EFFECT OF GROWTH REGULATORS ON GROWTH AND YIELD OF MUNGBEAN UNDER DIFFERENT LATE SOWING CONDITIONS IN KHARIF-II SEASON

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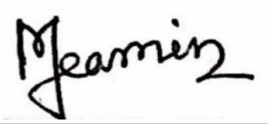

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CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF GROWTH REGULATORS ON GROWTH AND YIELD OF MUNGBEAN UNDER DIFFERENT LATE SOWING CONDITIONS IN KHARIF II SEASON" 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 (MS) in AGRONOMY, embodies the results of a piece of bona fide research work carried out by A.M. MUNIM HOSSAIN KHAN, Registration No. 17-08200 under my supervision and guidance. No part of this 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.

Dated:
Dhaka, Bangladesh

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ABSTRACT

A field experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2017 to January 2018 to study the effect of growth regulators on growth and yield of mungbean under different late sowing conditions in kharif-II season. The experiment was comprised of two factors; factor A: growth regulators (6) viz. G_0 = distilled water, G_1 = 20 ppm BAP (Benzylaminopurine), G_2 = 40 ppm BAP, G_3 = 20 ppm GA_3 (Gibberellic acid), G_4= 40 ppm GA_3, G_5 = 60 ppm GA_3 and factor B: sowing date (2) viz. S_1 = sowing on 31th October, 2017, S_2 = sowing on 14th November, 2017. The experiment was laid out in randomized complete block design (RCBD) in factorial arrangements with three replications. Results revealed that in case of growth, plant height (38.35 cm), and dry weight (9.57g) plant^{-1} were significantly higher in G_5 (60 ppm GA_3) treatment. In terms of yield and yield attributes, number of pods plant^{-1} (6.56), number of seeds pod^{-1} (5.52), weight of 1000- seeds (35.07 g), seed yield (0.26 t ha^{-1}), and harvest index (37.75 %) were higher in G_5 (60 ppm GA_3) treatment). Sowing at 31th October showed better results in case of all growth and yield parameters than sowing at 14th November. Results from Interaction effect between different levels of growth regulators and different sowing conditions revealed that the highest plant height (39.43 cm), number of pods plant^{-1} (8.80), number of seeds pod^{-1} (7.22), weight of 1000-seeds (38.74 g), seed yield (0.45 t ha$^{-1)}$ were observed in S_1G_5 (Sowing on 31th October with 60 ppm Gibberellic acid) interaction. The results in this study indicated that the plants performed better in respect of growth, yield and others yield contributing characters in S_1G_5 (Sowing on 31th October with 60 ppm Gibberellic acid) treatment.

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CHAPTER I

INTRODUCTION

Pulses occupy a strategic position in the agriculture economy of Bangladesh. They contain high percentage of protein three times more than cereals. Pulses contain vitamin B, minerals and also contain quality fibers, which is desirable in human diet because of medical importance. Pulse crops fertilize the soil through symbiotic nitrogen fixation from atmosphere. Being a rich source of protein, they maintain soil fertility through biological nitrogen fixation in soil and thus, play a vital role in sustainable agriculture. Mungbean (*Vigna radiata* L. wilezek) is also known as green gram, it is an important pulse crop. It is green with husk and yellow when dehusked. The beans are small, ovoid in shape and green in color (Anonymous, 2016).

Pulses are the essential protein source for the majority of the people of Bangladesh. It contains protein about twice as much as cereals. It also contains amino acid, lysine, which is generally deficit in food grains (Elias, 1986). Mungbean (*Vigna radiata* L.) is one of the most emergent pulse crops of Bangladesh. Mungbean is regard as the best of all pulses from the nutritional viewpoint and which comprised of 51% carbohydrate, 26% protein, 4% minerals and 3% vitamins (Kaul, 1982, Uddin *et al.,* 2009).

Improving physical, chemical and biological properties of soil by fixing nitrogen from atmosphere through symbiosis process is another important character of mungbean. The climatic condition of Bangladesh is friendly for winter farming of local mungbean but it can cultivate in both summer and winter (Bose, 1982 and Miah *et al.,* 2009).

It is a short duration crop and less water requirement as compared to summer crops. Moreover, it is drought resistant that can resist adverse environmental conditions, and hence successfully be grown in rain fed areas (Anjum *et al*., 2006).

Plant growth regulators (PGRs) help to increase the number of flowers on the plant when applied at the time of flowering. The flower and pod drop may be reduced to some extent by spraying various growth regulators on foliage (Ramesh and Thirumuguran, 2001). The foliar application of PGRs significantly increased seed yield per plant (Patil *et al*., 2005). Mungbean cultivation is gaining popularity day by day among the farmers. There has been a continuous reduction in the production of pulses in the last decades. Mungbean had been cultivated in both Rabi and Kharif season in the past but now high yielding varieties of mungbean has been cultivated only in Kharif season due to susceptibility to Rabi season for low temperature stress. Mungbean is a extensively cultivated legume crop having wide adaptability to different environmental conditions. Mungbean plant is grown in temperate regions and can be grown in all seasons throughout the year in tropical countries, whereas this plant may face Low temperature (LT) or chilling stress in the winter (Chen *et al*., 2005).

Low temperature (LT) or chilling temperature often adversely affects plant growth and productivity. Every year, plants covering a vast area of the world suffer from LT stress, which leads to substantial crop losses and thus LT stress is considered as one of the major abiotic stresses (Sanghera *et al*., 2001). Low temperature stress causes physiological and metabolic disorder leading to reduced growth and vigor. Obstacles in plant–water relationships, reduced stomatal conductance, photosynthetic efficiency, changes in protein structure and enzyme activities are some of the most common and primary LT injury symptoms within plants (Yadav, 2010).

Inhibition of photochemistry efficiency under LT stress increases generation of reactive oxygen species (ROS), which may include singlet oxygen ($1O_2$), superoxide anion (O^{2-}), hydrogen peroxide (H_2O_2), and hydroxyl radical (OH) (Gill and Tuteja, 2010). ROS act as secondary messengers in signal transduction and play vital roles in plant growth and stress responses (Baxter *et al*., 2014).

Low temperature stress has adverse effects on water relations like RWC, exudation rate, different physiological attributes. Different exogenous hormonal treatments have positive effects on such types of negative effects in plants. Benzylaminopurine (BAP) and Gibberellic acid (GA_3) is a growth promotional hormone. Therefore exogenous BAP and GA_3 application might have the positive effect to overcome the low temperature effects on mungbean due to late sowing in kharif-II season.

The present study was undertaken to

(1) Screen out the optimum dose of growth regulators for optimum growth and yield of mungbean under different late sowing conditions in kharif- II season.

(2) Study the interaction effect of growth regulators and different sowing dates on the growth and yield of mungbean.

CHAPTER II

REVIEW OF LITERATURE

This chapter includes research findings of different researchers in home and abroad regarding the effect of growth regulators and different sowing dates on the growth and yield of mungbean. Since the work on the influence of plant growth regulators on mungbean is scanty, an attempt has therefore been made to review the work on mungbean and other crops. The information have been reviewed and cited under the following headings.

2.1. Effect of sowing date

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

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 mungbean (Hussain *et al*. 2004). There must be a specific sowing date, especially in the summer season for different varieties to obtain maximum yield.

For maximum mungbean 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).

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

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

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

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 mungbean (Singh *et al*. 2010).

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.

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

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

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).

Farrag (1995) reported in a field study conducted on mungbean *(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.

Mungbean 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 mungbean cultivars decreased with delay in sowing time (Thakar and Dhingra, 1993)

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

(Raza and Hasanzada, 1995) showed that mungbean yield were 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 mungbean 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.

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.

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 mungbean 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.

Singh *et al.* (2012b) conducted a field experiment at Ludhiana (Punjab) during kharif season for evaluation of date of sowing for mungbean. 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 mungbean sown in last week of July as compared to first week of August and resulted higher grain yield.

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%).

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

Delayed sowing after March and early sowing before February reduce yield of summer mungbean (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 mungbean caused a substantial decrease in growth and yield of mungbean. 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 findings closely resembles to those reported by Sinha *et al.* (1989) and Miah *et al.* (2009) who opined that mungbean 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.

Singh *et al.* (2010) at Ludhiana tested mungbean 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.

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

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.

In Hazipur (Bangladesh), Razzaque *et al.* (2005*)* tested sowing of mungbean from January to May and reported that I5 February gave 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 mungbean 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 cluster 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.

Chahal (1998) at Ludhiana (Punjab) conducted an experiment with four sowing dates and the grain yield of the mungbean 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.

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 mungbean 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 mungbean 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 mungbean 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 tonnes) 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).

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.

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

2.2. Effect of growth regulators

Bai *et al*. (1987) investigated the effect of growth regulators (NAA and GA) on the yield performance of mungbean. They found that 25 ppm of NAA and 50 ppm of GA_3 increased the yield of mungbean when compared with control.

Jaiswal and Bhambil (1989) conducted a field experiment to determine the effect of growth regulators on mungbean. It was observed that GA_3 and NAA resulted in the reduction of yield and yield components.

Rahman *et al.* (1989) in a pot experiment on grasspea showed that foliar application of 50 mili liter of GA_3 increased seed yield.

Lee (1990) found that soaking of groundnut seeds in solutions of 0, 50, and 100 ppm of GA_3 before sowing produced plants with greater number of flowers than those of the control.

Kelaiya *et al.* (1991) conducted an experiment with four growth regulators, such as CCC (chlormequat), NAA, and triacontanol and sprayed at 25, 50 and 75 days after sowing (DAS) on groundnut. In that experiment, they observed that where NAA was found to be most effective one in increasing the plant height. They also reported that groundnuts when sprayed with 40 ppm of NAA at 25 and 50 DAS increased plant dry weight.

Gibberellic acid (GA_3) is known to be importantly concerned in the regulation of plant responses to external environment (Chakrabarti and Mukherji, 2003).

Also, application of another plant growth bio-regulator has increased the salt tolerance of many crop plants (Haroun *et al.* 1991). GA_3 has also been shown alleviate the effects of salt stress on water use efficiency (Aldesuquy and Ibrahim, 2001).

Gibberellic acid (GA_3) is an important PGR that affects plant growth and development by inducing metabolic activities and regulating nitrogen utilisation (Sure *et al*. 2012).

Gibberellic acid (GA_3) plays a significant role in seed germination, endosperm mobilisation, stem elongation, leaf expansion, reducing the maturation time and increasing flower and fruit set and their composition (Roy & Nasiruddin, 2011).

Gibberellic acid GA_3 delays senescence, improves growth and development of chloroplasts, and intensifies photosynthetic efficiency which could lead to increased yield (Yuan & Xu, 2001).

Previously it was reported that there is a continual effect of gibberellic acid (GA_3) on *Catharanthus roseus* L. plant phenotype. Earlier studies have reported that GA_3 application (at 50, 100 and 500 g m) as foliar spray on transplanted cutting of *Catharanthus roseus* L. increased plant height. Gibberellins (GA_3) increased shoot length by increasing their rate of elongation in majority of the plants (Shil *et al*. 2007).Therefore, GA and its used can be able to overcome to variable extents the adverse effects of stress imposed.

Cytokinins have been shown to enhance pod set when applied directly to individual racemes in soybean and mungbean. However, the application of BAP increased both, total seed weight and pod number (Patil *et al.* 2005).

Studies have showed that external application of planofix (NAA) reduced the premature abscissions of flowers, young pods and thus increased the number of pods and consequently the yield of groundnut (Mani and Raja, 1976).

A foliar application of 40 ppm NAA on groundnut increased the number of pods per plant and eventually the pod yield (Gupta and Singh, 1982).

Singh *et al.* (1982) conducted an experiment on groundnut to determine the effect of NAA. They observed that two foliar spray of 100-ppm planofix (NAA) to groundnut at 40 and 50 days after sowing increased the number of leaves per plant.

Subbian and Chamy (1982) mentioned that two foliar sprays of 40-ppm planofix (NAA) when applied to summer mungbean at the flower initiation stage and 15 days later significantly increased the seed yield.

Reddy and Shah (1984) reported that application of planofix (NAA) at the rate of 50 ppm significantly produced the higher number of leaves in groundnut.

Subbian and Chamy (1984) carried out a field trial in summer with 2 foliar applications of 0, 20 or 40 ppm NAA to greengram. They found increased number of flowers and pods per plant with increasing NAA rate. They also reported that seed yield was increased from 0.8 to 1.2 tha^{-1} with increasing NAA concentrations.

Venkaten *et al.* (1984) pointed out that both in rabi and in kharif seasons application of NAA at various concentrations sprayed at 30 and 50 days after sowing increased the number of pods per plant and 1000 seed weight in groundnut.

Gurpreet *et al.* (1988) mentioned that grain yield was increased from 0.71 t ha^{-1} to 0.78 t ha^{-1} with applications of NAA in mungbean.

Kalita (1989) reported that applying a foliar spray at the rate of 50 ppm of NAA mungbean increased seed yield from 0.64 to 0.88 t ha^{-1}.

Sharma *et al.* (1989) reported from the result of a field trial with foliar applications of NAA at anthesis and 10 days later on mungbean. It was found that the NAA treated plants gave higher seed yield of 795 - 849 kg ha^{-1} compared with 611-694 kg ha^{-1} of without NAA. Results revealed that the NAA application increased the number of pods per plant, number of seeds per pod and 1000 seed weight.

Arora *et al.* (1998) reported that NAA applied at 50% flowering stage to chickpea increased the number of flowers as compared with the untreated ones. Flowering and fruiting were also reported to be increased by foliar spraying with NAA on groundnut (Manikandan and Hakim, 1999).

Mahla *et al.* (1999) reported that spraying 20 ppm NAA on blackgram had greater effect in increasing the number of branches.

Lakshrnamma and Rao (1996a) conducted a field experiment during the rabi season at Rajendranagar, Andhra Pradesh. Blackgram was sprayed with 0, 5, 10 or 20 ppm NAA at 50% flowering stage. They found that application of NAA increased plant height of blackgram.

Lakshmamma and Rao (1996b) conducted a field experiment at Rajendranagar in Andhra Pradesh during rabi season. They found that blackgram when sprayed with 20 ppm of NAA at 50 % flowering stage decreased flower drop and increased seed yield.

Kandagal *et al.* (1990) observed that a foliar application of 50 ppm of NAA at flowering stage of mungbean gave seed yields of 0.66 tha^{-1} compared with 0.55 t/ha with the untreated control.

Chaplot *et al.* (1992) reported that increases in seed yield of mungbean due to NAA application by 5.7-21%.

Das and Prasad (2003) conducted a study on sandy clay loam soil in New Delhi, India, during summer 1999. The treatments comprised of three summer mungbean cultivars and two levels of NAA (20 and 40 ppm). NAA sprayed at 30 days after sowing and at flowering stages. Both the concentrations of NAA significantly increased the total dry matter production, number of leaves, number of flowers and number of pods per plant, pod length, number of seeds per pod, 1000 grain weight and grain yield of summer mungbean.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka, during the period of October 2017 to January 2018 to study the effect of growth regulators on growth and yield of mungbean under different late sowing conditions in kharif -II season. Materials used and methodologies followed in the present investigation have been described in this chapter.

3. Description of the experimental site

3.1. Site and soil

Geographically the experimental field was located at 23° 77′ N latitude and 90° 33' E longitudes at an altitude of 9 m above the mean sea level. The soil belonged to the Agro-ecological Zone - Modhupur Tract (AEZ-28). The land topography was medium high and soil texture was silty clay with pH 6.1. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix III.

3.2. Climate and weather

The climate of the locality is subtropical which is characterized by 3 distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October, high temperature and heavy rainfall during Kharif season (April-September) and scanty rainfall during Rabi season (October-March) associated with moderately low temperature.

3.3. Plant materials

BARI mung-6 was used as planting material. BARI Mung-6 was developed by Bangladesh Agricultural Research Institute in 2003. The seeds of BARI mung-6 for the experiment were collected from BARI, Joydepur, Gazipur. The seeds were medium shaped, dull and greenish and free from mixture of other seeds, weed seeds and extraneous materials.

3.4. Treatments

The experiment consisted with following two treatment factors:

Factor A: Growth regulators - 6

G_0 = Distilled water

G_1 = 20 ppm BAP (Benzylaminopurine)

G_2 = 40 ppm BAP (Benzylaminopurine)

G_3 = 20 ppm GA_3 (Gibberellic acid)

G_4 = 40 ppm GA_3 (Gibberellic acid)

G_5 = 60 ppm GA_3 (Gibberellic acid)

Factor B: Sowing Date - 2

S_1 = sowing on 31 October

S_2 = sowing on 14 November

Treatment combination: Twelve treatment combinations are as follows

i. $S_1 \times G_0$

ii. $S_2 \times G_0$

iii. $S_1 \times G_1$

iv. $S_2 \times G_1$

v. $S_1 \times G_2$

vi. $S_2 \times G_2$

vii. $S_1 \times G_3$

viii. $S_2 \times G_3$

ix. $S_1 \times G_4$

x. $S_2 \times G_4$

xi. $S_1 \times G_5$

xii. $S_2 \times G_5$

3.5. Experimental design and layout

The experiment was laid out in randomized complete block design (RCBD) in a factorial arrangement with three replications. There were 12 treatment combinations. The total number of unit plot was 36. The size of unit plot was 3.24m^2 (2.7 m x 1.2 m). The distances between plot to plot and replication to replication were 0.30 m and 0.70m, respectively.

3.6. Land preparation

The land was irrigated before ploughing. After having irrigated condition the land was first opened with the tractor. Ploughed soil was brought into desirable fine tilth by 3 ploughing and cross-ploughing, harrowing and laddering.

All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on October 31, 2017 according to experimental design. Individual plots were cleaned and finally prepared the plot.

3.7. Fertilizer application

Urea, TSP, and MOP were applied at the rate of 45, 90 and 35 kg per hectare respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation during final land preparation.

3.8. Sowing of seeds

The seeds of BARI Mung-6 were sown as per the sowing date of treatment i.e. 1st sowing October 31 and 2nd sowing November 14, 2017. The seeds of mungbean were sown by hand in 25 cm apart from lines with continuous spacing at about 3 cm depth.

3.9. 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 sowing on 31 October but sowing on 14 November the percentage of germination was more than 80% on the 5th day.

3.10. Preparation of Benzylaminopurine (BAP) and Gibberellic acid (GA_3) solution

Benzylaminopurine and Gibberellic acid in different concentrations viz. 20, 40 and 60 ppm were prepared following the procedure mentioned below. 20 ppm solution of Benzylaminopurine and Gibberellic acid was prepared by dissolving 20 mg of Benzylaminopurine and Gibberellic acid each with distilled water. Then distilled water was added to make the volume 1 liter of 20 ppm solution. 40 and 60 ppm solution of Benzylaminopurine and Gibberellic acid was prepared by dissolving 40 mg and 60 mg of Benzylaminopurine and Gibberellic acid respectively each with distilled water. Then distilled water was added to make the volume 1 liter of 40 and 60 ppm solution, respectively. These solutions were applied to plants at 20 DAE (Days after emergence) as per treatment.

3.11. Intercultural operations

3.11.1. Thinning

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

3.11.2. Weed control

Weed control was done as per experimental treatments.

3.11.3. Irrigation

Irrigation water was added to each plot, first irrigation was done as pre sowing and others were given as per requirement.

3.12. Harvesting and sampling

Maturity of crop was determined when 80-90% of the pods become blackish in colour. Three harvesting were done. The harvesting was done by hand picking. The harvested pods were sorted into individual bags for each plot and carried to the threshing floor. The collected pods were sun dried by spreading those on the threshing floor. The seeds were separated, cleaned and dried in the sun for 3 days for achieving safe moisture of seed.

3.13. Threshing

The crop was sun dried for three days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks.

3.14. Drying, cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a safe level. The dried seeds and straw were cleaned and weighed.

3.15. Recording of data

The data were recorded on the following parameters

A. Crop Growth parameters

a. Plant height (cm) at 20, 35, 50 and 65 DAS

b. plant dry weight at 20, 35, 50 and 65 DAS

B. Yield contributing parameters

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

b. Pod length (cm)

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

d. 1000 seeds weight (g)

C. Yields parameter

a. Grain yield (t ha^{-1})

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

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

d. Harvest index (%)

3.16. Procedures of Data Collection

i. Plant height (cm)

Five plants were collected randomly from each plot. The height of the plants were measured from the ground level to the tip of the plant at 20, 35, 50 and 65 days after sowing (DAS) .

ii. Plant dry weight (g)

Five plants were collected randomly from each plot at 20, 35, 50 and 65 days after sowing (DAS) and at harvest time. The sample plants were oven dried for 72 hours at 70°C and then plant dry weight was determined.

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

Number of pods plant^{-1} was counted from the 5 plant sample and then the average pod number was calculated.

iv. 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.

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

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 pod^{-1} was determined.

vi. 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.

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

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

viii. Stover yield (t 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$^{-1.}$

ix. Biological yield (t ha^{-1})

The summation of seed yield and above ground stover yield was the biological yield Biological yield = Grain yield + Stover yield.

x. Harvest index (%)

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

$$\text{Harvest index (\%)} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

3.17. 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 MSTAT- C developed by Russel (1986) and the The differences between pairs of means were compared by Duncan's New Multiple Range Test (DMRT).

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

Significant differences were observed due to the application of different levels of Growth regulators at 20, 35, 50 and 65 DAS on plant height (Figure1). However among the different levels of growth regulators G_5 (60 ppm GA_3) showed the highest plant height (22.17, 36.12, 38.35, cm at 20, 50 and 65 DAS, respectively). The lowest plant height (16.42, 22.94, 29.42 and 29.90 cm at 20, 35, 50 and 65 DAS, respectively) was observed from the G_0 treatment where no growth regulators were applied. But at 35 DAS G_4 (40 ppm GA_3) treatment showed highest plant height (31.49 cm). This result is similar with the findings of (Mojtaba *et al*. 2014) who found significant effect of gibberellin on Plant height of mungbean. The maximum Plant height of treatments 50 ppm gibberellin was obtained. Gibberellins increases growth at most plant species especially rosette plants (Archbold**,** 1988.).

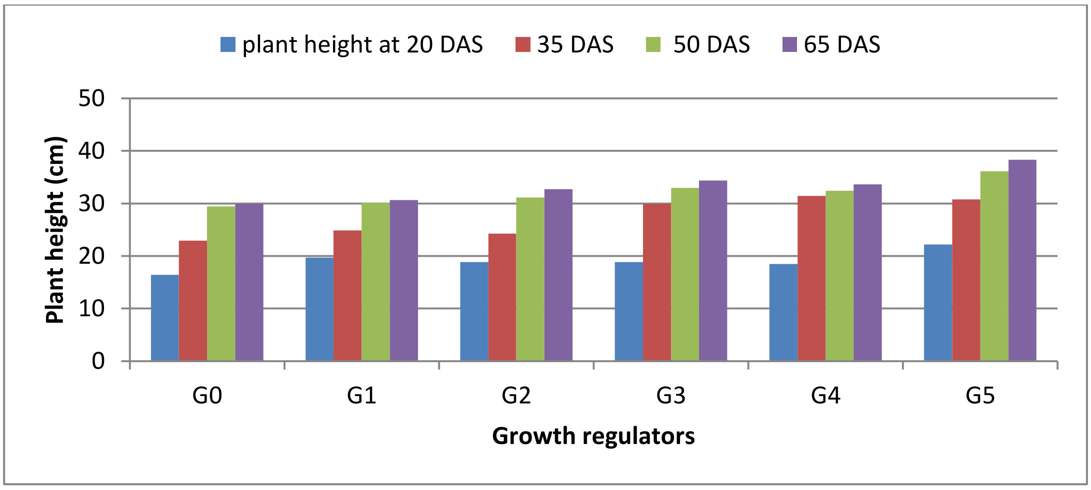

Figure 1. Effect of growth regulators on plant height of mungbean at different days after sowing (DAS) [G_0= Distilled water, G_1 = 20 ppm BAP (Benzylaminopurine) G_2 = 40ppm BAP, G_3 = 20 ppm GA_3 (Gibberellic acid), G_4 = 40 ppm GA_3, G_5 = 60 ppm GA_3]

The plant height was varied significantly influenced by different sowing dates at all stages of growth (Figure2). At 20, 35, 50 and 65 DAS, the highest plant height (20.15, 28.86, 33.46 and 34.51 cm, respectively) was recorded in S_1 (Sowing on 31 October) where the lowest was measured at 20, 35, 50 and 65 DAS (18.00, 25.86, 30.59 and 32.01 cm, respectively) in S_2 (Sowing on 14 November) treatment.

The result was in agreement with the findings of Rehman *et al.* (2009) who reported that the plant height differed among various sowing dates. S_2 (13 September) showed the highest plant height due to favorable environmental condition. Lowest plant height was obtained from S_4 (23 October) due to delay sowing. Delay planting generally shifts vegetative growth to reproductive growth into less favorable conditions with shorter days and lower radiation and temperature.

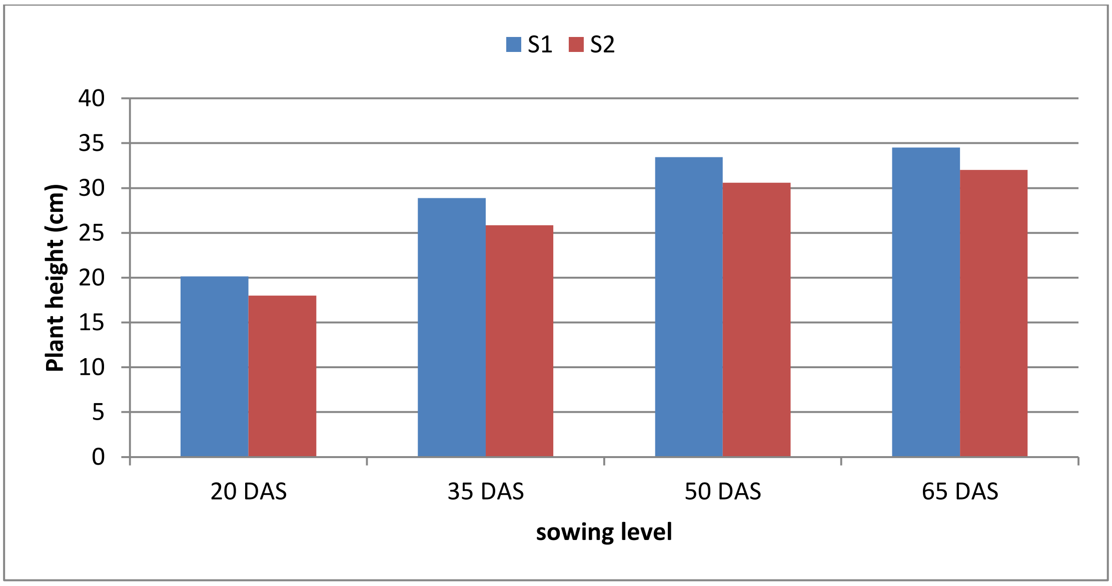

Figure 2. Effect of different sowing dates on plant height of mungbean at different days after sowing (DAS) [S_1 = Sowing on 31 October, S_2 = Sowing on 14 November]

Statistically significant differences were recorded due to the interaction effect of growth regulators and different sowing conditions for plant height at 20, 35, 50 and 65 DAS (Table 1). The highest plant height (23.25, 37.63 and 39.43 cm at 20, 50 and 65 DAS, respectively) was observed from S_1G_5 treatment (Sowing on 31 October with 60 ppm GA_3).

The lowest plant height (15.40, 21.10, 28.22 and 28.51 cm at 20, 35, 50 and 65 DAS, respectively) was observed control from S_2G_0 treatment (Sowing on 14 November with no growth regulators). The highest plant height (32.47 cm) at 35 DAS was obtained from S_1G_4 treatment (Sowing on 31 October with 40 ppm GA_3).

Table 1. Interaction effect of different sowing dates and growth regulators on plant height of mungbean at different days after sowing (DAS)

Interaction	Plant height (cm) at			
	20 DAS	35 DAS	50 DAS	65 DAS
S_1 X G_0	17.43 ef	24.77 f	30.62 cde	31.29 cd
S_2 X G_0	15.40 g	21.10 i	28.22 f	28.51 e
S_1 X G_1	20.43 bc	26.07 e	31.03 cd	31.74 cd
S_2 X G_1	18.93 cde	23.61 g	29.20 ef	29.53 de
S_1 X G_2	19.79 bc	25.80 e	30.83 cde	32.84 c
S_2 X G_2	17.93 def	22.68 h	31.49 c	32.57 c
S_1 X G_3	20.85 b	32.00 a	36.27 a	36.02 b
S_2 X G_3	16.80 fg	27.83 d	29.61 def	32.65 c
S_1 X G_4	19.17 cd	32.47 a	34.37 b	35.71 b
S_2 X G_4	17.83 def	30.42 b	30.42 cde	31.55 cd
S_1 X G_5	23.25 a	32.06 a	37.63 a	39.43 a
S_2 X G_5	21.10 b	29.49 c	34.61 b	37.27 ab
LSD $_{(0.05)}$	1.49	0.80	1.51	2.17
LS	*	*	*	*
CV (%)	9.22	3.47	5.57	7.71

In a column having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability
CV= Coefficient of variation, LS= Level of significance, *= Significant at 5% level of Probability, LSD = Least significant difference, [G_0 = Distilled water, G_1 = 20 ppm BAP (Benzylaminopurine), G_2 = 40 ppm BAP, G_3 = 20 ppm GA_3 (Gibberellic acid), G_4= 40 ppm GA_3, G_5= 60 ppm GA_3, S_1 = Sowing on 31 October, S_2 = Sowing on 14 November]

4.2. Plant dry weight

Plant dry weight at 20, 35, 50 and 65 DAS varied significantly when different growth regulators were applied (Figure 3). Among the different levels, G_5 (60 ppm GA_3) treatment showed the highest Plant dry weight (1.30, 4.82, 6.99 and 9.57 g at 20, 35, 50 and 65 DAS, respectively). On the contrary, the lowest Plant dry weight (0.86, 3.27, 4.95 and 7.65g at 20, 35, 50 and 65 DAS, respectively) was observed with G_0 where no growth regulators were applied. This result is supported with the findings of Foysal (2014) who stated that Plant dry weight varied significantly with different levels of plant growth regulators, the maximum Plant dry weight was produced from 40 ppm NAA (G_{40}) treatment while, the minimum was found from 0 ppm NAA (G_0) treatment.

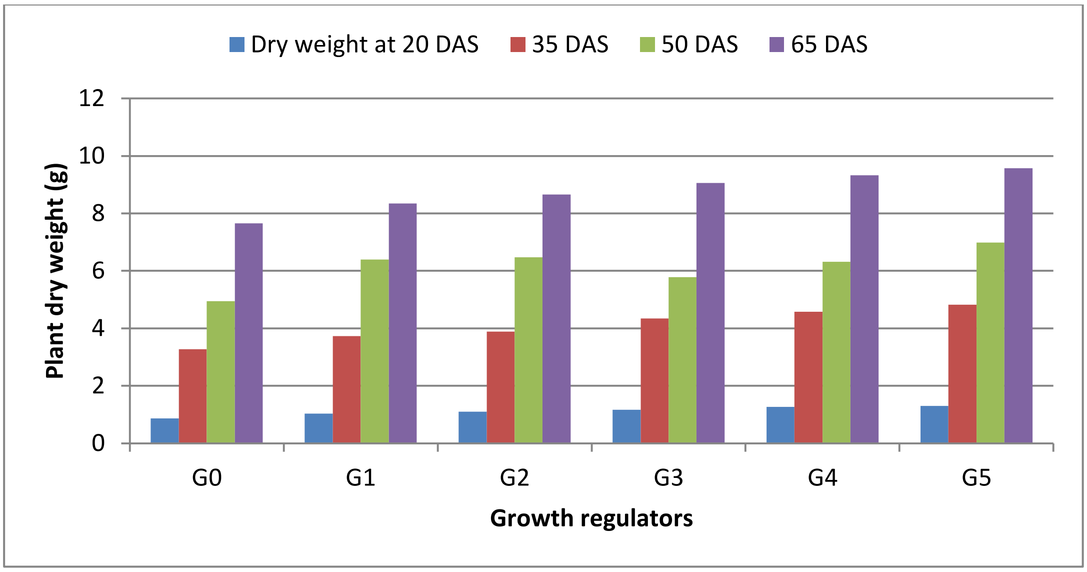

Figure 3. Effect of growth regulators on plant dry weight of mungbean at different days after sowing (DAS) [G_0 = Distilled water, G_1 = 20 ppm BAP (Benzylaminopurine), G_2 = 40 ppm BAP, G_3 = 20 ppm GA_3 (Gibberellic acid), G_4= 40 ppm GA_3, G_5= 60 ppm GA_3]

Plant dry weight was significantly influenced by different sowing dates at all stages of growth (Figure 4). At 20, 35, 50 and 65 DAS the maximum plant dry weight (1.15, 5.01, 7.32, and 9.67 g, respectively) was recorded in S_1 (Sowing on 31 October). The lowest plant dry weight (1.09, 3.20, 4.98 and 7.86 g at 20, 35, 50 and 65 DAS, respectively) was achieved with S_2 (Sowing on 14 November).

The result was in agreement with the findings of Chahal (1998) who reported that total dry matter accumulation were significantly higher at second sowing date than those of other three planting dates. Delay sowing decrease the dry matter content of plant.

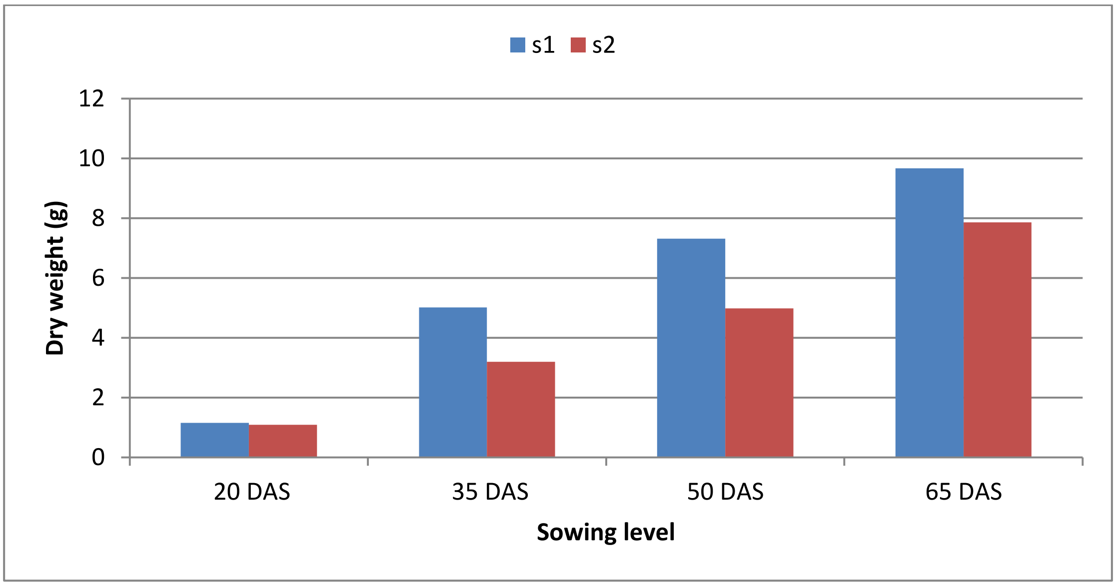

Figure 4. Effect of different sowing dates on plant dry weight of mungbean at different days after sowing [S_1 = Sowing on 31 October, S_2 = Sowing on 14 November]

Interaction effect between different levels of growth regulators and different sowing conditions showed significant effect on plant dry weight at 20, 35, 50 and 65 DAS (Table 2). The highest plant dry weight (1.30, 5.73, 8.34 and 10.68 g at 20, 35, 50 and 65 DAS, respectively) was observed in the sowing on 31 October with 60 ppm GA_3 ($S_1 \times G_5$). The lowest plant dry weight (0.78, 2.53, 3.49, and 6.93 g at 20, 35, 50 and 65 DAS, respectively) was observed from sowing on 14 November with no growth regulators ($S_2 \times G_0$).

Table 2. Interaction effect of different sowing dates and growth regulators on plant dry weight of mungbean at different days after sowing (DAS)

Interaction	Dry weight (g) at			
	20 DAS	35 DAS	50 DAS	65 DAS
S_1 X G_0	0.93 e	4.00 d	6.40 d	8.36 g
S_2 X G_0	0.78 f	2.53 g	3.49 i	6.93 k
S_1 X G_1	1.07 c	4.87 c	7.39 c	9.13 e
S_2 X G_1	0.99 d	2.59 fg	5.38 ef	7.55 j
S_1 X G_2	1.13 b	5.12 b	7.83 b	9.57 d
S_2 X G_2	1.06 c	2.65 f	5.10 gh	7.74 i
S_1 X G_3	1.16 b	5.15 b	6.58 d	9.92 c
S_2 X G_3	1.17 b	3.53 e	4.96 h	8.19 h
S_1 X G_4	1.27 a	5.18 b	7.37 c	10.35 b
S_2 X G_4	1.26 a	3.97 d	5.27 fg	8.30 g
S_1 X G_5	1.30 a	5.73 a	8.34 a	10.68 a
S_2 X G_5	1.29 a	3.91 d	5.63 e	8.46 f
$LSD_{(0.05)}$	0.05	0.10	0.25	0.09
LS	*	*	*	*
CV (%)	5.13	2.97	4.76	1.19

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly 5% level of probability
CV= Coefficient of variation, LS= Level of significance, *= Significant at 5% level of Probability, LSD = Least significant difference, [G_0= Distilled water, G_1 = 20 ppm BAP (Benzylaminopurine), G_2= 40 ppm BAP , $G_{3=}$ 20 ppm GA_3 (Gibberellic acid), G_4 = 40 ppm GA_3, $G_{5=}$ 60 ppm GA_3, S_1 = Sowing on 31 October, S_2 = Sowing on 14 November]

4.3. Pods plant^{-1}

Pods per plant showed significant variation due to the effects of different growth regulators (Table 3). The highest number of pods per plant (6.56) was obtained from the G_5 (60 ppm GA_3) treatment. The lowest number of pods per plant (3.14) was found when the plants were raised without growth regulators (G_0). This result is supported with the findings of Foysal (2014) who found pods plant^{-1} of mungbean differed significantly due to plant growth regulator. The highest number of pods plant^{-1} (24.89) was recorded from 40 ppm NAA (G_{40}) treatment whereas, the lowest (16.56) was found from 0 ppm NAA (G_0) treatment.

Pods plant^{-1} was significantly influenced by different sowing dates at all growth stages of mungbean (Table 4). S_1 (Sowing on 31 October) treatment showed maximum number of pods plant^{-1} (7.19). The lowest number of pods plant^{-1} (2.65) was achieved by S_2 (Sowing on 14 November). The results were in conformity with the findings of Choi *et al.* (1991) who tested four sowing dates and reported that 2nd sowing date (2 September) gave the highest number of pods per plant and highest grain yield compared to 3rd (27 September) and 4th sowing (22 October). On 2nd sowing crops may have utilized the factors of favorable environment which ultimately influences plant to have more growth and development.

Interaction effect between growth regulators and different sowing conditions showed significant variation on pods plant^{-1} (Table 5). The highest Number of pods plant^{-1} (8.80) was observed in the sowing on 31 October with 60 ppm GA_3 ($S_1 \times G_5$). The lowest Number of pods plant-^{1} (0.40) was observed from the sowing on 14 November with no growth regulators ($S_2 \times G_0$).

Table 3. Effect of growth regulators on yield attributes of mungbean

Growth regulators	Pods plant^{-1}(no)	Pod length (cm)	Seeds pod^{-1} (no)	Weight of 1000 seeds (g)
G_0	3.14 f	3.41 c	3.02 d	20.25 b
G_1	4.04 e	5.01 b	4.67 c	30.23 a
G_2	4.76 d	5.40 ab	4.74 c	31.19 a
G_3	5.33 c	5.43 ab	4.92 bc	32.33 a
G_4	5.70 b	5.50 a	5.29 ab	34.01 a
G_5	6.56 a	5.75 a	5.52 a	35.07 a
LSD $_{(0.05)}$	0.36	0.44	0.37	5.01
LS	*	*	*	*
CV (%)	6.12	7.24	6.58	13.70

In a column having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability
CV= Coefficient of variation, LS= Level of significance, *= Significant at 5% level of Probability, LSD = Least significant difference, [G_0 = Distilled water, G_1= 20 ppm BAP (Benzylaminopurine), G_2 = 40 ppm BAP, G_3 = 20 ppm GA_3 (Gibberellic acid), $G_{4=}$ 40 ppm GA_3, G_5 = 60 ppm GA_3]

Table 4. Effect of different sowing dates on yield attributes of mungbean

Sowing level	Pods plant^{-1} (no)	Pod length (cm)	Seeds pod^{-1} (no)	Weight of 1000 seeds (g)
S_1	7.19 a	6.75 a	6.43 a	35.64 a
S_2	2.65 b	3.41 b	2.96 b	25.39 b
LSD $_{(0.05)}$	0.20	0.25	0.21	2.89
LS	*	*	*	*
CV (%)	6.12	7.24	6.58	13.70

In a column having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability
CV= Coefficient of variation, LS= Level of significance, *= Significant at 5% level of Probability, LSD = Least significant difference, [S_1 = Sowing on 31 October, S_2 = Sowing on 14 November]

Table 5. Interaction effect of different sowing dates and growth regulators on yield attributes of mungbean

Interaction	Pods plant^{-1} (no)	Pod length (cm)	Seeds pod^{-1} (no)	Weight of 1000 seeds (g)
S_1 X G_0	5.88 e	6.10 c	5.45 e	32.22 cde
S_2 X G_0	0.40 k	0.73 f	0.60 h	8.28 g
S_1 X G_1	6.15 d	6.73 b	6.20 d	34.62 bcd
S_2 X G_1	1.93 j	3.28 e	3.15 g	25.84 f
S_1 X G_2	7.06 c	6.77 b	6.28 d	35.35 abc
S_2 X G_2	2.46 i	4.03 d	3.20 g	27.03 f
S_1 X G_3	7.60 b	6.83 b	6.58 c	35.86 abc
S_2 X G_3	3.06 h	4.03 d	3.26 g	28.79 ef
S_1 X G_4	7.66 b	6.90 ab	6.86 b	37.03 ab
S_2 X G_4	3.73 g	4.10 d	3.72 f	30.99 de
S_1 X G_5	8.80 a	7.20 a	7.22 a	38.74 a
S_2 X G_5	4.33 f	4.30 d	3.82 f	31.40 de
LSD $_{(0.05)}$	0.25	0.31	0.26	3.54
LS	*	*	*	*
CV (%)	6.12	7.24	6.58	13.70

In a column having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability
CV= Coefficient of variation, LS= Level of significance, *= Significant at 5% level of Probability, LSD = Least significant difference, [G_0= Distilled water, G_1 = 20 ppm BAP (Benzylaminopurine), G_2= 40 ppm BAP, G_3= 20 ppm GA_3 (Gibberellic acid), G_4= 40 ppm GA_3, G_5= 60 ppm GA_3, S_1 = Sowing on 31 October, S_2 = Sowing on 14 November]

4.4. Pod length

Pod length showed significant variation due to the application of different growth regulators (Table. 3). G_5 (60 ppm Gibberellic acid) treatment showed the highest pod length (5.75 cm). The lowest pod length (3.41 cm) was obtained by G_0 treatment (No growth regulators). Foysal (2014) also found the similar result. The maximum length of pod (9.68 cm) was recorded from 40 ppm NAA treatment and the minimum (7.09 cm) was found in 0 ppm NAA treatment.

The pod length was varied significantly influenced by different sowing dates at all stages of growth (Table. 4). The highest pod length (6.75 cm) was recorded from S_1 (Sowing on 31 October) and the lowest pod length (3.41 cm) was achieved by S_2 (Sowing on 14 November). The result was similar with the result of Soomro and Khan (2003) who found that the early sowing showed the highest length (9.2 cm) of pod and least (5.1 cm) was observed in last sowing.

Interaction effect between growth regulators and different sowing conditions showed significant variation on Pod length (Table 5). The highest Pod length (7.20 cm) was observed in Sowing on 31 October with 60 ppm GA_3 ($S_1 \times G_5$). The lowest Pod length (0.73 cm) was observed from the sowing on 14 November with no growth regulators ($S_2 \times G_0$).

4.5. Seeds pod^{-1}

Application of growth regulators at different levels showed significant variation on number of seeds per pod (Table. 3). Among the different growth regulators levels G_5 (60 ppm Gibberellic acid) treatment showed the highest number of seeds per pod (5.52). The lowest number of seeds per pod (3.02) was recorded with G_0 treatment where no growth regulators were applied. Foysal (2014) found that number of seeds per pod significantly increased by growth regulators.

Results presented in Table 4 on number of seeds pod^{-1} influenced by different sowing dates were statistically significant. The present study showed that the highest number of seeds pod^{-1} (6.43) was recorded in S_1 (Sowing on 31 October) treatment and the lowest number of seeds pod^{-1} (2.96) was achieved by S_2 (Sowing on 14 November). This result was consistent with the findings of Sadeghipour (2008) and Sarkar *et al.* (2004) who reported that number of seeds pod^{-1} were affected by sowing date. Maximum number of seeds pod^{-1} was recorded on 2nd sowing under the study probably due to prevailing favorable condition for growth and development of mungbean.

Interaction effect between growth regulators and different sowing conditions showed significant variation on seeds pod^{-1} (Table 5). The highest number of seeds pod^{-1} (7.22) was observed in the sowing on 31 October with 60 ppm GA_3 ($S_1 \times G_5$).

The lowest number of seeds pod^{-1} (0.60) was observed from the sowing on 14 November with no growth regulators ($S_2 \times G_0$).

4.6. Weight of 1000 seeds

Application of growth regulators at different levels showed significant variation on thousand seeds weight (Table 3). Among the different growth regulators levels G_5 (60 ppm Gibberellic acid) treatment showed the highest thousand seed weight (35.07 g). The lowest thousand seeds weight (20.25 g) was recorded with G_0 treatment where no growth regulators were applied. This result was consistent with the findings of Foysal (2014) who found 1000 grains weight of mungbean differed significantly due to plant growth regulator. The highest 1000 grains weight (44.50 g) was recorded from the 40 ppm NAA treatment and the lowest (37.14 g) was found in the 0 ppm NAA treatment.

Results showed that weight of 1000 seeds influenced by different sowing dates were statistically significant (Table 4). The highest weight of 1000 seeds (35.64 g) was recorded in S_1 (Sowing on 31 October) treatment whereas the lowest weight of 1000 seeds (25.39 g) was achieved by S_2 (Sowing on 14 November). The result corroborates with the findings of Farghali and Hussein (1995). They observed that mungbean 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.

Interaction effect between different levels of growth regulators and different sowing conditions showed significant effect on weight of 1000 seeds (Table 5). The highest weight of 1000 seeds (38.74 g) was observed in the treatment combination of sowing on 31 October with 60 ppm GA_3 ($S_1 \times G_5$). The lowest weight of 1000 seeds (8.28 g) was observed from the interaction of sowing on 14 November with no growth regulators ($S_2 \times G_0$).

4.7. Seed yield

There was a significant variation in the seed yield of mungbean due to the application of growth regulators (Table 6). From the table it was found that G_5 (60 ppm Gibberellic acid) treatment showed the highest seed yield (0.26 t ha^{-1}). The lowest seed yield (0.19 t ha^{-1}) was observed from G_0 treatment where no growth regulators were applied. This result was consistent with the findings of Foysal (2014) where Grain yield of mungbean varied significantly due to plant growth regulator. The highest grain yield was recorded from the 40 ppm NAA treatment whereas, the lowest was found in the 0 ppm NAA treatment.

Seed yield of mungbean influenced by different sowing dates were statistically significant (Table 7). The highest grain yield (0.40 t ha^{-1}) was recorded in S_1 (Sowing on 31 October) treatment while the lowest grain yield (0.04 t ha^{-1}) was achieved by S_2 (Sowing on 14 November). This findings closely resembles to those reported by Sinha *et al.* (1989), Poehlman (1991) and Miah *et al.* (2009) who opined that mungbean 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 rnungbean. Late sown crop could not attain proper growth which resulted in drastic reduction in yield.

Interaction effect between different levels of growth regulators and different sowing conditions showed significant effect on seed yield at harvest (Table 8). The highest seed yield (0.45 t ha^{-1}) was observed in sowing on 31 October with 60 ppm Gibberellic acid ($S_1 \times G_5$). The lowest seed yield (0.01 t ha^{-1}) was observed from the sowing on 14 November with no growth regulators ($S_2 \times G_0$).

Table 6. Effect of growth regulators on yields and harvest index of mungbean

Growth regulators	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	HI (%)
G_0	0.19 e	0.31 e	0.50 d	23.87 b
G_1	0.21 d	0.35 d	0.56 c	36.84 a
G_2	0.21 cd	0.36 cd	0.57 c	37.02 a
G_3	0.22 c	0.37 c	0.59 c	37.23 a
G_4	0.24 b	0.39 b	0.63 b	37.43 a
G_5	0.26 a	0.41 a	0.67 a	37.75 a
LSD $_{(0.05)}$	0.011	0.012	0.038	6.23
LS	*	*	*	*
CV (%)	4.44	3.79	4.08	14.86

In a column having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability
CV= Coefficient of variation, LS= Level of significance, *= Significant at 5% level of Probability, LSD = Least significant difference, [G_0= Distilled water, G_1 = 20 ppm BAP (Benzylaminopurine), G_2= 40 ppm BAP, G_3= 20 ppm GA_3 (Gibberellic acid), G_4= 40 ppm GA_3, G_5= 60 ppm GA_3]

Table 7. Effect of different sowing dates on yields and harvest index of mungbean

Sowing level	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	HI (%)
S_1	0.40 a	0.66 a	1.06 a	37.82 a
S_2	0.04 b	0.07 b	0.11 b	32.23 b
LSD $_{(0.05)}$	0.007	0.007	0.022	3.59
LS	*	*	*	*
CV (%)	4.44	3.79	4.08	14.86

In a column having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability
CV= Coefficient of variation, LS= Level of significance, *= Significant at 5% level of Probability, LSD = Least significant difference, [S_1 = Sowing on 31 October, S_2 = Sowing on 14 November]

Table 8. Interaction effect of different sowing dates and growth regulators on yields and harvest index of mungbean

Interaction	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	HI (%)
S_1 X G_0	0.36 e	0.61 e	0.97 e	37.33 a
S_2 X G_0	0.01 j	0.02 j	0.03 i	10.41 b
S_1 X G_1	0.38 e	0.63 e	1.01 d	37.50 a
S_2 X G_1	0.04 i	0.06 i	0.10 h	36.18 a
S_1 X G_2	0.39 d	0.64 d	1.03 cd	37.74 a
S_2 X G_2	0.04 i	0.07 i	0.11 gh	36.30 a
S_1 X G_3	0.40 c	0.65 c	1.05 c	37.97 a
S_2 X G_3	0.04 hi	0.08 h	0.12 fgh	36.48 a
S_1 X G_4	0.43 b	0.69 b	1.12 b	38.09 a
S_2 X G_4	0.05 gh	0.08 h	0.13 fg	36.77 a
S_1 X G_5	0.45 a	0.73 a	1.19 a	38.29 a
S_2 X G_5	0.06 g	0.09 g	0.15 f	37.21 a
LSD $_{(0.05)}$	0.008	0.008	0.027	4.40
LS	*	*	*	*
CV (%)	4.44	3.79	4.08	14.86

In a column having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability
CV= Coefficient of variation, LSD = Least significant difference, LS= Level of significance, *= Significant at 5% level of Probability, [G_0 = Distilled water, G_1= 20 ppm BAP (Benzylaminopurine), G_2 = 40 ppm BAP, G_3 = 20 ppm GA_3 (Gibberellic acid), G_4 = 40 ppm GA_3, G_5 = 60 ppm GA_3, S_1 = Sowing on 31 October, S_2 = Sowing on 14 November]

4.8. Stover yield

Different levels of growth regulators showed significant variations in terms of stover yield of mungbean (Table 6). Among the different levels of growth regulators, G_5 (60 ppm Gibberellic acid) treatment showed the highest stover yield (0.41 t ha^{-1}). On the contrary, the lowest stover yield (0.31 t ha^{-1}) was observed from G_0 treatment where no growth regulators were applied.

This result was not consistent with the findings of Foysal (2014), the maximum stover yield (2.13 t ha^{-1}) was recorded from the G_0 (0 ppm NAA) treatment whereas, the minimum (1.30 ha^{-1}) was found in the G_{40} (40 ppm NAA) treatment.

Stover yield of mungbean varied significantly due to different sowing dates (Table 7). The highest stover yield (0.66 t ha^{-1}) was recorded in S_1 (Sowing on 31 October) treatment while the lowest stover yield (0.07 t ha^{-1}) was achieved by S_2 (Sowing on 14 November). This result was 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.

Interaction effect between different levels of growth regulators and different sowing conditions showed significant effect on stover yield at harvest (Table 8). The highest stover yield (0.73 t ha^{-1}) was observed in sowing on 31 October with 60 ppm Gibberellic acid ($S_1 \times G_5$). The lowest stover yield (0.02 t ha^{-1}) was observed from the sowing on 14 November with no growth regulators ($S_2 \times G_0$).

4.9. Biological yield

Different levels of growth regulators showed significant variations in respect of biological yield of mungbean (Table 6). Among the different levels of growth regulators, G_5 (60 ppm Gibberellic acid) treatment showed the highest biological yield (0.67 t ha^{-1}). The lowest biological yield (0.50 t ha^{-1}) was observed from G_0 treatment where no growth regulators were applied. This result was not similar with the findings of Foysal (2014) where the highest biological yield (3.24 t ha^{-1}) was observed from 0 ppm NAA (G_0) treatment and the lowest (2.98 t ha^{-1}) was found in 40 ppm NAA (G_{40}) treatment.

Biological yield was significantly influenced by different sowing dates (Table 7). The maximum biological yield (1.06 t ha^{-1}) was recorded in S_1 (Sowing on 31 October) treatment while the lowest biological yield (0.10 t ha^{-1}) was achieved by S_2 (Sowing on 14 November). 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.

Interaction effect between different levels of growth regulators and different sowing conditions showed significant effect on biological yield at harvest (Table 8). The highest biological yield (1.19t ha^{-1}) was observed in sowing on 31 October with 60 ppm Gibberellic acid ($S_1 \times G_5$). The lowest biological yield (0.03 t ha^{-1}) was observed from the sowing on 14 November with no growth regulators ($S_2 \times G_0$).

4.10. Harvest Index

Different levels of growth regulators showed significant variations in respect of harvest index of mungbean (Table 6). Among the different levels of growth regulators, G_5 (60 ppm Gibberellic acid) treatment showed the highest harvest index (37.75 %). The lowest harvest index (23.87 %) was observed from G_0 treatment where no growth regulators were applied. The similar result was reported by Foysal (2014) where maximum harvest index (56.42 %) was recorded from 40 ppm NAA (G_{40}) treatment whereas, the minimum (34.64 %) was found from 0 ppm NAA (G_0) treatment.

There was a significant variation in Harvest index in terms of different sowing dates (Table 7). The maximum Harvest index (37.82 %) was recorded in S_1 (Sowing on 31 October) treatment while the lowest Harvest index (32.23 %) was achieved by S_2 (Sowing on 14 November). 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. There is similar result was reported by Mohsina (2014) where Sowing date showed significant differences on harvest index, the highest harvest index (57.84 %) was recorded in S_2 (13 September) and the lowest harvest index (47.26 %) in S_4 (23 October).

Interaction effect between different levels of growth regulators and different sowing conditions showed significant effect on harvest Index (Table 8). The highest harvest index (38.29 %) was observed in sowing on 31 October with 60 ppm Gibberellic acid ($S_1 \times G_5$). The lowest harvest Index (10.41%) was observed from the sowing on 14 November with no growth regulators (S_2 x G_0).

4.11. Yield increase

The rate of yield increase in mungbean at sowing on 31 October by growth regulators (G_1, G_2, G_3, G_4 and G_5 was 4.68%, 7.43%, 10.19%, 17.63, 24.79%, respectively) and at sowing on 14 November by growth regulators (G_1, G_2, G_3, G_4 and G_5 was 270%, 290%, 350%, 390%, 460%, respectively). The rate of increase in yield is higher at 2nd sowing than 1st sowing because at 2nd sowing the stress condition for plant is more than 1st sowing and the stress condition was overcomed by applying growth regulators at 2nd sowing than the 1st sowing. So the rate of yield increase is higher at 2nd sowing.

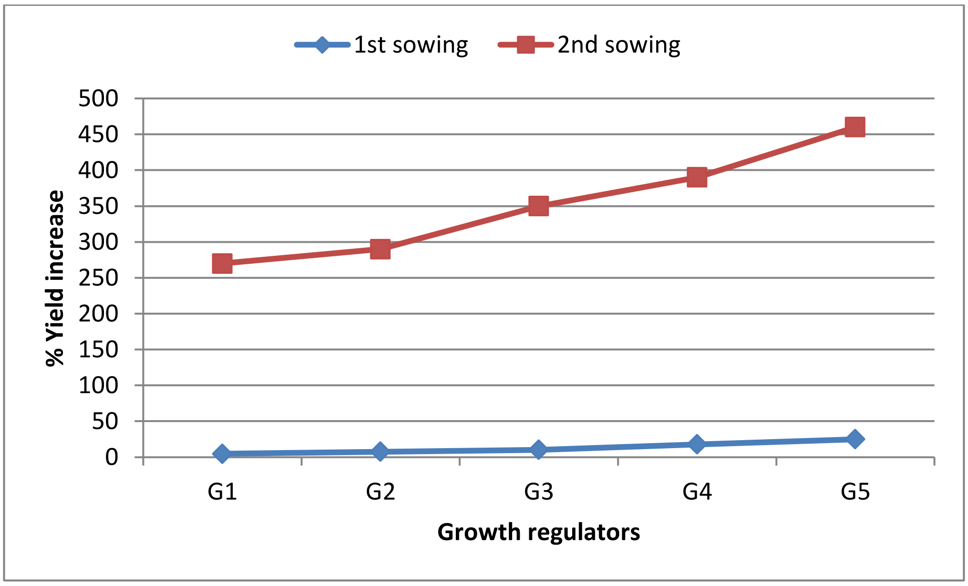

Figure 5. Yield increase (%) in mungbean by growth regulators over yield without growth regulators at different sowing conditions [G_0= Distilled water, G_1 = 20 ppm BAP (Benzylaminopurine), G_2= 40 ppm BAP, G_3= 20 ppm GA_3 (Gibberellic acid), G_4= 40 ppm GA_3, G_5= 60 ppm GA_3, S_1 = Sowing on 31 October , S_2 = Sowing on 14 November]

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the research field laboratory of Sher-e-Bangla Agricultural University, Dhaka, during the period of October 2017 to January 2018 to study the effect of growth regulators on growth and yield of mungbean under late sowing conditions in kharif-II season. The experiment was comprised of two factors; factor A: growth regulators (6) viz. G_0 = distilled water, G_1 = 20 ppm BAP (Benzylaminopurine), G_2 = 40 ppm BAP, G_3 = 20 ppm GA_3 (Gibberellic acid), G_4 = 40 ppm GA_3, G_5 = 60 ppm GA_3 and factor B: sowing date (2) viz. S_1 = sowing on 31 October, S_2 = sowing on 14 November. The experiment was laid out in randomized complete block design (RCBD) in factorial arrangements with three replications.

The data on crop growth parameters like plant height (cm), plant dry weight (g) were recorded at different days after sowing (DAS). Five plants were randomly selected from each unit plot for taking observations on plant height, plant dry weight (g) with 15 days interval at 20, 35, 50 and 65 days after sowing (DAS). Yield and other crop characters like number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1}, 1000-seeds weight (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) were recorded after harvest. Thousand seed weight was measured from the sampled seed.

Results showed that growth regulators had significant effect on crop growth characters. The maximum plant height and plant dry weight was observed from the G_5 (60 ppm GA_3) compared to the other growth regulators. The study also revealed that growth regulators had significant influence on yield and other crop characters. The highest number of pods per plant (6.56) was obtained from the G_5 (60 ppm GA_3) treatment and the lowest number of pod per plant (3.14) was found when the plants were raised without growth regulators (G_0). G_5 (60 ppm Gibberellic acid) treatment showed the highest pod length (5.75 cm). The lowest pod length (3.41 cm) was obtained by G_0 treatment (No growth regulators). G_5 (60 ppm Gibberellic acid) treatment showed the highest number of seeds per pod (5.52). The lowest number of seeds per pod (3.02) was recorded with G_0 treatment where no growth regulators were applied.

G_5 (60 ppm Gibberellic acid) treatment showed the highest thousand seed weight (35.07 g). The lowest thousand seed weight (20.25 g) was recorded with G_0 treatment. The higher seed yield (0.26 t ha^{-1}) and higher harvest index (37.75 %) was found from the G_5 (60 ppm Gibberellic acid) and the lowest seed yield (0.19 t ha^{-1}) and lower harvest index (23.87 %) was obtained from the G_0. The G_5 produced higher stover yield (0.41 t ha^{-1}) and biological yield (0.67 t ha^{-1}) where the G_0 produced lower stover yield (0.31 t ha^{-1}) and biological yield (0.50 t ha^{-1}). The plant height was varied significantly influenced by different sowing dates at all stages of growth. At 20, 35, 50 and 65 DAS, the highest plant height (20.15, 28.86, 33.46 and 34.51 cm, respectively) was recorded in S_1 (Sowing on 31 October) where the lowest was measured at 20, 35, 50 and 65 DAS (18.00, 25.86, 30.59 and 32.01 cm, respectively) in S_2 (Sowing on 14 November) treatment. Plant dry weight was significantly influenced by different sowing dates at all stages of growth. At 20, 35, 50 and 65 DAS the maximum Plant dry weight (1.15, 5.01, 7.32, and 9.67 g, respectively) was recorded in S_1 (Sowing on 31 October). The lowest Plant dry weight (1.09, 3.20, 4.98 and 7.86 g at 20, 35, 50 and 65 DAS, respectively) was achieved with S_2 (Sowing on 14 November).

The findings showed that sowing date also significantly influenced yield attributes. The highest pods $plant^{-1}$ (7.19), pod length (6.75 cm), number of seeds pod^{-1} (6.43), 1000-seeds wt. (35.64 g), seed yield (0.40 t ha^{-1}), stover yield (0.66 t ha^{-1}) and biological yield (1.06 t ha^{-1}) were obtained from the S_1 (Sowing on 31 October) and the lowest number of pods $plant^{-1}$ (2.65), pod length (3.41 cm), number of seeds pod^{-1} (2.96), 1000-seeds wt. (25.39 g), seed yield (0.04 t ha^{-1}), stover yield (0.07 t ha^{-1}) and biological yield (0.11 t ha^{-1}) were obtained from the S_2 (Sowing on 14 November). The highest harvest index (37.82%) was found from the S_1 (Sowing on 31 October) treatment and the lowest harvest index (32.23%) was from the S_2 (Sowing on 14 November) treatment.

Interaction effect between different levels of growth regulators and sowing conditions significantly affected growth as well as yield and yield contributing characters. The tallest plant (23.25, 37.63 and 39.43 cm at 20, 50 and 65 DAS, respectively) was observed from S_1G_5 treatment (Sowing on 31 October with 60 ppm GA_3) and the shortest plant (15.40, 21.10, 28.22 and 28.51 cm at 20, 35, 50 and 65 DAS, respectively) was obtained from S_2G_0 treatment (Sowing on 14 November with no growth regulators). The highest plant dry weight (1.30, 5.73, 8.34 and 10.68 at 20, 35, 50 and 65 DAS, respectively) was observed in the Sowing on 31 October with 60 ppm GA_3 ($S_1 \times G_5$). The lowest plant dry weight (0.78, 2.53, 3.49, and 6.93 cm at 20, 35, 50 and 65 DAS, respectively) was observed from the Sowing on 14 November with no growth regulators (S_2 x G_0). The highest number of pods plant^{-1} (8.80), pod length (7.20 cm), number of seeds pod^{-1} (7.22), 1000-seed wt. (38.74 g), seed yield (0.45 t ha^{-1}), stover yield (0.73 t ha^{-1}), biological yield (1.19 t ha^{-1}), and harvest index (38.29 %) were obtained from the interaction of S_1G_5 treatment (Sowing on 31 October with 60 ppm GA_3) and the lowest number of pods plant-1 (0.40), pod length (0.73 cm), number of seeds pod^{-1} (0.60), 1000-seeds wt. (33.38 g), seed yield (0.01 t ha^{-1}), stover yield (0.02 t ha^{-1}) biological yield (0.03 t ha^{-1}) and harvest index (10.41 %) were obtained from the interaction of S_2G_0 treatment (Sowing on 14 November with no growth regulators).

Percent yield increase over control (without growth regulators) by G_1, G_2, G_3, G_4 and G_5 were 4.68%, 7.43%, 10.19%, 17.63% and 24.79%, respectively at sowing on 31 October, whereas these figures were 270%, 290%, 350%, 390% and 460% , respectively at sowing on 14 november.

Based on the results of the present study, the following conclusions may be drawn-

- Gibberellic acid @ 60 ppm showed highest seed yield (0.26 t ha^{-1}) than others
- Sowing on 31 October showed highest seed yield (0.40 t ha^{-1}) compared to the other sowing date studied.
- The highest seed yield (0.45 t ha^{-1}) was recorded from the interaction of sowing on 31 october with 60 ppm Gibberellic acid.
- Growth regulators remarkebly increased % yield over control at sowing on 14 November compared to that of sowing on 31 october.

However, to reach a specific conclusion and recommendation, the same experiment need to be repeated and more research work should be done over different agroecological zones with different growth regulators and with sowing conditions.

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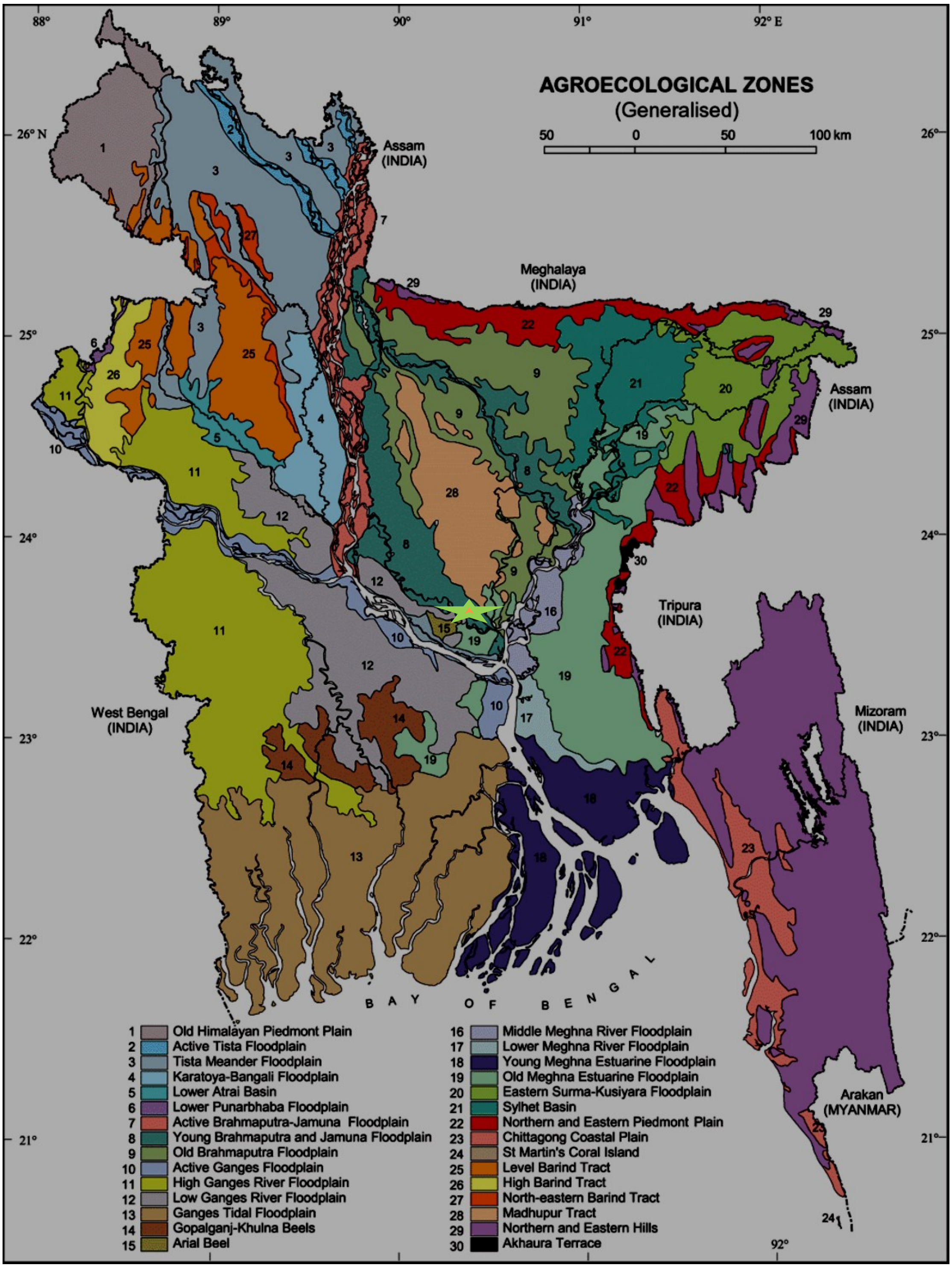
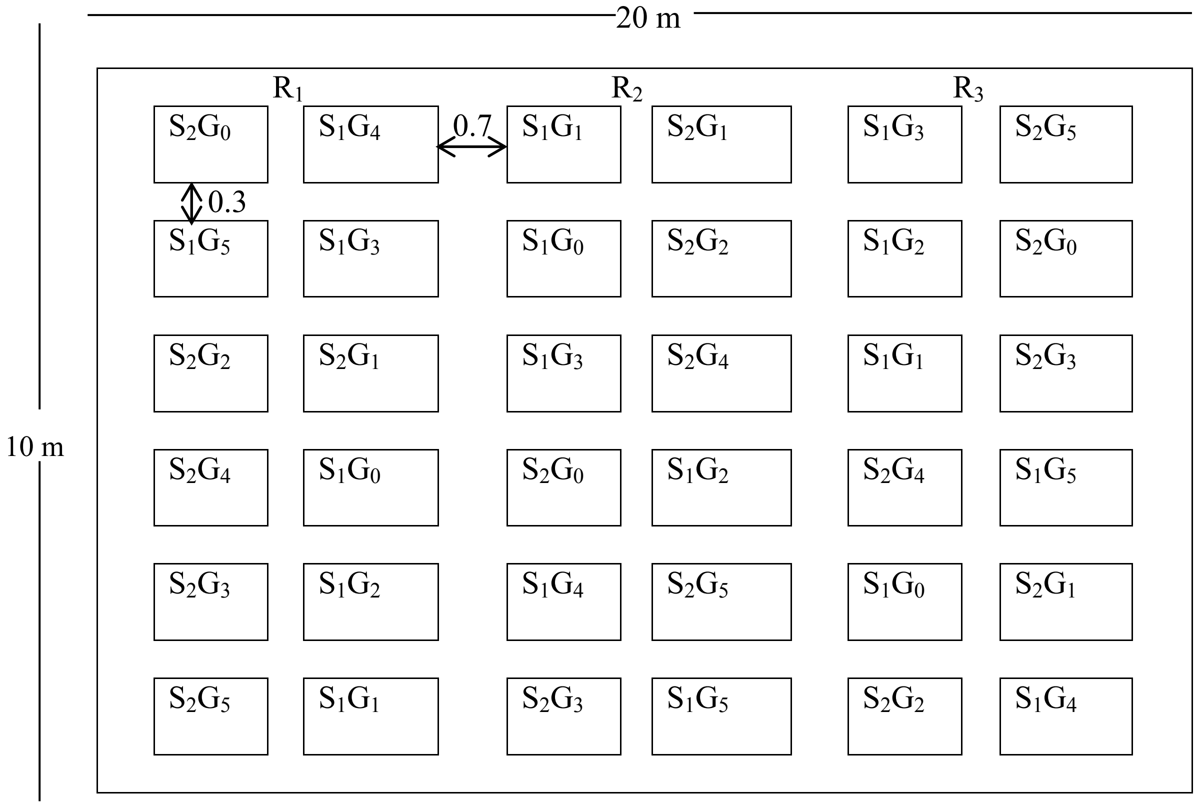
APPENDICES

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



★ : **The experimental site**

Appendix II. Layout of the experimental field



Factor A: Growth regulators - 6
G_0: Distilled water
G_1: 20 ppm BAP (Benzylaminopurine)
G_2: 40 ppm BAP
G_3: 20 ppm GA_3 (Gibberellic acid)
G_4: 40 ppm GA_3
G_5: 60 ppm GA_3

Factor B: Sowing Date - 2
S_1: 1st sowing at 31th October, 2017
S_2: 2nd sowing at 14th November, 2017

Plot size= 2.7 m x 1.2 m
Plot Spacing= 0.3 m
Between replications=0.7 m

Appendix III. Morphological characteristic of the soil of experimental field

Morphological features	Characteristics
Location	Experimental Field, SAU, Dhaka
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

Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
%Silt	43
%Clay	30
Textural class	Silty-clay
pH	6.1
Organic matter (%)	1.13
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100g soil)	0.10
Available S (ppm)	23

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

Appendix IV. Analysis of variance (ANOVA) of plant height of mungbean at different days after sowing (DAS)

Sources of variation	Degrees of freedom	Mean squares values at			
		20 DAS	35 DAS	50 DAS	65 DAS
Replication	2	1.081	2.283	10.957	13.635
Factor A	5	20.965*	84.684*	34.724*	54.785*
Factor B	1	41.775*	81.270*	73.989*	55.901*
AB	5	1.441*	0.964*	8.760*	2.619*
Error	22	3.096	0.902	3.183	6.568

* = Significant at 5% level of Probability

Appendix V. Analysis of variance (ANOVA) of plant dry weight of mungbean at different days after sowing (DAS)

Sources of variation	Degrees of freedom	Mean squares values at			
		20 DAS	35 DAS	50 DAS	65 DAS
Replication	2	0.017	0.005	0.023	0.110
Factor A	5	0.160*	2.021*	2.974*	3.002*
Factor B	1	0.023*	29.539*	49.515*	29.394*
AB	5	0.006*	0.349*	0.388*	0.127*
Error	22	0.003	0.015	0.086	0.011

* = Significant at 5% level of Probability

Appendix VI. Analysis of variance (ANOVA) of yield attributes of mungbean

Sources of variation	Degrees of freedom	Mean squares values at			
		Pods plant^{-1}	Pod length	Seeds pod^{-1}	1000 seed weight
Replication	2	0.101	0.188	0.074	15.189
Factor A	5	8.938*	4.363*	4.662*	170.627*
Factor B	1	185.414*	100.567*	108.681*	945.460*
AB	5	0.411*	1.576*	0.709*	68.901*
Error	22	0.091	0.136	0.096	17.488

* = Significant at 5% level of Probability

Appendix VII. Analysis of variance (ANOVA) of yields and harvest index of Mungbean

Sources of variation	Degrees of freedom	Mean squares values at			
		Seed yield	Stover yield	Biological yield	HI
Replication	2	0.001	0.001	0.004	27.822
Factor A	5	0.003*	0.007*	0.020*	179.721*
Factor B	1	1.186*	3.164*	8.219*	281.457*
AB	5	0.001*	0.001*	0.003*	163.681*
Error	22	0.0001	0.0001	0.001	27.077

* = Significant at 5% level of Probability