovatia, P.K., Ahiawat. R.P. and Trivedi. S.J. (1993). Growth and yield of summer green gram as affected by different dates of sowing, Rhizobium inoculation and levels of phosphorus. *India. J. Agron*. 38: 492-494.

Dharmalingam, C. and Basu R.N. (1993). Determining optimum season for the production of seeds in Mung bean. *Madras Agric. J*., 80: 684–688.

Dudeja, S.S., Sheokand, S., and Kumari, S. (2012). Legume Root Nodule Development and Functioning under tropics and subtropics: Perspectives and Challenges. *Legume Res*., 35(2): 85-103.

El-Noemani A. A, El-Zeiny H. A, El-Gindy A. M, Sahhar E.A. and El-Shawadfy M. A. Performance of some bean (Phaseolus Vulgaris L.) varieties under different irrigation systems and regimes. *Aust J Basic Appl Sci*. 2010; 4:6185–96.

FAO (Food & Agriculture Organization). (1984). Mung bean: A Guidebookon Production of Pulses in Bangladesh, p: 27. Project Mannual,Khamarbari, Farmgate, Dhaka, Bangladesh.

Farghali, M.A. and Hussein, H.A. (1995). Potential of genotypic and seasonal effect on growth and yield of Mung bean (Vigna radiata (L.) Wilczek). *Asian J. Pl. Sci*. 26: 13-21.

Farrag, M.M. (1995). Yield of 23 Mung bean accessions as affected by planting dates under El- Minia conditions. *Ann. Agril. Res*. 26: 49-62.

Fraz, R.A., Iqbal, J. and Bakhsh, M.A.A.H.A. (2006). Effcct of sowing dates and planting patterns on growth and yield of Mung bean (Vigna radiata L) cv. M-6. *Int. J. Agric. Biol*. 8: 363- 65.

Gaaster, P. (1993). Climatic control of photosynthesis and respiration. In:Evans, L.T. (ed.), Environmental Control of Plant Growth, pp: 113–118. Academic Press, New York.

Gebologlue, N., A. Ecc and Yazgan, A. (1996). The effect of different sowingperiods on the agronomic characteristics of Mung bean (Vigna radiata L) in the ecological conditions of Tokat/Turkey. *Acta Hortic.J*., 1: 259–64.

Hamama, A.A. (2015). Cultivar, Planting Date, and Row Spacing Effects on Mung Bean Performance in Virginia. HortScience, 50, 1309-1311. Retrieved from http://www.ashs.

Hanlan, T.G., Ball, R. A. and Vandenberg, A. (2006). Canopy growth and biomass partitioning to yield in short-season lentil. *Canadian J. Pl. Sci*. 86(1): 109-119.

Hasanuzzaman, M., K. Nahar and Fujita, M. (2013). Extreme temperatures, oxidative stress and antioxidant defense in plants. In: Abiotic Stress Plant Responses and Applications in Agriculture, pp. 169-205. K. Vahdatiand and C. Leslie (eds.): InTech, Rijeka, Croatia.

Hassan, M.U, Aamer, M., Chattha, M.U, Haiying, T., Shahzad, B., Barbanti, L., Nawaz, M., Rasheed, A., Afzal, A., Liu, Y. and Guoqin, H. (2020b). The critical role of zinc in plants facing the drought stress. *Agriculture*, 10(9): 396.

Hassan, M.U., Chattha, M.U., Barbanti, L., Mahmood, A., Chattha, M.B., Khan, I., Mirza, S., Aziz, S.A., Nawaz, M. and Aamer, M. (2020c). Cultivar and seeding time role in sorghum to optimize biomass and methane yield under warm dry climate. *Industrial Crops and Products*, 145: 111983.

Hassan, M.U., Chattha, M.U., Khan, I., Chattha, M.B., Barbanti, L., Aamer, M., Iqbal, M.M., Nawaz, M., Mahmood, A., Ali, A. and Aslam, M.T. (2020a). Heat stress in cultivated plants: Nature, impact, mechanisms, and mitigation strategies. A review. *Plant Biosystems*, 155: 211-234.

Hossain, M.A., Jannatul F. and Salim, M.M.R. (2006). Relative abundance and yield loss assessment of lentil aphid, Aphis craccivora Koch in relation to different sowing dates. *J. Agric. Tural Dev*. Gazipur. 4 (1/2): 101-106.

Hussain, A., Khalil, S.K. and Khan, H. (2004). Effect of sowing time and variety on grain yield of Mung bean. *Sarhad. J. Agric*. 20(4): 481-484.

Infante, N., Madriz, P. and Gonzalez, T. (2003). Phases of development and yield components of three Mung bean cultivars (Vigna radiata L. Wilczek). in Maracay,Aragua state, Venezuela. *Revista Faculty of Agronomy*. 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 Mung bean. *Intl. J. Bot*. 2(1): 36-41.

Jahan, N. and Adam, A.M.G. (2012). Growth and yield performance of BariMung- 5 under different time of sowing. *J. Bangladesh Acad. Sci*. 36: 227-31.

Jan, A., F.H. Taj., Khan, I.A. and Khan, N. (2002). Effect of sowing dates on yield and yield components of Mashbean varieties. *Asian Journal of Plant Science*, 10: 622-624.

Kabir, M.H. and Sarkar, M.A.R. (2008). Seed yield of Mung bean as affected by variety and plant spacing in Kharif-I season. *J. Bangladesh Agril. Univ*. 6(2): 239–244.

Kabir, M.H. and Sarkar, M.A. (2008). Seed yield of Mung bean as affected by variety and plant spacing in kharif-I season. *J. Bangladesh Agric. Univ*. 6: 239-244.

Karim, M.A., Fracheboud, Y. and Stamp, P. (1999). Photosynthetic activity of developing leaves of Zea mays is less affected by heat stress than that of developed leaves. *Physiol. Plant*. 105:685-693.

Kaushal, N., Awasthi, R., Gupta, K., Gaur, P., Siddique, K.H., and Nayyar, H. (2013). Heat-stress-induced reproductive failures in chickpea (Cicer arietinum) are associated with impaired sucrose metabolism in leaves and anthers. *Functional Plant Biology*, 40(12), 1334-1349.

Kazemekas, O. (2001). Seed yield of lentils in relation to sowing time and seed rate. *Zemdirbyste, Mokslo Darbai*. 74: 128-134.

Lobell, D.B.; Schlenker, W.; Costa-Roberts, J. Climate trends and global crop production since 1980. Science 2011, 333, 616–620.

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

Mahbub, M.M., Rahman, M.M., Hossain, M.S., Nahar. L.,and Shirazy, B.J. (2016). Morphophylogical Variation in soybean (Glycine max (L.) Merrill). Am-Euras. *J. Agric. & Environ. Sci*., 16(2): 234-238.

McClung, C.R.; Davis, S.J. Ambient thermometers in plants: From physiological outputs towards mechanisms of thermal sensing. *Curr. Biol*. 2010, 20, 1086–1092.

Mehmet OZ. Nitrogen rate and plant population effects on yield and yield components in soybean. *Afr Biotechnol J*. 2008;7(24):4464–70.

Miah, M.A., Anwar, M.P., Begum, M., Juraimi, A.S. and Islam, M. (2009). Effects of sowing date on growth and yield of Mung bean. *J. Agric. Soc*. 5: 3-76.

Mittler, R.; Blumwald, E. Genetic engineering for modern agriculture: Challenges and perspectives. *Ann. Rev. Plant Biol*. 2010, 61, 443–462.

Mohsina, A. (2014). Effect of sowing date and spacing on Growth and yield of Mung bean.

Mondal, M.M.A., Dutta, R.K. and Islam, M.A. (2004). Yield performance of some Mung bean mutants in the northern region of Bangladesh. *Bangladesh J. Nuclear Agric*., 19: 32-35.

Monem, R., Mirtaheri, S.M. and Ahmadi, A. (2012). Investigation of row orientation and planting date on yield and yield components of Mung bean. *Ann. Biol. Res.* 3: 1764-67.

Muhammad, M., Khalil, A., Khan, H. U. and Khan, F.U. (2005). Yield performance of Mung bean as affccted by various sowing dates. *ind. J. P1. Sci*. 4: 222-26.

Muhsin, M., Nawaz, M., Khan, I., Chattha, M.B., Khan, S., Aslam, M.T., Iqbal, M.M., Amin, M.Z., Ayub, M.A., Anwar, U. and Hassan, M.U. (2021). Efficacy of seed size to improve field performance of wheat under late sowing conditions. *Pakistan Journal of Agricultural Research,* 34(1): 247-253.

Nag, B.L., Rahman, A.M., Goswami, B.K., Haldar, N.K. and UIlah, M.H. (2000). Effect of sowing time of Mung bean on seed yield under rainfed condition. *Bangladesh J. Agril. Res*. 25: 203-230.

Oplinger, E.S., Hardman, L.L., Kaminski, A.R., and Combs, S.M. (1990). J.D. Doll. Mung bean. Alternative Field Crops Manual. University of Wisconsin-Extension, Cooperative Extension, Madison, WI. Retrieved from https://hort.purdue.edu/newcrop/afcm/Mungbean.html

Parvez, M.T., Paul, S.K., and Sarkar, M.A.R. (2013). Yield and yield contributing characters of Mung bean as affected by variety and level of phosphorus. *J. Agrofor. Environ*., 7(1): 115- 118.

Patel, D.B., Purphit, K.K.R. and Shah, R.R. (1992). Physiological analysis of yield variation in Mung bean. *J. Agron. Crop Sci*. 168: 128-132.

Poehlman, J.M. (1991). The Mung bean. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. India. 27-30.

Poehlman, J.M.M. (1991). The Mung bean, 1st edition, PP: 27-29. Oxford and IBH publication Co. Pvt. Ltd., New Delhi, India.

Pratap, A., Gupta, S., Basu, S., Tomar, R., Dubey, S., Rathore, M. (2019a). “Towards Development of Climate-Smart Mung bean: Challenges and Opportunities,” in Genomic Designing of Climate Smart Pulse Crops. Ed. C. Kole (New York:

Springer Nature). (In press). doi: 10.1007/978-3-319-96932-9_5.

Quresh, Z. and Rahim, M. (1987). Harvest index, grain yield and biological yield of soybean as affected by sowing dates and varieties. *Pakistan. J. Agric. Res*. 8: 387-93.

Rahman, M.S., M. Eunus, M.A. Mannan, M.R. Ali and M.M. Hoque. (2002). Relation between dry matter production and yield of Mung bean Vigna radiata L.) varieties influenced by planting method and sowing time at summer. *Pak. I. Biol. Sci*., 5: 255-258.

Rakesh, D., Prakash, O. and Ahiwat, I. (2000). Response of spring greengram to date of sowing. *Annal. Agric. Res. CCS Univ. India*. 21(4): 570-571.

Ramzan, C.M., Nadeem, M., Khan. R. H. and Khan, M. A. (1992). Effect of sowing date on Mung bean seed yield under rainfed conditions. *J. Agric. Res. Lahore*. 30: 205-11.

Rasul, F., Cheema, M.A., Sattar, A., Saleem, M. F. and Wahid, M.A. (2012). Evaluating the performance of three Mung bean varieties grown under varying inter-row spacing. *The Journal of Animal & Plant Sciences*, 22(4): 1030-1035.

Raza, A. and Hasanzada, A. (1995). Effect of planting date and plant density on yield, yield components and their vertical distribution in greengram (Vigna radiata L) *Iranian. J. Agric. Sci*. 26(2): 19-31.

Razzaque, M.A., Ratiquzzaman S., Kabir, A.H.M.F. and Ali, M.A. (2005). Effects of sowing time on yield of Mung bean under rainfed condition. *J. Agric. Rural. Dev*. 3: 103-06.

Reddy, A.A. (2009). Pulses production technology: Status and way forward. *Economic and Political Weekly*, 44: 73-80.

Rehman, A., Khalil, S.K., Rehman, S., Nigar, S., Haq, I., Akhtar, S., Khan, A., Shah, S.R. (2009). Phenology, plant height and yield of Mung bean varieties in response to planting date. *Sarhad.j. Agric*. 25:147-5 I.

Sadeghipour, O. (2008). Response of Mung bean varieties to different sowing dates. *Pakistan. J. Biol. Sci*. 11:248-50.

Samanta, S.C., A.K.M. Faruk-E-Azam and Rashid M.H. (1999). Effects of sowing dates on grain yield protein and mineral contents of 5 murig bean cultivars. *Thai. J. Agric. Sci*., 32: 171-1 7.

Samanta, S.C., M.H. Rashid, P. Biswas and Hasan M.A. (1999). Performance of five cultivars of Mung bean under different dates of sowing. *Bangladesh J. Agric. Res*., 24: 521–527

Samanta, S.C., Rashid. M.H., Biswas. P. and Hasan, M.A. (1999). Performance of five cultivars of Mung bean under different dates of sowing. *Bangladesh. J. Agric. Res*. 24: 521-527.

Sandhu, T.S., J.S. Brar, H.S Sekhon and Malhotra, R.S. (1978). Summer Mung bean for additional Production Indian Farming, 28(6):13-14.

Sangakkara, U.R. (1998), Impact of planting time on seed yield and quality of Mungbean. *Thai.j. Agri. Sci*. 3l: 352-359.

Sarkar, A.R, Kabir H, Begum M, Salam A. (2004). Yield performance of Mung bean as affected by planting date, variety and plant density. *J Agron*. 3:18–24.

Sarkar, A.T., Islam, M.Q. and kaul, A.K. (1982). Mung bean a potential summer pulse crop for Bangladesh. Proc. Natl. Workshop on pulses, Kaul, A. K. (ed.) Aug. 18-19.,1981.

Sarkar, M.A.R., Kabir. M.H. Begum, M. and Salam, A. (2004). Yield performance Mung bean as affected by planting date, variety and plant density. *J. Agron*. 3(1): 18-24.

Seijoon, P., Wookhan, K. and Rakehun, S. (2000). Influence of different planting time on harvest index and yield determination factors in soybean. *Korean. J. Crop. Sci*. 45: 97-102.

Sekhon, H.S. (2008). Vigna in cropping system. In: MC Kharkwal, editor. Proceedings of the fourth international food legumes research conference. New Delhi: *Indian Society of Genetics and Plant Breeding*; p. 675–682.

Sekhon, S., Singh, C. and Brar, J.S. (2002). Effect of population density and planting geometry on the growth and yield of Mung bean [Vigna radiata (L.) Wilczek] genotypes. *Envir. Ecol*. 20: 897-901.

Senanayake, L., Knievel, D.P. Stevena, S.E. (1987). Nodulation and symbiotic nitrogen fixation of cowpea (Vigna unguiculata L.). *Plant Soil* 99: 435-439.

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

Sharma, P., Sekhon, H.S., Singh, G. and Sharma, P. (2007). Effect of date of sowing on flower drop, dry matter accumulation and growth parameter in Kharif Mung bean. *Environ. Ecol*. 25: 838-42.

Sharma, S.N. and Prasad, R. (1999). Effects of sesbania green manuring and Mung bean residue incorporation of productivity and nitrogen uptake of a rice-wheat cropping system. *Bioresource Technology*., 67(2): 171-175.

Singh, G., and Sekhon, H.S. (2002). Relative contribution of different inputs in Mung bean [Vigna radiata (L.) Wilezek] in summer and kharif seasons. *Enviro. Ecol*. 20: 757-61.

Singh, G., Sekhon, H.S., Sandhu, J.S., Singh, S.J., Gumber, R.K. and Randhawa. A. (2003). Effect of location and seed rate on three genotypes of Mung bean. *Trop. Sci*. 43(1): 16-20.

Singh, G., Sekhon. H.S Ram, H., Gil, K.K. and Sharma, P. (2010). Effect of date of sowing on nodulation, growth, thermal requirement and grain yield of kharif Mung bean genotypes. *J. Food. Leg*. 23(2): 132-34.

Singh, J.B. Singh, R.B. and Balai, L.P. (2012 a). Manipulation of sowing dates and interrow spacing an ecofriendly management of Mung bean (Vigna radiata) web blight. *Trends Biol. Sci*. 5: 152-53.

Singh, S., Sandhu, S.K., Dhaliwal. L.K. and Singh. I. (2012b). Effect of planting geo metry on microclimate, growth and yield of Mung bean (Vigna radiate l.) *J. Agril. Physiol*. 12: 70- 73.

Sinha. S., Bhargave, S.C. and Baldev, B. (1989). Physiological aspect of pulse crops in: Pulse Crops. Baldev, B., Ramnujan, S. and Jzin, H.K. (eds.). Oxford and IH Publication Co. Pvt. Ltd. New Delhi, India. pp: 421-455.

Solaiman, A.R.M., Hossain, D. and Haque M.M. (2003). Response of Mung bean varieties to Rhizobium inoculation in respect of nodulation, nitrogenase activity, dry matter yield, and nitrogen uptake. Department of soil science, Bangabandhu Sheikh Mujibur Rahman Agricultual university. Gazipur, Bangladesh. *Korean J. crop sci*. 48(5): 355-360.

Soomro, N.A. and Khan. H.R. (2003). Response of Mung bean genotypes to diflèrent dates of sowing in kharif season under rainfed conditions. *Asian J. Pl. Sci*. 2:377-79.

Thakar, S. and Dhingra, K.K. (1993). Response of Mung bean (Vigna radiata L.) cultivars to time of sowing under south western region of Punjab. *J. Res. Punjab. Agric. Uni*. 30(34): 157-159.

Thakuria, K. and Saharia, P. (1990). Response of green gram genotypes to plant density and phosphorus levels in summer. *Indian J. Agron*. 35: 431-432.

Tomar, S.S. and Tiwari A.S. (1996). Response of green gram and black gram genotypes to plant density. *Gurat Agric. University Res. J.*, 21: 88–92.

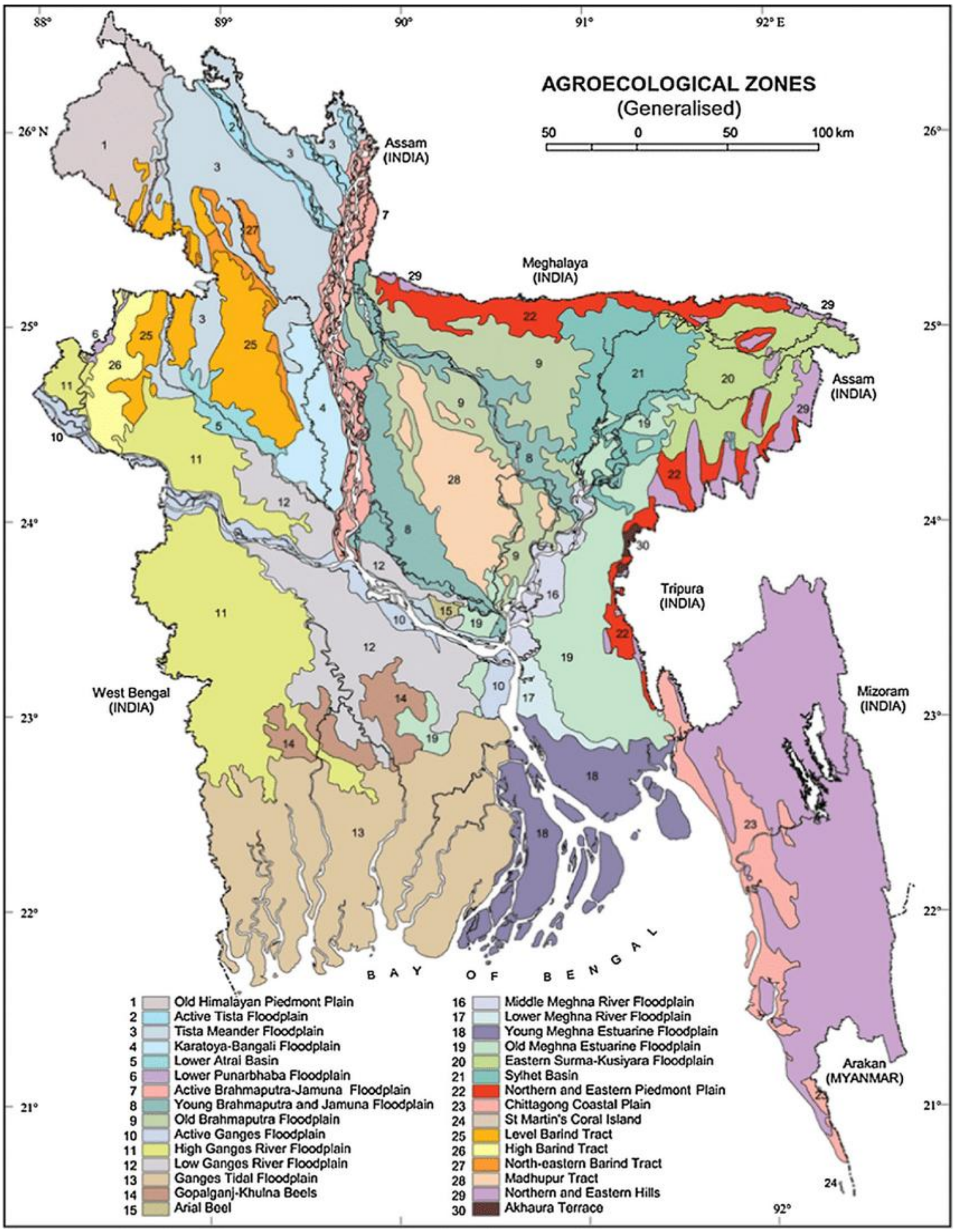
Vega, A.J., and Hall, A.J. (2002). Effects of planting date, genotype, and their interactions on sunflower yield. *Crop Science,* 42: 1191-1201.

Weis, E. and Berry, J.A. (1988). Plants and high temperature stress. In S.P. Long and F.I. Woodward eds., Symposia of the Society for Experimental Biology. Vol. XLII. The Co. Biologist, Camb, UK. 329-346.

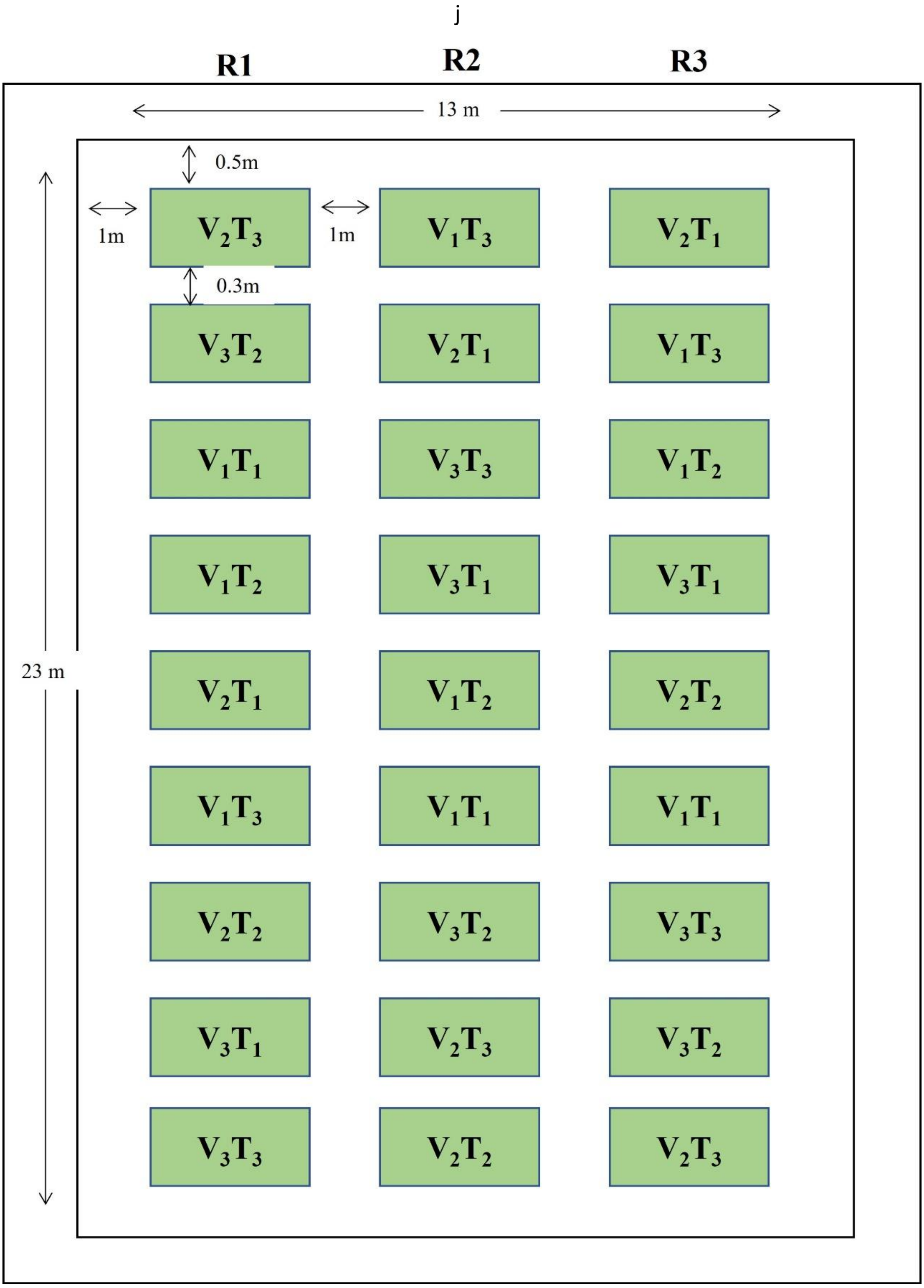
Zapata, F., Danso, S.K.A., Hardarson, G., and Fried, M. 1987. Nitrogen fixation and translocation in field-grown fababean. *Agronomy Journal* 79: 505-509.

APPENDICES

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



Appendix II: Layout



Factor A:	Plot no=31(3)
T_1: 15 March,2020	Plot size=3m*2m
T_2: 30 March,2020	Plot spacing=0.3m
T_3: 15 April,2020	Between spacing=1m

Appendix III: Soil characteristics of the research field of the department of Agricultural Botany of Sher-e-Bangla Agricultural University are analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka

A. Morphological characteristics of the experimental field

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

Source: SRDI

B. Physical and chemical properties of the initial soil

Characteristics	Value
Sand (%)	16
Silt (%)	56
Clay (%)	28
Textural class	Silt clay loam
pH	5.56
Organic matter (%)	0.25
Total N (%)	0.02
Available P (µgm/gm soil)	53.64
Available K (me/100g soil)	0.13
Available S (µgm/gm soil)	9.40

Source: SRDI

Appendix IV: Analysis of variance of the data on plant height of different varieties of Mung bean at different days after sowing (DAS)

Sources of variation	Degrees of freedom	30 DAS				Harvest			
		SS	MS	F	P	SS	MS	F	P
Replication	2	6.41	3.20			9.01	4.50		
Treatment	8	248.52	31.06	7.61	0.0003	656.57	82.07	41.27	0.000
Error	16	65.27	4.08			31.81	1.98		
Total	26	320.216				697.40			

Significant at 5% level of Probability

Appendix V: Analysis of variance (ANOVA) of yield attributes of Mung bean

Sources of variation	Degrees of freedom	Pods plant-1				Pod length				Seeds pod-1				1000 seed weight			
		SS	MS	F	P	SS	MS	F	P	SS	MS	F	P	SS	MS	F	P
Replication	2	0.519	0.259	41.76	0.000	3.09	1.54	1.34	0.29	0.72	0.36	1.88	0.135	1.06	0.53	7.07	0.0005
Treatment	8	295.407	36.92			24.16	3.02			18.05	2.256			153.41	19.17		
Error	16	14.145	0.884			35.98	2.24			19.25	1.20			43.35	2.71		
Total	26	310.074				63.25				38.03				197.86			

Significant at 5% level of Probability

Appendix VI: Analysis of variance (ANOVA) of yields and harvest index of Mung bean

Sources of variation	Degrees of freedom	Seed yield				Stover yield				Biological yield				HI			
		SS	MS	F	P	SS	MS	F	P	SS	MS	F	P	SS	MS	F	P
Replication	2	0.02	0.01	5.99	0.001	0.005	0.002	13.52	0.00	0.02	0.01	22.85	0.00	14.741	7.32	2.28	0.076
Treatment	8	0.230	0.028			0.80	0.10			1.56	0.19			90.519	11.31		
Error	16	0.077	0.004			0.11	0.007			0.13	0.01			79.259	4.95		
Total	26	0.33				0.92				0.71				184.519			

Significant at 5% level of Probability

Appendix VII: Monthly records of air temperature, relative humidity and rainfall during the period from March, 2020 to June, 2020

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	Min	Mean		
2020	March	35.20	21.00	28.10	52.44	20.4
2020	April	34.70	24.60	29.65	65.40	165.0
2020	May	32.64	23.85	28.25	68.30	182.2
2020	June	34.00	27.30	30.65	76.00	134.0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212