GROWTH AND YIELD OF MUNGBEAN AS INFLUENCED BY SOWING TIME, AUXIN AND GIBBERELLIC ACID

SUPRIO NATH PRINCE

DEPARTMENT OF AGRICULTURAL BOTANY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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BY
SUPRIO NATH PRINCE
REGISTRATION NO. 19-10164

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APPROVED BY:

Dr. Mohammad Mahbub Islam
Professor
Department of Agricultural Botany
SAU, Dhaka
Supervisor

Dr. Md. Ashabul Hoque
Professor
Department of Agricultural Botany
SAU, Dhaka
Co-Supervisor

Asim Kumar Bhadra
Professor and Chairman
Examination Committee

DEPARTMENT OF AGRICULTURAL BOTANY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
Phone: 9134826

CERTIFICATE

This is to certify that the thesis entitled "**GROWTH AND YIELD Of MUNGBEAN AS INFLUENCED BY SOWING TIME, AUXIN AND GIBBERELLIC ACID**" submitted to the Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRICULTURAL BOTANY**, embodies the result of a piece of bona fide research work carried out by **SUPRIO NATH PRINCE**, being Registration No. **19-10164** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Prof. Dr. Mohammad Mahbub Islam
Supervisor
Department of Agricultural Botany
Sher-e-Bangla Agricultural University Dhaka-1207

Dated:
Dhaka, Bangladesh

Dedicated to

My

Beloved Family

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ABSTRACT

The field experiment was conducted at the Research Farm of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, during the period from February to June 2022 to find the effect of sowing time and the application of auxin and gibberellin on growth and yield of mungbean. The experiment comprised of two factors viz. Factor A: Sowing time (3), i) S_1 = 5 March, ii) S_2 = 15 March and iii) S_3 = 25 March; factor B: Plant growth regulators (4), i) G_0 = Control, ii) G_1 = IAA 30 ppm, iii) G_2 = GA_3 30 ppm and iv) G_3 = IAA 30 ppm + GA_3 30 ppm. The results revealed that S_3 treatment (sowing at 25 March) exhibited its superiority to other sowing time of 5 March and 15 March in terms of growth and seed yield of mungbean. Sowing time (25 March) S_3 out-yielded over S_2 by 11.67% higher yield. As S_3 showed the highest number of pods plant^{-1} (23.80), the highest number of seeds pod^{-1} (10.41), highest length of mungbean pod (7.82 cm), the highest weight of 1000-seeds (40.21 g) and the highest seed yield plot^{-1} (192.16 g) than other sowing time in this experiment. Significant differences existed among different plant growth regulator treatments with respect to yield and yield contributing parameters of mungbean. A yield advantages of 0.05 t ha^{-1}, 0.05 t ha^{-1} and 0.07 t ha^{-1} was observed from G_3 treatment over G_2, G_1 and G_0 treated plot, respectively. The higher amount of yield from G_3 treatment was possibly aided by the highest number of pods plant^{-1} (23.00), the highest number of seeds pod^{-1} (10.54), highest pod length (7.98 cm), the highest weight of 1000-seeds (44.26 g) and the highest seed yield plot^{-1} (183.06 g). Significantly the highest seed yield ha^{-1} (0.72 t ha^{-1}) was recorded from S_3G_3 [25 March × (IAA 30 ppm + GA_3 30 ppm)] interaction due to the the highest number of pods plant^{-1} (27.60), the highest number of seeds pod^{-1} (12.23), highest pod length (9.13 cm), the highest weight of 1000-seeds (46.54 g), and the highest seed yield plot^{-1} (205.84 g). Mungbean seed sown at 25 March and applied with IAA 30 ppm + GA_3 30 ppm seems promising for producing significantly higher yield of mungbean under the climatic and edaphic conditions of Sher-e-Bangla Agricultural University.

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ABBREVIATIONS

%	:	Percentage
@	:	At the rate of
Abstr.	:	Abstract
AEZ	:	Agro-Ecological Zone
Agric.	:	Agriculture
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BBS	:	Bangladesh Bureau of Statistics
Cm	:	Centimeter
cv.	:	Cultivar
DAS	:	Day After Sowing
et al.	:	et alii (and others)
FAO	:	Food and Agriculture Organization Of the United Nations
Fig.	:	Figure
FW	:	Fresh weight
G	:	Gram
Hort.	:	Horticulture
i.e.	:	That is
J.	:	Journal
Kg	:	Kilogram
LSD	:	Least Significant Difference
M	:	Meter
No.		Number
NS	:	Not significant
0C	:	Degree Celsius
RCBD	:	Randomized Complete Block Design
SAU	:	Sher-e-Bangla Agricultural University
Sci.	:	Science
Soc.	:	Society
T	:	Ton
t/ha	:	Ton per hectare
TSP	:	Triple Super Phosphate
Viz.	:	Namely

CHAPTER I

Introduction

Pulse crops belong to seed legume under family Fabaceae. Pulses of many types are grown in Bangladesh. Pulses are the main source of plant protein for the people, particularly for the poor section of Bangladesh and it is called the poor men's meat as it is the cheapest source of protein. But at present pulses are beyond the reach of the poor people because of its high price due to less production. Additionally, through nitrogen fixation, crops have the power to improve soil health. Lysine, which is lacking in rice, is abundant in pulse protein. Lentil, chickpea, cowpea, blackgram, mungbean, fieldpea, and grasspea are the important pulse crops. Mungbean (*Vigna radiata* L.) is one of Bangladesh's most important pulse crops. Mungbean also called green gram, golden gram, mung, mug is an important pulse crop in the world, because it produces high quality and quantity protein (Tomooka *et al*., 2002). Mungbean seed includes 1-3 percent fat, 5.4 percent carbohydrates, 25.67 percent protein, 3.5-4.5 percent fibers, and 4.5-5.5 percent ash, respectively, while calcium and phosphorus content are 132 and 367 mg per 100^{-1} g of seed, respectively (Frauque *et al*., 2000). It contains almost double amount of protein as compared to cereals. Its edible seed is notable for its good digestion, flavor, high protein content, and lack of flatulence (Ahmad *et al*., 2008).

The agro-ecological condition of Bangladesh is favourable for mungbean cultivation almost throughout the year. The crop is usually cultivated during *rabi* season. But because of poor yield and marginal profit as compared to cereal crops, farmers prefer growing boro rice, maize and wheat than mungbean during rabi season. During kharif season the crop fits well into the existing cropping system of many areas in Bangladesh. Mungbean is commonly sown in the southern, north, and north-western regions of Bangladesh during the *kharif*-I (2nd week of February to 1st week of March) and *kharif*-II (1st week of August to 1st week of September) seasons, respectively, though it is cultivated in both summer and winter seasons in many countries around the world. The area under pulse crops in Bangladesh is 919251.02 acre with a production of 424713.74 metric tons where mungbean is cultivated in the area of 109304.77 acre with production of 41189.26 metric tons (BBS, 2021). In Bangladesh, it ranks third in protein content and fourth in both acreage and production (Sarkar *et al*., 2012). In Bangladesh, total pulse production is barely 0.65 million tons, despite a demand of 2.7 million tons. This suggests that there is a deficit of nearly 75% of the total requirement (Rahman and Ali, 2007). The number of pulses produced nationally is insufficient to satisfy our country's needs.

The agricultural land of our country is decreased. But the population is very high. More people need more food. We have to produce more food in our limited land. To meet up the increased demand of food, farmers are growing more cereal crops. Due to the high population pressure, the total cultivable land is decreasing day by day along with the pulse cultivable land. So, at present the cultivation of pulse has gone to marginal land because farmers do not want to use their fertile land in pulse cultivation. Pulse cultivation is also decreasing because of its low yield and production. The long term cereal crop cultivation also effects soil fertility and productivity. The farmers of Bangladesh generally grow mungbean by one ploughing and hardly use any fertilizer and irrigation due to its lower productivity and also to their poor socio-economic condition and lack of proper knowledge. As a result, the yield becomes low. There is an ample scope for increasing the yield of mungbean with improved management practices.

The best time to sow depends on the variety and the weather conditions. Growers frequently alter sowing times in order to achieve greater growth, quality and yield. The time of sowing is also changed to match the harvesting season with market demand. For any advancement, superior parents must be selected, i.e., parents with higher heritability and genetic progress for specific qualities (Ahmad *et al*., 2008). Mungbean sowing timing, a non-monetary input, is a key aspect in obtaining the best yield (Samanta *et al*., 1999). As a result, taking advantage of the best sowing time for mungbean farming is unavoidable. Due to differences in agro-ecological circumstances, the best time to sow mungbean varies from variety to variety and season to season. As a result, specific sowing dates for individual types must be established, particularly during the summer season, in order to maximize production. Summer mungbean yields are reduced by late sowing after March and early sowing before February. The best time to plant summer mungbeans is around the middle of February (Chovatia *et al*., 1993). In the *Kharif*-II season, delayed seeding after September and early sowing before August diminish mungbean production. In the *Kahrif*-II season, the best time to sow mungbean is around mid-August (Dharmalingam and Basu, 1993). The growth of mungbean plants is hampered by delayed seeding after September in the *Kharif*-II season. It's because of the cold temperatures that prevailed during the crop's growing season. However, little is known about the effect of different sowing time on *Kharif*-I season on growth and yield of mungbean under climatic and edaphic conditions of Sher-e-Bangla Agricultural University.

Plant growth regulators (PGRs) are known to influence plant growth and development at very low concentrations. Moreover, the response of the plant to PGRs may vary with species, varieties, environmental conditions, physiological and nutritional status, stage of development and endogenous hormonal balance (Naeem *et al*., 2004) delays senescence (Shah 2007). Plants have the ability to store excessive amounts of exogenously supplied hormones in the form of reversible conjugates which release active hormone when the plants need them during the growth period (Davies 2004). Ammanullah *et al*., (2010) mentioned that plant growth substances are known to enhance the source-sink relationship and stimulate the translocation of photo assimilates to sink thereby helping in effective flower formation, fruit, and seed development and ultimately enhancing the productivity of crops. PGRs are divided into five categories: auxins, cytokinins, gibberellins, abscisic acid, and ethylene. Plants respond differently to each type of growth regulator.

IAA (indol-3-acetic acid), a naturally generated growth hormone, is critical for crop growth and development, as it increases the amount of food available to the growing plant when it is needed. As plant density rises, competition between plants rises, potentially resulting in poorer food production by individual plants, which could stymie nodule creation. Artificially administered auxin may promote root and shoot growth, allowing individual plants to harvest more light, water, nutrients, and other resources in order to generate more food. As a result, artificially applied auxin may have a favorable influence on nodulation and yield quality at various plant densities. IAA and 4-Cl-IAA increases mungbean growth and Nitrogen fixation, according to (Ali *et al*., 2008). Various plant growth regulators which regulate growth under normal or stress conditions are auxins. Generally, auxins are the best hormones for use because they are non-toxic to plants over a wide range of concentration and effective in promoting the root system of a large number of plant species. Auxins might regulate cell elongation, cell division, tissue swelling, formation of adventitious roots, callus initiation, induction of embryogenesis, and promoting cell wall loosening at very low concentrations (Taiz and Zeiger 2006). The principal auxin in plants is indole-3-acetic acid (IAA) that produced mainly in the shoot apex bud and young leaves of plants. Other meristematic tissues, flowers, fruits, and young seeds have also been shown to be sites of this hormone production (Sadak *et al*., 2013).

The most essential growth regulator is gibberellic acid (GA_3), which breaks seed dormancy, boosts germination, internodal length, hypocotyl growth and cell division in the cambial zone, and increases leaf size. Gibberellic acid with the chemical formula $C_{19}H_{22}O_6$, is a white to pale yellow solid with a molar mass of 346.37 g/mol, a melting point of 233 to 235°C, and a solubility in water of 5 mg/l at 200°C. GA_3 promotes hydrolytic enzymes that are required for the breakdown of the cells around the radicle, speeding up germination by encouraging cereal seedling elongation growth (Rood *et al*., 1990). Gibberellins (GAs) are a class of plant hormones and natural components known as terpenoids that have a wide range of applications, with GA_3 being the most often used (Hartmann *et al*., 1999). GA_3 enhances growth activities to plant, stimulates stem elongation and increases dry weight and yield (Deotale *et al*., 1998). Gibberellins (GAs) are the most important natural growth regulators and generally involved in the growth and development of different plant. They control seed germination, leaf expansion, stem elongation, and flowering (Magome *et al*., 2004 and Kumar *et al*., 2018). Gibberellic acid (GA_3) is used to induce great changes in the growth characters, chemical composition, and yield criteria of the plant. Choudhury *et al*., (2013) and Kumar *et al*., (2014) stated that GA_3 treatment increased the growth and yield of mungbean.

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

i. To find the suitable time of sowing for mungbean cultivation based on growth, yield contributing characters and seed yield,

ii. To investigate the effect of foliar application of auxin and gibberellin on growth and yield of mungbean,

iii. To study the interaction effect of sowing time and plant growth regulators (auxin and gibberellin) on growth and yield of mungbean under the climatic and edaphic condition of Sher-e-Bangla Agricultural University.

CHAPTER II

REVIEW OF LITERATURE

Mungbean is one of the most important pulse crops in Bangladesh as well as many countries of the world. The crop has conventional less concentration by the researcher on various aspects because normally it grows with less care and management practices. For that a very few studies related to yield and development of mungbean have been carried out in the country as well as many other countries of the world. So, the research as far done in Bangladesh is not adequate and conclusive. In this chapter, an attempt has been made to review the available information in home and abroad regarding the effect of sowing time and plant growth regulator on the yield of mugbean.

2.1 Effect of sowing time on growth and yield of different pulse crops including mungbean

A research trial was planned at Research Area, College of Agriculture, University of Sargodha, Pakistan to investigate the impact of different sowing dates on growth and yield on mungbean cultivars. The research trial was arranged out in randomized complete block design (RCBD) under split plot arrangement followed by 3 replicas. In this study four different sowing dates (1st March, 15th March, 29th March and 12th April and two cultivars (AZRI-2006 and NM-92) were used. On the bases of result of this study it was concluded that sowing date of 1st march and variety AZRI-2006 play important role in aching maximum yield of mungbean (Ali *et al*., 2021).

Ahmed *et al*., (2021) conducted an experiment to determine the effect of variable sowing dates and cultivars on the growth and productivity of mungbean. The experiment consisted of different sowing dates (SD); 25th April, 5th May and 15th May and variable mungbean cultivars. In conclusion, mungbean should be sown on 25th April to get the maximum production in rice-wheat cropping system (RWCS). Additionally, cultivar NM-2006 can be grown in RWCS to get maximum production.

Kundu *et al*., (2021) found that sowings in mid-March and early April resulted in better vegetative growth in terms of plant height, branching habit and dry matter production due to high temperature compared to early sowing in mid-February. Mungbean sown on 11 March recorded the highest grain yield (684.3 kg/ha), which was 14.5% and 68.8% greater over 15 February (597.8 kg/ha) and 4 April (405.5 kg/ha) sowings.

A field experiment was conducted at the Agricultural Research Station, BARI, Rajbari, Dinajpur by during the kharif-1 season of 2016-17 and 2017-18. The aim of the study was to determine the optimum sowing date for maximizing the yield of mungbean in Dinajpur area of Bangladesh. It exposed that sowing should preferably be done around 15 March and sowing is not desirable beyond 25 March at all under agro-climatic conditions of Dinajpur areas of Bangladesh (Khanum *et al*., 2019).

Uddin *et al*., (2013) the variety BARIMung-6 planted on 15 September with 80 kg P_2O_5 ha^{-1} was superior in relation to plant height at harvest, number of pods $plant^{-1}$, tallest pod, number of seed pod^{-1}, number of seed $plant^{-1}$, seed weight $plant^{-1}$, straw yield, 1000-seed weight and harvest index which resulted in the highest seed yield. BARIMung-5 planted on 15 September with 80 kg P_2O_5 ha^{-1} also produced the similar yield. In contrast, the lowest plant height at harvest, number of pods $plant^{-1}$, tallest pod, number of seed pod^{-1}, number of seed $plant^{-1}$, seed weight $plant^{-1}$, seed yield, straw yield, 1000-seed weight and harvest index were found in BINAMung-6 planted on 15 October with control (no phosphorus application) treatment.

Rashid *et al*., (2013) studied the effect of dates of sowing on the incidence and severity of diseases and yield of Mungbean. Results revealed that the disease incidence of Mungbean Yellow Mosaic Virus (MYMV) of six varieties/lines, BMXK2 03000, BMXK2 03005-4 and BARImung-6 showed highly resistance (HR), resistant (R) and resistant to moderately resistant reaction, at the sowing time of January 15, February 01-15 and April 01 respectively.

Rabbani *et al*., (2013) found that, summer mungbean varieties BINA moog7 or BINA moog6 sown during the period from 15 February to 2 March for obtaining higher seed yield.

Kumar *et al*., (2015) revealed that yield attributes, yield, N, P and K uptake of mungbean was recorded significantly higher in 5^{th} April than April 15^{th} sown crop. However, yield attributes, yield, N, P and K uptake of mungbean was noted markedly higher with seed rate of 35 kg/ha, which was significantly superior to 20, 25 and 30 kg/ha. Similarly, application of 50% RDF+PSB produced significantly higher yield attributes, yield, N, P, K uptake by mungbean.

Islam (2008) conducted two experiments in kharif-I and khiarif-II seasons of 2006 with BARI mung-2 under well-watered and water-stress conditions with growth regulators.

He observed water content and exudation rate varied with the growing season due to different sowing date.

Number of branches plant^{-1} of short-season lentil varied significant for different sowing time. Hanaln *et al*., (2006) observed that highest canopy traits such as rapid growth, light interception of lentil.

Anwar *et al*., (2003) conducted an experiment with kabuli chickpea in cool temperature sub-humid climate under different dates of sowing and found that relative water content and exudation rate were significantly influenced by sowing date.

Brand *et al.,* (2003) found that the optimum sowing dates for mungbean cultivars in 2000 were mid-June to early July and in 2001 mid-May to mid-June. The effects of sowing date, plant density phosphorus level and ethephon application were investigated in the semiarid region in the north of Jorden by Turk *et al*., (2003) and observed that yields were obtained for early sowing (1 January).

Mian *et al*., (2002) in mungbean number of branches plant-^{1}, number of pods plant-^{1}, number of seed pod-^{1}, 1000 seed weight and seed yield were significantly influenced by the dates of sowing.

The highest yield was obtained when seeds were sown on 25 January followed by 05 February and 15 January and the lowest in 5 march planting. The lowest yield obtained from early and delay planting. The lower seed yield plant-^{1} at the last sowing was due to significant decrease in the number of seeds pod^{1} and 1000 seed weight of chickpea (Siddique *et al*., 2002).

Kazemekas (2001) found that the earliest sowing date were optimum for the optimum flowering and maturity of greengram.

Al-Hussien *et al*., (2002) reported that different sowing dates (early and late) significantly affect number of branches plant^{-1} of lentil.

Nag *et al*., (2000) observed seed yield in mungbean is a function of number of pods plant^{-1}, number of seed pod^{-1}, 1000 seed weight and seed size of mungbean.

Siddique *et al.*, (1998a) observed sowing in late April or early May allowed a longer period for vegetative and reproductive growth, rapid canopy development, more water use and hence, greater vegetative growth and number of branches of lentil.

Rahman and Sarkar (1997a) reported that high-yielding cultivars also had more leaves and petioles at both vegetative and reproductive phases and number of branches plant^{-1} of lentil.

Sowing times affect not only seed quality but also on the productivity of field crops. Mungbean sown in wet season (early September, mid-October and late December) produced greater seed yields than in dry season (late April, mid-May and late June) at pasadeniya, Srilanka (Sangakkara, 1998)

Yield potentiality is an inherent character of crop cultivars. The productivity of a crop is governed by such inherent genetic makeup and physiological expression under certain growth environment (Baset *et al*., 1996).

2.2 Effect of auxin and gibberellic acid on growth and yield of different pulse crops including mungbean

Kumawat *et al*., (2022) found that Spray of 75 ppm SA, being at par with 100 ppm SA, recorded significantly higher yield of mungbean attributes, seed (1,031 kg/ha), stover (1,806 kg/ha) and biological (2,838 kg/ha) yields as compared to control.

Shahzadi *et al*., (2022) conducted a study aims to explore the O_3 stress tolerance potential of mungbean genotypes under exogenous application of growth regulators. Overall, silicic acid application proved more effective in reducing the negative effects of O_3 on mungbean genotypes as compared to that of the ascorbic acid. Three mungbean genotypes (NM 20–21, NM-2006, and NM-2016) were identified to have a better adaptive mechanism for O_3 toxicity tolerance and may be good candidates for future variety development programs.

A research was conducted with ten treatments of plant growth regulators of salicylic acid (100 & 150 ppm), GA_3 (50 & 100 ppm), NAA (10 & 20 ppm) and chlormequat chloride (146 & 337 ppm) foliar spray at 25 and 35 DAS and replicated thrice in mungbean plant. Among the different treatments, treatment 4 (GA_3 100ppm Foliar spray at 35 DAS) was recorded maximum plant height, more number of branches per plant, more number of nodules per plant and significantly high seed yield of mungbean plant. Highest gross returns, net returns and B: C ratio was also noted under treatment 4 (GA_3 100ppm Foliar spray at 35 DAS) (Navya *et al*., 2021).

Kumar *et al*., (2018) found that foliar spray of two plant growth regulators (PGRs) of different concentrations *viz*., Salicylic acid (50, 100, 150 and 200 ppm) and GA_3 (50, 100, 150 and 200 ppm) along with untreated control (distilled water spray) & spraying was done at 25 DAS in mungbean plant. All the PGRs *viz*., salicylic acid and GA_3 induced positive influence on chlorophyll, nitrate reeducates, protein and nitrogen content in plants but the foliar spraying of SA 150 ppm at 25 DAS was found more profound among all treatments. On the basis of above investigation it may be concluded that foliar spray of PGRs at 25 DAS may be used as a potential tool to improve growth and yield of mungbean.

Prakash *et al*., (2019) found that the growth parameters, yield attributing traits and quality of green gram were significantly increased due to foliar sprayed of plant growth regulators. The foliar sprayed of salicylic acid 100 ppm was found most effective for increasing growth and yield followed by foliar sprayed of GA_3 100 ppm over rest of the treatments. However, growth parameter like plant height was measured significantly increased due to foliar spared of GA_3 100 ppm followed by foliar sprayed of salicylic acid 100 ppm over other treatments including control.

Ali *et al*., (2008) IAA and 4-Cl-IAA boost mungbean growth and nitrogen fixation. The seedlings were percolated with 0, 10-10, 10-8, or 106 M of IAA or 4ClIAA at 7 and/or 14 days. At 30 days after sowing (DAS), samples of the plants were taken in order to evaluate their growth and several biochemical traits. The auxin's effects persisted up to harvest, during which time they had a noticeable impact on seed production, seed mass and the number of pods per plant. The best response was produced by 4 Cl IAA at a modest concentration (10 8 M). However, the higher concentration (106 M) of 4Cl IAA produced a similar response. The hormone was applied twice (at 7 and 14 DAS), and this was significantly more effective than a single administration (at 7 or 14 DAS). It was determined that IAA and 4 ClIAA enhanced mungbean growth and nitrogen fixation. The 4ClIAA performed better than the IAA.

El-Saeid *et al*., (2010) demonstrated the cowpea plant's reaction to IAA. The plants' foliage was twice sprayed with Indole-3-acetic acid (IAA) solutions of (25, 50, and 100 mg/L) at 70 and 80 days after sowing, while the control plants received distilled water spraying. IAA treatments enhanced the number of leaves, shoot dry weight, generated flowers per plant, number of pods, weight of pods and seeds per plant at rates of 25 and 50 mg/L of IAA. The number of flowers removed from the cowpea plant also dropped significantly at doses of 50 and 100 mg of IAA.

Fassler *et al*., (2010) investigate the effects of indole-3-acetic acid (IAA) on sunflower growth and heavy metal uptake in combination with ethylene diaminedisuccinic acid (EDDS). The study's hypothesis were that, when combined with the biodegradable chelating agent ethylene diaminedisuccinic acid, the growth-promoting phytohormone 10 phytohormoneauxin (indole-3-acetic acid, IAA) can lessen the harmful effects of metals on plants and boost metal phytoextraction (EDDS). We conducted two series of studies on sunflowers (*Helianthus annuus* L.) in hydroponic solution to explore these ideas. With 1010 M IAA, metal-stressed plants' root and shoot growth could be improved most effectively. At this treatment concentration, metal extraction could also be significantly improved.

Newaj *et al.*, (2002) studied on effect of indole acetic acid (IAA) on yield of mungbean (*Vigna radiata* L.). Two types of mungbean were studied to see how foliar applications of 300, 600 and 900 ppm IAA affected yield and yield-contributing traits (BARI 2 and BARI 4). The number of seeds/plants, seed yield per plant, seed yield (tonha-^{1}) and weight of 1000 seeds all considerably increased at 600 ppm of IAA. The BARI 4 variety performed better than the BARI 2 variety. The maximum pod length, seed yield/plant, seed yield and quantity of seeds were seen in BARI 4 plants treated with 600 ppm of IAA. So, compared to control and other treatments, the plants treated with IAA at 600 ppm had greater performance.

Sinsiri and Laohasiriwong (2007) examined the impact of various concentrations of the growth regulator indole-3- acetic acid (IAA) on cowpea cultivars' ability to develop roots from detached leaves when grown in a tunnel. The experiment included 21 treatments, and the IAA concentrations employed were 0, 250, 500, 750, 1000, 1500 and 2000 mg L-^{1} of distilled water. The findings demonstrated that IAA treatments had a significant impact on root length, quantity of roots, and root hairs, with level 3 being the best level (500 mg L-^{1}). In most cases, the effects resulting from an interaction between variables A (cultivars) and B (IAA levels) were extremely significant. The impacts owing to IAA levels and cultivars were both highly significant.

Barazani and Friedman (1999) described on IAA the major root growth factor secreted from plant-growth-mediating bacteria in lettuce plant. In this instance, four detrimental rhizobacteria (DRB) excreted large concentrations of IAA (76.6 M) over the course of an incubation period of 84 hours. The inhibition of root growth was caused by the toxic rhizobacteri, which emitted high levels of IAA. Root elongation was similarly hindered by other unidentified fractions in the DRB eluates, but to a lesser degree. Similar to DRB, IAA was released by four isolates of PGPR (Agrobacterium sp., *Alcaligenes piechaudii* and two distinct strains of *Comamonas acidovorans*), but at lower concentrations (16.4 M over a comparable incubation period). In addition to IAA, PGPR also released additional chemicals that are now being studied.

Indole-3-acetic acid (IAA), 4-chloroindole-3-acetic acid (4-Cl-IAA), and indole-3-butyric acid (IBA), three auxins, were examined for their effects on nitrogen metabolism in chickpeas (*Cicer arietinum* L.). At 60 days following planting, plants were produced from seeds that had been immersed in water (control), 108 M of IAA, IBA or 4-Cl-IAA for 12 hours. Observations revealed that auxins greatly boosted nodulation, leghemoglobin content, nodule nitrogen content and nitrogen absorption enzymes regardless of the analogue. The 4-Cl-IAA was the auxin that increased these parameters the fastest out of the three. When compared to the water-soaked control, the seed production increased by 27% (Hayat *et al.,* 2009).

Ravichanadran and Ramaswami (1991) studied the source-sink relationship in soybean as influenced by TIBA. They discovered that applying TIBA (50 ppm) prior to blooming lowered LAI but enhanced dry matter output, CGR and NAR.

Senthil *et al*., (2005) studied the impact of growth regulators on the activities of IAA oxidase, peroxidase and NRAse in groundnuts at various salinity levels revealed that seed treatment with GA_3 and IAA solutions increased the activity of NRAse enzyme while decreasing the activity of IAA oxidase. Similar findings were made by Reddy *et al*., (2009), who demonstrated that nitrate reductase activity rose until 60 DAS before declining.

Khudhur and Omer (2015) examined the impact of NAA and IAA on *Dalbergia sissoo* (Roxb) stem cuttings. The cutting's bottom was submerged in the mentioned solutions for 30 seconds in this study's treatments, which include hormones of naphthalene acetic acid in four concentrations (0, 100, 300 and 500 ppm). The results showed that the IAA treatment with a concentration of 500 ppm and the NAA treatment with a concentration of 500 ppm had the highest percentages of shooted cuttings, shoot length, number of main branches, diameter of main branch, leaf area, number & length of root, fresh & dry weight of root, biomass & dry matter of root and chlorophyll a.

Tagade *et al*., (1998) investigated the effects of PGRs by soaking soybean seeds in 25–150 ppm IAA and kinetin before planting. They found that seed yield, seed protein and seed oil contents all increased with IAA concentration up to 100 ppm before declining with higher concentrations.

Zaidi and Singh (1995) conducted an experiment where soybean seeds were soaked for four hours in either distilled water, 100 ppm GA_3/IAA or 200 ppm GA_3/IAA. Following their sowing, they were exposed to salinities of 0.8, 10 or 20 dS/m in 13 plots. Presoaking in GA3 or IAA removed the negative effects of salinity on dry matter distribution and productivity.

Nabi *et al*., (2014) carried out an experiment to study on growth and yield performance of cowpea cv. BARI Falon-^{1} under different treatment of GA_3 as foliar spray to investigate the responses and most optimum level of gibberellic acid regarding growth and yield that are suitable to cultivate in coastal region of Bangladesh. In comparison to other GA_3 treatments, 33.33 ppm GA_3 significantly produced the tallest plant (61.07 cm), the most leaves and branches plant-^{1} (28.50 and 19.73 respectively), the highest LAI (1.10) and the highest TDM plant-^{1} (81.95 g), while the control had lower levels of the aforementioned characteristics. Growth characters such as CGR, RGR and NAR had also higher (0.99 and 1.65 mg cm-^{2} day-^{1} for CGR, 0.43 and 0.72 g g-^{1} day-^{1} for RGR and 0.027 and 1.275 mg cm-^{2} day-^{1} for NAR) in 33.33 ppm GA_3 at the stage between 30 to 60 DAS and 60 to 90 DAS respectively. Yield contributing characters among other observation of yield and yield contributing characters, 33.33 ppm GA_3 further registered the maximum pods plant-^{1} (11.50), longest pod (17.05 cm), higher 9 weight fresh (3.78 g) and dry pod (1.99 g), higher weight of 100–seed (12.25), seed yield (18.57 g plant-^{1} and 2986.72 kg ha-^{1}) and higher HI (22.45%).

Kumar *et al*., (2014) conducted a study to investigate the effects of gibberellic acid on tomato growth, fruit yield and quality. One tomato variety, Golden, and six treatments with five amounts of gibberellic acid made up the experiment (GA_3- 10 ppm, 20 ppm, 30 ppm, 40 ppm and 50 ppm). The highest plant height, number of leaves, number of fruits and fresh weight have all been noted. Ascorbic acid, total soluble solid (TSS) and ascorbic acid concentration have been estimated for GA_3 at 50 ppm.

Choudhury *et al*., (2013) conducted a field experiment to evaluate the impact of various plant growth regulators on tomato throughout the summer of 2011. The study made use of four different plant growth regulators (PGR), namely PGR0 = Control, PGR1 = 4-CPA (4-chloro phenoxy acetic acid) @ 20 ppm, PGR2 = GA_3 (Gibberellic Acid) @ 20 ppm and PGR3 = 4-CPA + GA_3 @ 20 ppm of each. Due to various plant growth regulators, the growth and yield contributing characteristics were notably variable. The PGR3 treatment had the highest plant height at 60 DAT (86.01 cm), the most flower clusters per plant (10.60), the most flowers per plant (39.69), the most fruits per plant (36.54), the heaviest single fruit (74.01 g) and the highest yield (28.40 t ha^{-1}); the lowest values were found in the control (PGR0) treatment.

Archbold (1986) presented that Honeoye species treated with 100 ppm GA_3 in 1986 saw a decrease in fruit average weight and a rise in per-plant production, fruits and runners in 1987.

Bishnoi and krishnamoorty (1990) investigated how water logging and gibberellic acid affected peanut nodulation and nitrogen fixation. In trials conducted in a greenhouse, groundnut cv. MH-2 seedlings were waterlogged for 0, 7 and 14 days before being treated with water, 10 or 100 mg of gibberellic acid (GA), or both, at the vegetative, flowering, and pod-filling stages (35, 50 and 80 DAS respectively). Regardless of growth stage, waterlogging reduced the number, FW, DW, leghaemoglobin concentration and nitrogenase activity of nodules. When compared to other growth stages, the impact of waterlogging was more detrimental during pod filling. 10 mg GA/litre significantly increased the number, FW, DW and nitrogenase activity of the nodules and alleviated some of the effects of waterlogging.

Gelmesa *et al*., (2012) conducted an experiment in order to ascertain the effects of various quantities and mixtures of the plant growth regulators (PGRs) 2, 4-D and GA_3 spray on fruit setting and earliness of tomato cultivars. Three amounts of 2, 4-D (0, 5 and 10 ppm) and four levels of GA_3 were used in the experiment (0, 10, 15 and 20 ppm). According to the study, application GA_3 enhanced fruit set %, marketable fruit yield, fruit quantity per cluster and blooming and maturity times.

Abdel *et al*., (2011) studied on response of mungbean (*Vigna radiata* L., Wilczek) to gibberellic acid (GA_3) rates and varying irrigation frequencies. They examine how the local mungbean cultivar reacts to irrigation frequency changes and try to increase its capacity for drought resistance by adding 0, 100 and 200 mg/l GA_3. Results showed that irrigating mungbean plants every 8 days drastically reduced plant height 5 (46.8%), internodes length (32.1%), number leaves per plant (64.3%), leaf area per plant (9158.5%), leaf area index (179.3%), inflorescence number per plant (119%) pod length (22.6%), pod number per plant (117%), seed number per pod (23.8), biomass yield (74.6%), yield (91.3%) and seed yield per plant (83.7%). However, this treatment highly increased number first fruiting node (180.1%) and weight of 1000 seeds (11.5%).

Choma and himelrick (1984) showed between 2 short day and long day species of strawberry with application at (0, 50 and 100 ppm) GA_3, 50 ppm GA_3 increased runner and leave produced, and (50 and 100 ppm) GA_3 increased the yield.

Tsai and Arteca (1985) investigated that the effects of root applications of gibberellic acid on photosynthesis and growth in C3 and C4 plants. Four days after receiving the best GA_3 treatments, the relative growth rates (RGR) of barley, oat, squash, pepper, corn, sorghum, millet, pigweed and kocliia were higher than the control by 12.7 percent, 9.9 percent, 11.3 percent, 10.7 percent, 19.2 percent, 10.1 percent, 11.5 percent, 16.4 percent and 32.7 percent respectively. GA_3 has no impact on RGR in gomphrena, mungbean or wheat. Gibberellic acid reduced the chlorophyll concentration expressed on an area basis in barley, squash, pepper, sorghum and kochia by 20.0 percent, 13.9 percent, 20.9 percent, 17.1 percent, 11.9 percent and 28.0 percent, respectively.

Eshghi *et al*., (2012) reported (50, 100) application of GA_3 did not increase fruit weight and production, but 100 ppm GA_3 decreased inflorescence and increased runner in Merak species.

El-Shabasi *et al*., (2008) reported increased floral production of 100 ppm GA_3 in strawberry plants. In the Chandler variety, Sharma and Singh (2009) founded that 75 ppm GA_3 impacted the development pattern and reduced fruit weight.

Iqbal *et al*., (2001) examined the reaction of Chickpea (*Cicer arietinum* L.) growth to foliar Gibberellic Acid administration at various growth stages. To investigate the impact of GA_3 application on chickpea growth, experiment 6 was created. The treatment of GA_3 resulted in an increase in plant height as well as fresh and dry weights of the shoot. Branch count dropped after GA_3 treatments. More reduction was seen with G3 application during the vegetative stage than during the bloom initiation stage. The G3 treatment enhanced the dry weight of the root while having no effect on its length or fresh weight.

Milanesi *et al*., (2008) investigated the effects of irrigation and GA_3 application rate and timing on lentil plant shape and yield. Little is known about how or if GA_3 impacts lentil growth (*Lens culinaris*). In the field, lentil was exposed twice to four different concentrations of GA_3 and either irrigation or not. GA_3 concentration had an impact on plant height, branch and pod counts, 100-seed weight and yield. GA_3 at a concentration of 10 mgL^{-1} boosted yield and the proportion of pods with two seeds. With GA_3 at a concentration of 50 mgL^{-1}, more branches were generated. Application of GA_3 at flowering increased yield by 60%. Irrigation produced the greatest number of pods and the highest yield. Lentil production can be increased by applying concentrations of GA_3 between 10 and 50 mgL^{-1} at flowering.

Luangprasert (1994) applied (0, 100, 150 and 200) ppm GA_3 for one week at the fourth stage of the Tioga strawberry leaves, it was observed that runner production increased in all treatments without affecting the growth of the leaves or the crowns of the branches of strawberry plants. Fruit output also fell with high GA_3 application levels.

Hoque and Haque (2002) examined the impact of gibberellic acid on the physiological traits that contribute to mungbean productivity. The effects of seed treatment and foliar application of GA_3 at 0, 50, 100 and 200 ppm on growth, yield, and yield-contributing traits were examined in two cultivars of mungbean (*Vigna radiata* L.). At 50 ppm,GA_3 seed treatment increased plant height, number of leaves, fresh and dry weight of pods, number of seeds, 1000 seed weight and harvest index, while 200 ppm increased the number of pods and 100 ppm increased pod length, seed weight per plant and seed yield (kg ha-^{1}). A foliar application of GA_3 at 200 ppm increased plant height and the number of leaves by 7, while a foliar application at 100 ppm increased the number of pods, the fresh and dry weight of the pods, the number of seeds and the harvest index, while a foliar application at 50 ppm increased pod length, 1000-seed weight, seed yield per plant and seed yield (kg ha^{-1}) of the crop.

Pagire (2016) investigated the impact of plant growth regulators on pea variety growth, seed output and seed quality. She discovered that the use of plant growth regulators can boost the pea's seed output. Both the 200 ppm of GA_3 alone and in conjunction with 250 ppm of CCC produced significantly better yields than the control. The quantity and weight of pods, the number of seeds per pod and the weight of seeds per plant of peas all increased, which contributed significantly to the rise in output. The use of GA_3 200 ppm (seed soaking for 12 hours) and CCC 250 ppm (spray 15 days after sowing) was discovered to be helpful for enhancing the aforementioned characteristics in pea.

Keykha *et al*., (2014) investigated the impact of salicylic acid and gibberellic acid on a number of mungbean properties (*Vigna radiata*). The experiment was carried out in the goharkuhkhash (in Iran), which is loicated at a height of 1329 m above mean sea level and is positioned between 23° North latitude and 60° East longitude. The field experiment was set up using a factorial design with three replications and a randomized full block design. Salicylic acid and gibberellic acid had a substantial impact on all attributes, according to an analysis of variance.

Bishnoi and krishnamoorthy (1991) studied on effect of waterlogging and gibberellic acid on growth and yield of chickpea. The vegetative, blooming and DOd-filling stages of chickpea plants were waterlogged for a total of S and 10 days. Plants were treated with 10 and 100 mgL^{-1} of gibberellic acid after stress was released (GA_3). At all stages, waterlogging reduced the dry weight of the leaf, stem and root. The effects of five days of waterlogging on the dry weight of leaf and stem provided at the vegetative stage were reduced by GA at 100 $mgL\text{-}^{1}$.

Paroussi *et al*., (2002) reported (0, 50 and 200 ppm) GA_3 increased bud flower in 3 variety of strawberry (Seascape, Laguna and Camarosa) especially in Seascape species.

In 3 strawberry varieties (Seascape, Laguna and Camarosa), GA_3 boosted bud flowering, according to Paroussi *et al*. (2002), particularly in the Seascape species.

Perez de Camacaro *et al.,* (2008) by applying gibberellic acid due to promoting blooming and growth in strawberry plants, showed that 20 ppm GA_3 treatment had the highest effect on leave, runner, crown, inflorescence and flower production.

Chudasama and Thaker (2007) showed relationship between gibberellic acid and growth parameters in developing seed and pod of pigeon pea. Pigeon pea seeds and pods in development were examined for variations in endogenous gibberellic acid (GA) levels (*Cajanus cajan*). Indirect ELISA was created to estimate the level of GA after rabbits were bred to produce antibodies against GA_3. Based on the seed index value of two kinds, black seeded variety (V1) and B.D.N2 (V2), they were chosen. The two kinds notably differed in terms of pod length and seed density.

U Tkarshae *et al*., (2011) demonstrated the effects of gibberellic acid and oxygenated peptone on the germination of chickpeas. The Post Graduate Research Centre conducted tests to investigate the effects of Gibberellic Acid (50ppm) and Oxygenated Peptone (1 percent aqueous solution) on the germination of the chick pea (*Cicer arietinum* L. cv. Vijay) by pre-sowing soaking the seeds for six hours. The germination process was improved by both treatments. While oxygenated peptone outperformed GA treatment in terms of root length, shoot/root ratio, biomass and vigor index. GA treatment was beneficial for increasing shoot length, mobilization efficiency, emergence index, speed of germination and co-efficient of germination. Comparatively, GA increased the production of nucleic acids while oxygenated peptone increased the amount of total carbs and soluble protein.

CHAPTER III

MATERIALS AND METHODS

The details of the materials and methods of this research work were described in this chapter. It consists of a short description of experimental site, climate and weather, experimental design, layout, materials used for experiment, sowing, treatments, land preparation, manuring and fertilizing, intercultural operations, harvesting, collection of data and statistical analysis which are given below:

3.1 Experimental site

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, and Dhaka 1207. The location of the site was $23^0 74^/$ N latitude and $90^0 35^/$ E longitude with an elevation of 8.2 meter from sea level (Appendix I).

3.2 Experimental period

The experiment was carried out from February to June 2022.

3.3 Soil type

The experimental site was situated in the subtropical zone. The soil of the experimental site lies in agro-ecological regions of "Madhupur Tract" (AEZ No. 28). Its top soil is clay loam in texture and olive grey with common fine to medium distinct dark yellowish-brown mottles. The pH 4.47 to 5.63 and organic carbon contents is 0.8.

3.4 Materials used for experiment

BARI Mung-6 was used as planting material. The seeds of BARI Mung-6 were collected from Bangladesh Agricultural Research Institute, Joydepur, Gazipur. This variety is suitable for summer season. The plant height of the variety ranges from 60-70 cm. It is resistant to *Cercospora* leaf spot and yellow mosaic diseases. Its life cycle ranges from 65-70 days after sowing (DAS) and average yield is 1400-1600 kg ha^{-1}.

3.5 Treatments

The experiment comprised two factors.

Factor A: Different sowing times

i. S_1=5 March

ii. S_2=15 March

iii. S_3=25 March

Factor B: Different plant growth regulators

i. G_0=Control

ii. G_1=IAA 30 ppm

iii. G_2=GA_3 30 ppm

iv. G_3=IAA 30 ppm + GA_3 30 ppm

There were 12 (3 × 4) treatment combinations *viz*., S_1G_0, S_1G_1, S_1G_2, S_1G_3, S_2G_0, S_2G_1, S_2G_2, S_2G_3, S_3G_0, S_3G_1, S_3G_2 and S_3G_3.

3.6 Experimental design and layout

Field layout was done after final land preparation. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole plot was divided into three blocks each containing twelve (12) plots of 2.6 m x 1.1 m size, giving 36-unit plots. The space was kept 0.5 m between the blocks and 0.5 m between the plots were kept.

3.7 Growing of crops

3.7.1 Seed Collection

Seeds of experimental crop were collected from Bangladesh Agricultural Research Institute (BARI) on 05 February 2022.

3.7.2 Land preparation

The experimental field was thoroughly ploughed and cross ploughed and cleaned prior to seed sowing and application of fertilizers and manure were done in the field. The experimental field was prepared by thorough ploughing followed by laddering to have a good tilth. Finally, the land was properly leveled before transplanting. Then plots were prepared as per the design.

3.7.3 Application of fertilizers

Urea, Triple Super Phosphate (TSP) and Murate of Potash (MP) were used as sources of nitrogen, phosphorus and potash. BARI recommended dose were applied. Total TSP, MP and half of the urea was applied during land preparation and rest of was applied after 15 day of sowing.

Table 1. Fertilizer applied for the experimental field preparation

Nutrient	Source	Dose ($Kgha^{-1}$)
N (Nitrogen)	Urea (46% N)	30
P (Phosphorus)	TSP (48% P_2O_5)	48
K (Potassium)	MP (60% K_2O)	30

3.7.4 Seed Sowing

Seeds are sown according to treatments.

3.8. Preparation of plant growth regulator solutions

3.8.1 Preparation of IAA solution

For the preparation of 30 ppm solution, the 90 mg IAA was measured in the Agricultural Chemistry Laboratory and dissolved in a small quantity of ethanol and the volume was adjusted to 3L with distilled water.

3.8.2 Preparation of GA_3

For the preparation of 30 ppm solution, the 90 mg GA_3 was measured in the Agricultural Chemistry Laboratory and dissolved in a small quantity of ethanol and the volume was adjusted to 3L with distilled water.

3.9 Application of Plant growth regulators

Foliar application of auxin as IAA form was done after 20 DAS. As auxin, Gibberellin was also applied once after 20 DAS. Gibberellin was applied after 2 days the application of auxin in the treatments which were treated with both IAA and gibberellin.

3.10 Intercultural operation

3.10.1 Weeding and thinning

Several weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. First weeding was done at 20 days after sowing (DAS), 2nd and 3rd weeding was done at 35 and 50 DAS, respectively. Thinning was done to maintain plant to plant distance 10 cm. The first thinning was done at 8 DAS and second was done at 14 DAS.

3.10.2 Irrigation and drainage

Two irrigations were applied, first one at 10 DAS and second at 30 DAS. At the later stage of experiment there was little rainfall; so, drainage provision was maintained to drain out excess water.

3.10.3 Insect control

At early stage of growth few hairy caterpillar and virus vectors (Jassid) attacked the young plants and at later stage of growth pod borer attacked the plant. Hairy caterpillar and pod borer were successfully controlled by the application of Ripcord 10 EC @ 1 L ha-^{1} at the time of 50% pod formation stage.

3.11 General observation

The crops were frequently monitored to note any change in plant characters. The crops looked good since the initial stage and they maintained a satisfactory growth till harvest.

3.12 Determination of maturity

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

3.13 Harvesting and sampling

The crops were harvested from central 1.0 m^2 area of each plot for yield data on different dates as they attained maturity. Five randomly selected plants from each plot were marked for recording data on plant height, number of leaves, number of branches, fresh weight, dry weight, number of pods plant^{-1}, number of seeds pod^{-1}, pod length, 1000 seed weight, seed yield plot^{-1} and seed yield hectre^{-1}. Pods were collected twice throughout the growing period.

3.14 Threshing

The crop bundles were sundried for two days by placing them on threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks.

3.15 Drying, cleaning and weighing

The collected seeds were dried in the sun for reducing the moisture to about nearly14% level. The dried seeds were cleaned and weight of seeds plot-^{1} was recorded.

3.16 Recording of data

Different growth and yield data were recorded from the experiment.

3.16.1 Plant height

The height of pre-selected five plants were measured using a meter scale from the ground level to tip of the plants and then averaged. Plant height was taken at 30, 40 and 50 days after sowing from the selected plants.

3.16.2 Number of leaves

Number of leaves was counted from the sample plants and recorded from 30, 40 and 50 days of sowing to observe the growth rate of the plants.

3.16.3 Number of branches

Number of branches was counted from the sample plants and recorded from 30, 40 and 50 days of sowing to observe the growth rate of the plants.

3.16.4 Fresh weight

Randomly selected five fresh plants of 40 days age were measured using a balance. Mean weight was calculated and expressed in gram (g).

3.16.5 Dry weight

Earlier selected five plants were sun dried and oven dried for 48 hours at 70^{0} C then dry weight was taken by digital balance. Mean dry weight was calculated and expressed in grams (g).

3.16.6 Number of pods plant^{-1}

Numbers of pod plant^{-1} were counted two times. First time from first harvesting and second time after final harvesting. Both the pods of first and second harvest were considered to get the total number of pods plant^{-1}.

3.16.7 Number of seeds pod^{-1}

Number of seeds pod-^{1} was counted from five randomly selected pods of five individual selected plants of each harvesting and then the average seed number was calculated.

3.16.8 Pod length (cm)

Pod length was calculated from five randomly selected pods of five selected plants of each harvesting and then the average pod length was calculated.

3.16.9 1000 seed weight (g)

A composite sample was taken from the yield of five plants. The 1000 seeds of each plot were counted and weighed with a digital electric balance. The 1000 seed weight was recorded in gram.

3.16.10 Seed yield plot^{-1}

The crop was harvested and threshed respective plots wise. Seeds were separated, cleaned and dried in the sun. Then seed yield plot-^{1} was recorded at 12% moisture level.

3.16.11 Seed yield hectre^{-1}

The crop was harvested and threshed respective plots wise. Seeds were separated, cleaned and dried in the sun. Then seed yield plot-^{1} was recorded at 12% moisture level. The yield plot-^{1} was converted to hectare basis.

3.17 Analysis of data

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and the mean differences were adjusted by Least Significance Difference (LSD) test (Gomez and Gomez, 1984).

CHAPTER IV

RESULT AND DISCUSSIONS

The experiment was conducted to find out the effects of sowing time and application of auxin and gibberellin on growth and yield of mungbean. The analytical results have been presented and discussed with the help of tables and graphs and possible interpretations given under the following headings.

4.1 Plant height

Effect of different sowing time

Different time of seed sowing showed significant difference on the plant height of mungbean at 30, 40 and 50 DAS (Figure 1 and Appendix II). The result demonstrated that at 30, 40 and 50 DAS, the tallest plant 30.75 cm, 42.67 cm and 50.83 cm, respectively were recorded from the S_2, 15 March, 2022 sowing date and the shortest plant 20.45 cm, 32.19 cm and 40.35 cm, respectively were recorded from the first sowing date, S_1, 5 March, 2022. There is no significant difference on plant height between S_2 and S_3 of 50 DAS of mungbean. These results are partially supported by with the findings of Miah *et al*., (2009). Therefore all, together it suggest that sowing time influence the plant height of mungbean.

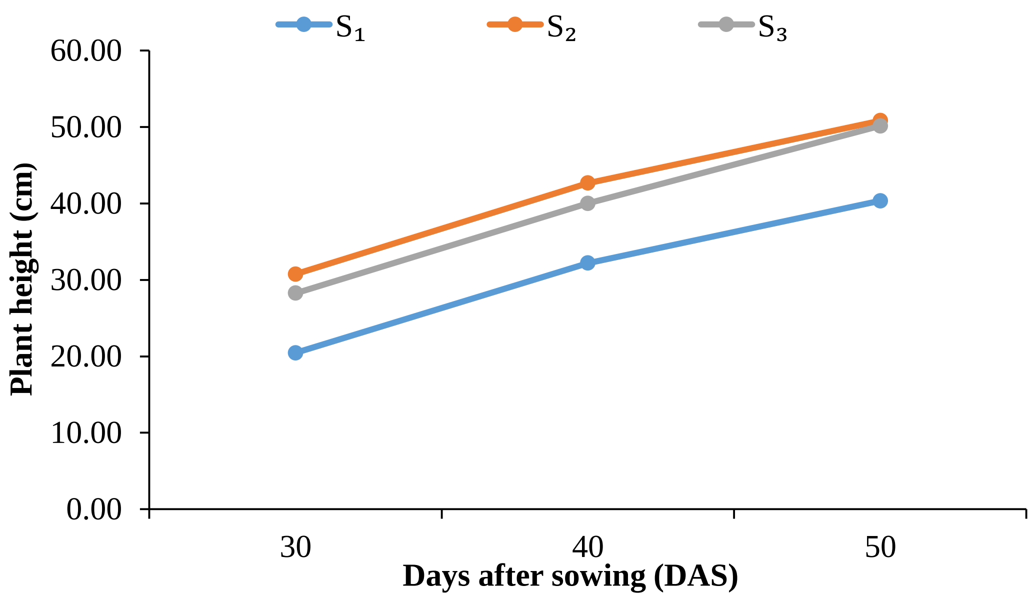

Figure 1. Effect of different sowing time on plant height of mungbean

(LSD value = 4.69, 5.25 and 4.38 at 30, 40 and 50 DAS, respectively, which are significant at 5% level of probability.) Here, Sowing date S_1= 5 March, Sowing date S_2= 15 March and Sowing date S_3= 25 March.

Effect of auxin and gibberellic acid

The plant height of mungbean was significantly influenced by different concentrations of plant growth regulators at 30, 40 and 50 DAS (Figure 2 and Appendix II). The results demonstrated that at 30, 40 and 50 DAS, G_2 (GA_3 30 ppm) produced the tallest plant 29.83 cm, 41.54 cm and 49.20 cm, respectively. On the other hand, at 30, 40 and 50 DAS, G_0 (control) produced the shortest plant 24.67 cm, 36.28 cm and 45.06 cm, respectively. There is no significant difference on plant height between G_1 and G_2 at 40 and 50 DAS of mungbean. These results are partially supported with the findings of Prakash *et al.*, (2019). Therefore all suggest that plant growth regulators influence the plant height of mungbean.

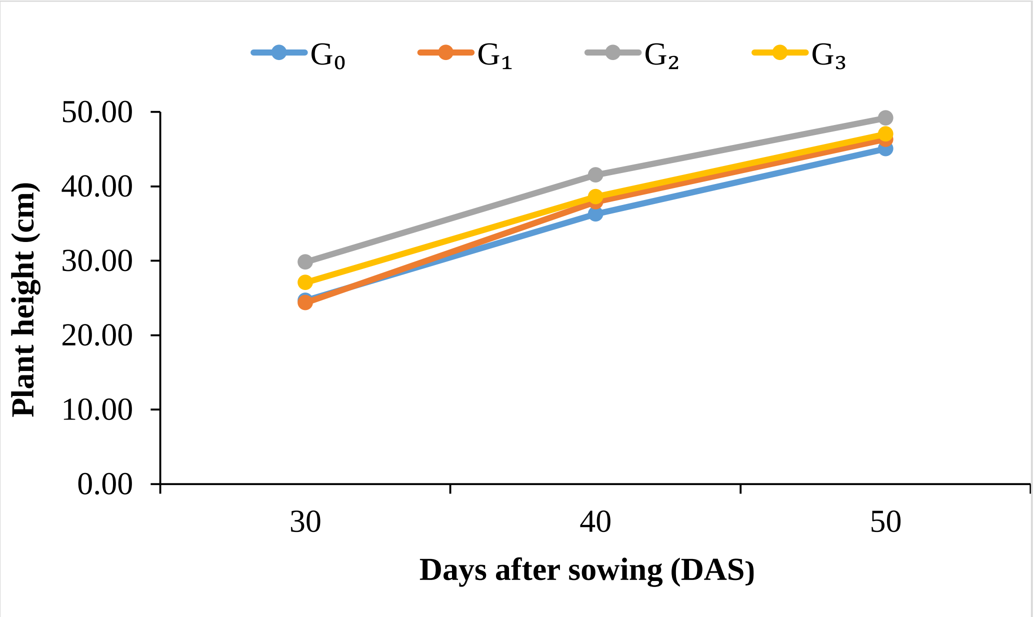

Figure 2. Effect of auxin and gibberellic acid on plant height of mungbean

(LSD value = 4.69, 5.25 and 4.08 at 30, 40 and 50 DAS, respectively, which are significant at 5% level of probability.) Here, G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm

Interaction effect different of sowing time, auxin and gibberellic acid

Interaction of different times of seed sowing and application of plant growth regulators showed significant variation on plant height of mungbean at 30, 40 and 50 DAS (Table 1 and Appendix II). At 30 DAS, the tallest plant (33.27 cm) was observed from the S_2G_2 treatment combination and the shortest plant (20.73 cm) was observed from S_1G_0

treatment combination. At 40 DAS, the tallest mungbean plant (43.73 cm) was observed from the S_2G_2 treatment combination whereas; the shortest mungbean plant (30.07 cm) was observed from the S_1G_0 treatment combination. At 50 DAS, the tallest plant (52.67 cm) was observed from the S_3G_2 treatment combination and the shortest plant (38.27 cm) was observed from S_1G_0 treatment combination. In this study, Single application of IAA or GA_3 enhance the plant height. Application of both IAA and GA_3 in a same plant also promote the plant height compered to control.

Table 2. Interaction effect of different sowing time, auxin and gibberellic acid on plant height of mungbean

Treatment Combination	Plant height (cm) at		
	30 DAS	**40 DAS**	**50 DAS**
S_1G_0	20.73 e	30.07 b	38.27 b
S_1G_1	21.63 e	32.13 b	39.93 b
S_1G_2	24.89 cd	33.33 b	42.60 b
S_1G_3	20.54 de	33.21 b	40.60 b
S_2G_0	27.13 bc	41.93 a	49.17 a
S_2G_1	28.40 bc	42.21 a	50.27 a
S_2G_2	33.27 a	43.73 a	52.33 a
S_2G_3	33.20 a	42.80 a	50.67 a
S_3G_0	25.33 c	38.00 a	48.40 a
S_3G_1	27.00 bc	39.57 a	48.66 a
S_3G_2	31.33 ab	41.67 a	52.67 a
S_3G_3	29.40 abc	39.87 a	50.83 a
Level of significance	*	*	*
LSD (0.05)	**4.69**	**5.25**	**4.38**
CV (%)	**10.50**	**8.14**	**5.52**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, Sowing date S_1= 5 March, Sowing date S_2= 15 March and Sowing date S_3= 25 March.
G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm
* = Significant at 5% level

4.2 Number of leaves plant^{-1}

Effect of different sowing time

Different time of seed sowing showed significant difference on the number of leaves plant^{-1} of mungbean at 30, 40 and 50 DAS (Figure 3 and Appendix III). The result demonstrated that at 30, 40 and 50 DAS the highest number of leaves plant^{-1} 5.40, 6.57 and 8.75, respectively were recorded from the second sowing date S_2, 15 March, 2022, sowing date and the lowest number of leaves plant^{-1} 5.07, 5.80 and 6.57, respectively were recorded from the first sowing date S_1, 5 March, 2022. These results are consistent with the plant height of mungbean of this study (Figure 1). Therefore, it suggested that sowing time has influence on both plant height and number of leaves of mungbean.

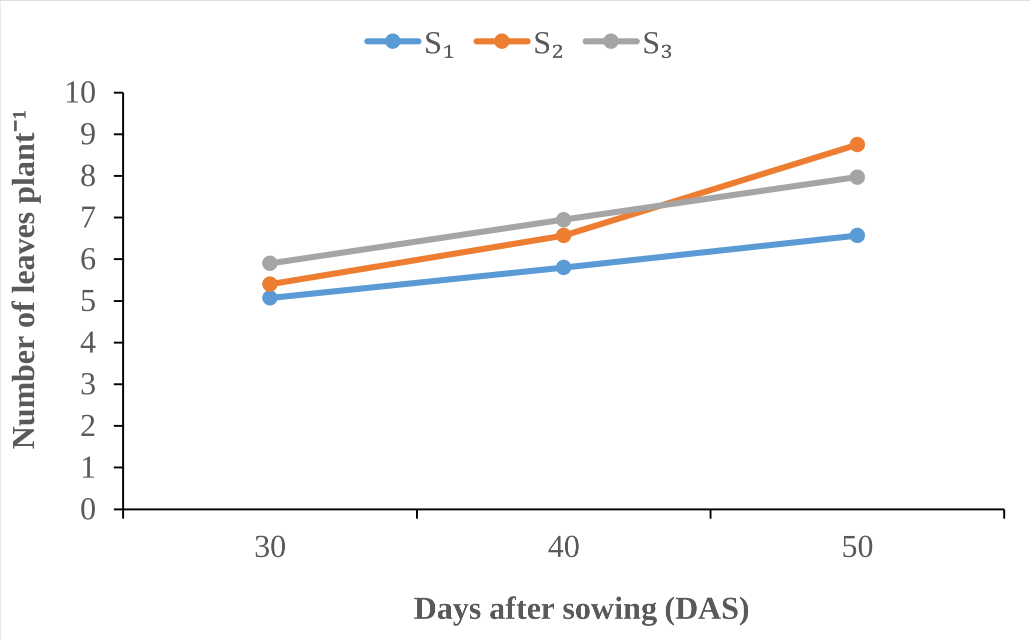

Figure 3. Effect of different sowing time on number of leaves plant-^{1} of mungbean

(LSD value = 0.80, 1.14 and 2.09 at 30, 40 and 50 DAS, respectively, which are significant at 5% level of probability). Here, Sowing date S_1= 5 March, Sowing date S_2= 15 March and Sowing date S_3= 25 March.

Effect of auxin and gibberellic acid

The number of leaves plant^{-1} of mungbean was significantly influenced by different concentrations of plant growth regulators at 30, 40 and 50 DAS (Figure 4 and Appendix III). The results demonstrated that at 30, 40 and 50 DAS, G_2 (GA_3 30 ppm) produced the highest number of leaves plant^{-1} 5.76 and 6.71, respectively while at 50 DAS, G_1 (IAA 30 ppm) showed the highest number of leaves plant^{-1} (8.86). On the other hand, at 30, 40 and 50 DAS, G_0 (control) produced the lowest number of leaves plant^{-1} 4.90, 5.20 and 6.71, respectively. There is no significant difference on number of leaves between G_1 and G_3 at 40 DAS and G_2 and G_3 50 DAS of mungbean. These results are consistent with the plant height of mungbean of this study (Figure 2). These results are partially supported by with the findings of Awan *et al*., (2015) and Deotale *et al*., (1998). Therefore, it suggested that plant growth regulators has influence on the both plant height and number of leaves of mungbean.

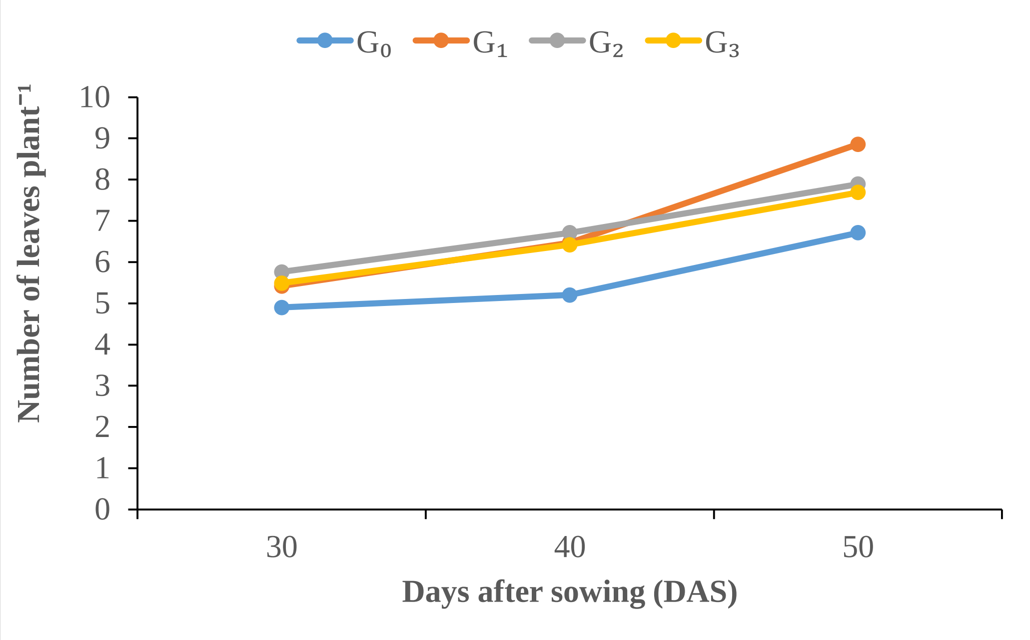

Figure 4. Effect of auxin and gibberellic acid on number of leaves plant-^{1} of mungbean

(LSD value = 0.82, 1.44 and 2.11 at 30, 40 and 50 DAS, respectively, which are significant at 5% level of probability.) Here, G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm

Interaction effect of different sowing time, auxin and gibberellic acid

Interaction of different times of seed sowing and plant growth regulators showed significant variation on number of leaves plant^{-1} of mungbean at 30, 40 and 50 DAS (Table 2 and Appendix III). At 30 DAS, the highest number of leaves plant^{-1} (6.00) was observed from the S_3G_1 treatment combination and the lowest number of leaves plant^{-1} (5.09) was observed from S_1G_3 treatment combination. At 40 DAS, the highest number of leaves plant^{-1} of mungbean (7.63) was observed from the S_3G_1 treatment combination whereas; the lowest number of leaves plant^{-1} of mungbean (5.80) was observed from the S_1G_3 treatment combination. At 50 DAS, the highest number of leaves plant^{-1} (8.93) was observed from the S_3G_1 treatment combination and the lowest number of leaves plant^{-1} (6.77) was observed from S_1G_0 treatment combination. In this study, single application of IAA or GA_3 enhance the number of leaves. Application of both IAA and GA_3 in a same plant also promote the number of leaves compared to control.

Table 3. Interaction effect of different sowing time, auxin and gibberellic acid on number of leaves plant^{-1} of mungbean

Treatment Combination	Number of leaves plant^{-1} at		
	30 DAS	**40 DAS**	**50 DAS**
S_1G_0	5.27 ab	5.87 b	6.77 b
S_1G_1	5.40 ab	5.87 b	8.53 ab
S_1G_2	5.73 ab	6.87 ab	7.73 ab
S_1G_3	5.09 b	5.80 b	7.13 ab
S_2G_0	5.33 ab	6.47 ab	8.27 ab
S_2G_1	5.33 ab	6.27 ab	7.80 ab
S_2G_2	5.53 ab	6.40 ab	8.07 ab
S_2G_3	5.40 ab	6.67 ab	8.07 ab
S_3G_0	5.53 ab	6.47 ab	8.00 ab
S_3G_1	6.00 a	7.63 a	8.93 a
S_3G_2	5.73 ab	6.87 ab	7.87 ab
S_3G_3	5.93 a	6.80 ab	7.87 ab
Level of significance	*	*	*
LSD (0.05)	**0.82**	**1.44**	**2.11**
CV (%)	**8.80**	**8.21**	**9.96**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, Sowing date S_1= 5 March, Sowing date S_2= 15 March and Sowing date S_3= 25 March.
G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm
* = Significant at 5% level

4.3 Number of branches plant^{-1}

Effect of different sowing time

Different time of seed sowing showed significant difference on the number of branches plant^{-1} of mungbean at 40 and 50 DAS but non-significant effect at 30 DAS (Figure 5 and Appendix IV). The result demonstrated that at 30 DAS, the highest number of branches plant^{-1} (0.30) were recorded from the second sowing date S_2, 15 March, 2022 and the lowest number of branches plant^{-1} (0.00) were recorded from the first sowing date S_1, 5 March, 2022. At 40 and 50 DAS, the highest number of branches plant^{-1} 1.72 and 3.08, respectively were recorded from the third sowing date S_3, 25 March, 2022 and the lowest number of branches plant^{-1} 0.70 and 2.06, respectively were recorded from the first sowing date S_1, 5 March, 2022. These results are consistent with the plant height (Figure 1) and number of leaves (Figure 3) of mungbean of this study. Therefore, it suggested that sowing time has influence on plant height, number of leaves and number of branches of mungbean.

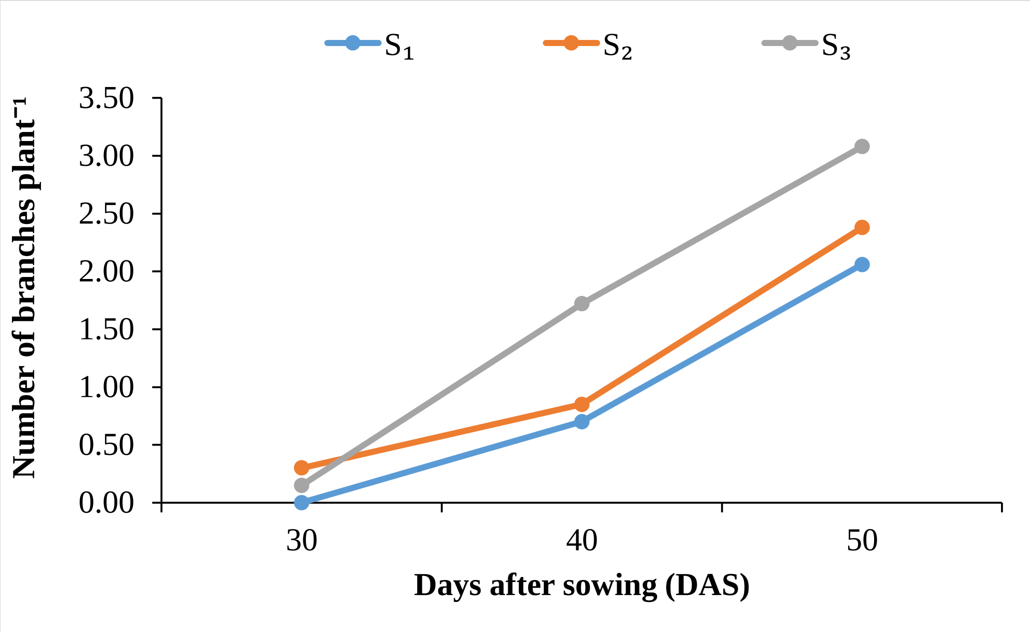

Figure 5. Effect of different sowing time on number of branches plant-^{1} of mungbean

(LSD value = NS, 0.97 and 1.11 at 30, 40 and 50 DAS, respectively, which are significant at 5% level of probability). Here, Sowing time S_1= 5 March, Sowing time S_2= 15 March and Sowing time S_3= 25 March.

NS = Non-significant

Effect of auxin and gibberellic acid

The number of branches plant^{-1} of mungbean was significantly influenced by different concentrations of plant growth regulators at 40 and 50 DAS but non-significant effect at 30 DAS (Figure 6 and Appendix IV). The results demonstrated that at 30 DAS, G_0 (control) produced the lowest number of branches plant^{-1} (0.0). On the other hand, at 30 DAS, G_2 (GA_3 30 ppm) produced the highest number of branches plant^{-1} (0.30). At 40 and 50 DAS, G_3 (IAA 30 ppm + GA_3 30 ppm) produced the highest number of branches plant^{-1} 1.39 and 3.22, respectively. On the other hand, at 40 and 50 DAS, G_0 (control) produced the lowest number of branches plant^{-1} 0.88 and 2.09, respectively. There is no significant difference on number of branches between G_1 and G_2 at 40 DAS of mungbean. These results are consistent with the plant height (Figure 2) and number of leaves (Figure 4) of mungbean of this study. These results are partially supported by with the findings of Navya *et al.*, (2021). Therefore, it suggested that plant growth regulators has influence on the plant height, number of leaves and number of branches plant^{-1} of mungbean.

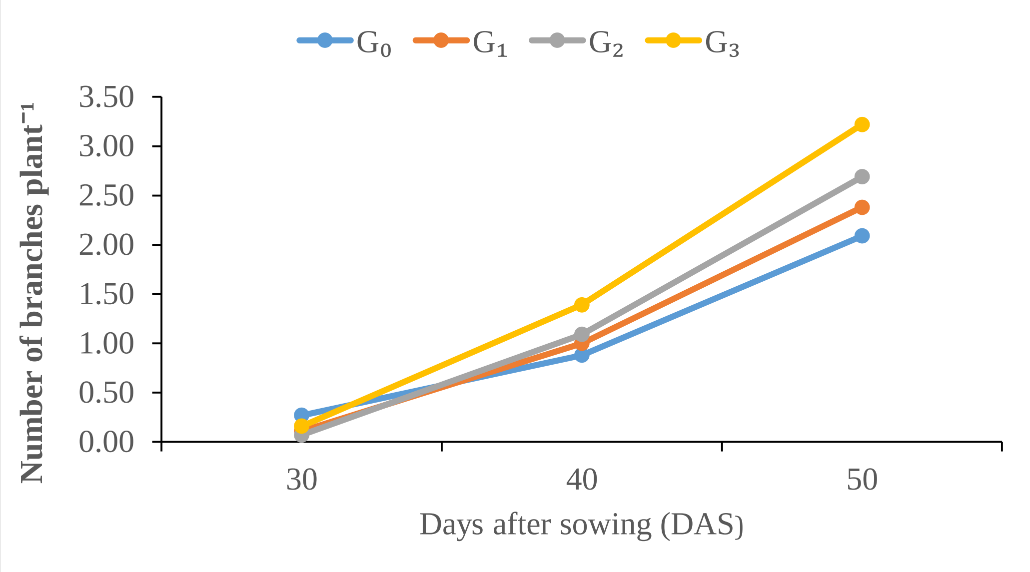

Figure 6. Effect of auxin and gibberellic acid on number of branches plant-1 of mungbean

(LSD value = NS, 0.47 and 1.11 at 30, 40 and 50 DAS, respectively, which are significant at 5% level of probability). Here, G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm

NS = Non-significant

Interaction effect of different sowing time, auxin and gibberellic acid

Interaction of different times of seed sowing and plant growth regulators significant difference on the number of branches plant^{-1} of mungbean at 40 and 50 DAS but non-significant effect at 30 DAS (Table 3 and Appendix IV). At 30 DAS, the highest number of branches plant^{-1} (0.57) was observed from the S_2 G_2 treatment combination and the lowest number of branches plant^{-1} (0.00) was observed from S_1G_0 , S_1G_1 , S_1G_2 and S_1G_3 treatment combination. At 40 DAS, the highest number of branches plant^{-1} of mungbean (1.80) was observed from both the S_3G_2 and S_3G_3 treatment combination whereas; the lowest number of branches plant^{-1} of mungbean (0.53) was observed from the S_2G_2 treatment combination. At 50 DAS, the highest number of branches plant^{-1} (3.47) was observed from the S_3G_2 treatment combination and the lowest number of branches plant^{-1} (1.80) was observed from S_2G_0 treatment combination which was statistically similar to S_1G_0 (2.00) treatment combination. In this study, Single application of IAA or GA_3 enhance the number of branches. Application of both IAA and GA_3 in a same plant also promote the number of leaves compared to control.

Table 4. Interaction effect of different sowing time, auxin and gibberellic acid on number of branches plant^{-1} of mungbean

Treatment Combination	Number of branches plant^{-1} at		
	30 DAS	40 DAS	50 DAS
S_1G_0	0.00	0.80 bcd	2.00 d
S_1G_1	0.00	0.67 cd	2.40 abcd
S_1G_2	0.00	0.67 cd	2.27 bcd
S_1G_3	0.00	0.67 cd	2.07 cd
S_2G_0	0.13	0.80 bcd	1.80 d
S_2G_1	0.13	0.67 cd	2.20 bcd
S_2G_2	0.57	0.53 d	2.33 bcd
S_2G_3	0.47	1.40 abcd	3.20 ab
S_3G_0	0.00	1.67 ab	3.13 abc
S_3G_1	0.20	1.60 abc	2.53 abcd
S_3G_2	0.07	1.80 a	3.47 a
S_3G_3	0.33	1.80 a	3.20 ab
Level of significance	**NS**	*	*
LSD (0.05)	**-**	**0.97**	**1.11**
CV (%)	**5.43**	**5.02**	**5.81**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, Sowing time S_1= 5 March, Sowing time S_2= 15 March and Sowing time S_3= 25 March.
G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm
* = Significant at 5% level
NS = Non-significant

4.4 Fresh weight plant^{-1}

Effect of different sowing time

Different time of seed sowing showed significant difference on the fresh weight plant^{-1} of mungbean at 40 DAS (Figure 7 and Appendix V). The result demonstrated that at 40 DAS, the highest fresh weight plant^{-1} of mungbean (10.87 g) were recorded from the third sowing date S_3, 25 March, 2022 and the lowest fresh weight plant^{-1} (9.18 g) were recorded from the second sowing date S_1, 5 March, 2022. These results are consistent with the plant height (Figure 1), number of leaves (Figure 3) and number of branches plant^{-1} (Figure 5) of mungbean of this study. Therefore, it suggested that sowing time has influence on plant height, leaf numbers, number of branches plant^{-1} and fresh weight of mungbean.

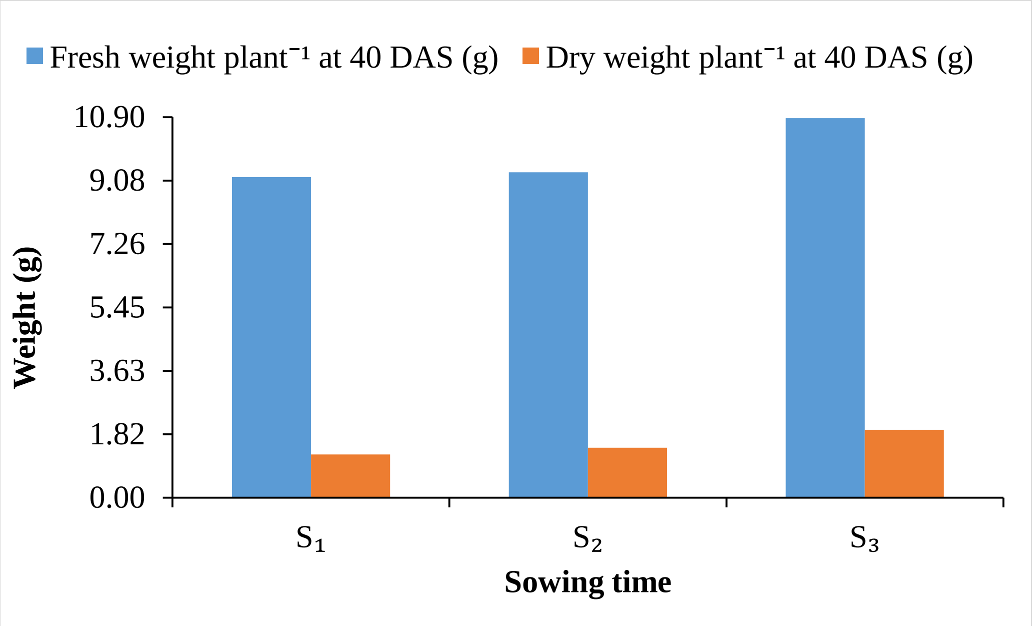

Figure 7. Effect of different sowing time on fresh and dry weight plant-^{1} at 40 DAS of mungbean

(LSD value = 1.54 and 0.66, respectively, which are significant at 5% level of probability). Here, Sowing time S_1= 5 March, Sowing time S_2= 15 March and Sowing time S_3= 25 March.

Effect of auxin and gibberellic acid

The fresh weight plant^{-1} of mungbean at 40 DAS was significantly influenced by different concentrations of plant growth regulators (Figure 8 and Appendix V). The result demonstrated that at 40 DAS, the highest fresh weight plant^{-1} of mungbean (10.69 g) were recorded from the G_3 (IAA 30 ppm + GA_3 30 ppm) and the lowest fresh weight plant^{-1} (8.36 g) were recorded from the G_0 (control). These results are consistent with the plant height (Figure 2), number of leaves (Figure 4) and number of branches plant^{-1} of mungbean of this study. Therefore, it suggested that plant growth regulators has influence on the plant height, leaf numbers, number of branches plant^{-1} and fresh weight of mungbean.

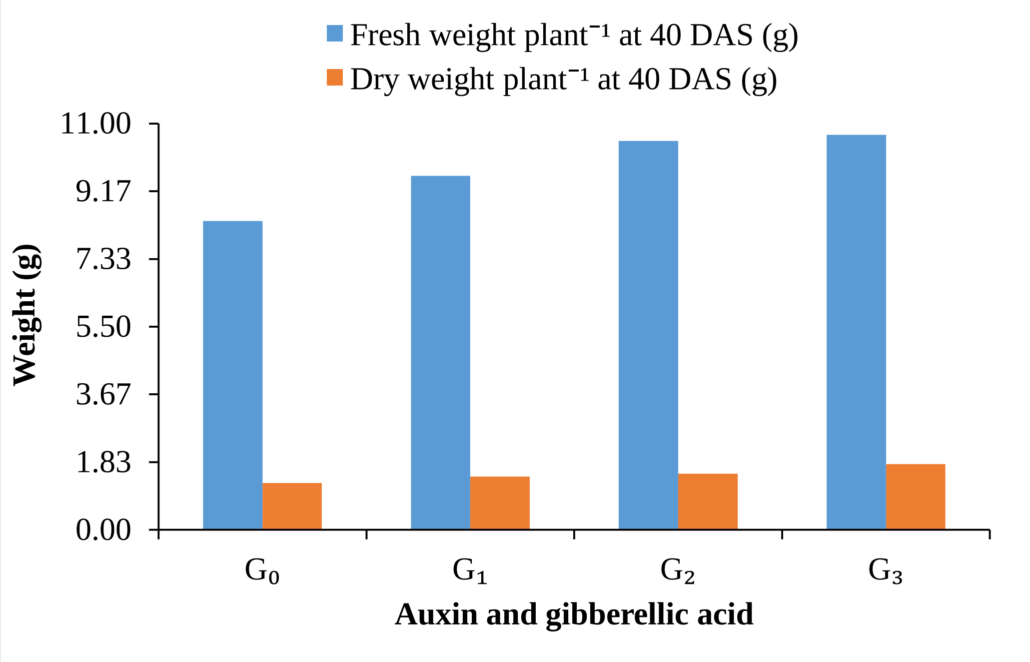

Figure 8. Effect auxin and gibberellic acid on fresh and dry weight plant-^{1} at 40 DAS of mungbean

(LSD value = 2.30 and 0.36, respectively, which are significant at 5% level of probability). Here, G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm

Interaction effect of different sowing time, auxin and gibberellic acid

Interaction of different times of seed sowing and plant growth regulators showed significant variation on fresh weight plant^{-1} of mungbean at 40 DAS (Table 4 and Appendix V). At 40 DAS, the highest fresh weight plant^{-1} of mungbean (12.47 g) was observed from the S_3G_2 treatment combination. On the other hand, the lowest fresh weight plant^{-1} of mungbean at 40 DAS (7.80 g) was observed from the S_1G_0 treatment combination. In this study, Single application of IAA or GA_3 enhance the fresh weigh of plant. Application of both IAA and GA_3 in a same plant also promote the fresh weight compared to control.

4.5 Dry weight plant^{-1}

Effect of different sowing time

Different time of seed sowing showed significant difference on the dry weight plant^{-1} of mungbean at 40 DAS (Figure 9 and Appendix V). The result revealed that at 40 DAS, the highest dry weight plant^{-1} of mungbean (1.94 g) were recorded from the third sowing date S_3, 25 March, 2022 and the lowest dry weight plant^{-1} (1.24 g) were recorded from the second sowing date S_1, 5 march 2022. These results are consistent with the plant height (Figure 1), number of leaves (Figure 3) and number of branches plant^{-1} (Figure 5) of mungbean of this study. Therefore, it suggested that sowing time has influence on plant height, number of leaves, number of branches plant^{-1}, fresh weight and dry weight of mungbean.

Effect of auxin and gibberellic acid

The dry weight plant^{-1} of mungbean at 40 DAS was significantly influenced by different concentrations of plant growth regulators (Figure 10 and Appendix V). The result demonstrated that at 40 DAS, the highest dry weight plant^{-1} of mungbean (1.78 g) were recorded from the G_3 (IAA 30 ppm + GA_3 30 ppm) and the lowest dry weight plant^{-1} (1.27 g) were recorded from the G_0 (control). These results are consistent with the plant height (Figure 2), number of leaves (Figure 4) and number of branches plant^{-1} (Figure 6) of mungbean of this study. These results are partially supported with the findings of Navya *et al*., (2021). Therefore, it suggested that plant growth regulators has influence on the plant height, number of leaves, number of branches plant^{-1}, fresh weight and dry weight of mungbean.

Interaction effect of different sowing time, auxin and gibberellic acid

Interaction of different times of seed sowing and plant growth regulators showed significant variation on dry weight plant^{-1} of mungbean at 40 DAS (Table 4 and Appendix V). At 40 DAS, the highest dry weight plant^{-1} of mungbean (2.32 g) was observed from the S_3G_3 treatment combination which. On the other hand, the lowest dry weight plant^{-1} of mungbean at 40 DAS (1.13 g) was observed from the S_1G_0 treatment combination. In this study, Single application of IAA or GA_3 enhance the dry weight of plant. Application of both IAA and GA_3 in a same plant also promote the dry weight compared to control.

Table 5. Interaction effect of different sowing time, auxin and gibberellic acid on fresh and dry weight of mungbean

Treatment Combination	Fresh weight plant^{-1} at 40 DAS (g)	Dry weight plant^{-1} at 40 DAS (g)
S_1G_0	7.80 e	1.13 bc
S_1G_1	8.40 a	1.26 bc
S_1G_2	8.60 de	1.44ab
S_1G_3	10.47cde	1.75 bc
S_2G_0	8.27 de	1.23 c
S_2G_1	8.67 cde	1.30 bc
S_2G_2	8.80 cde	1.46 abc
S_2G_3	11.00 abc	1.87 bc
S_3G_0	9.00 bcde	1.37 bc
S_3G_1	9.53 abcd	1.51 bc
S_3G_2	11.47 a	1.75 a
S_3G_3	12.47 ab	2.32 abc
Level of significance	*	*
LSD (0.05)	**2.50**	**0.66**
CV (%)	**5.15**	**6.01**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, Sowing time S_1= 5 March, Sowing time S_2= 15 March and Sowing time S_3= 25 March.
G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm
* = Significant at 5% level

4.6 Number of pods plant^{-1}

Effect of different sowing time

Different time of seed sowing showed significant difference on the number of pods plant^{-1} of mungbean at harvest (Figure 11 and Appendix VI). The result demonstrated that, the highest number of pods plant^{-1} (23.80) were recorded from the third sowing date S_3, 25 March, 2022 and the lowest number of pods plant^{-1} (15.38) were recorded from the first sowing date S_1, 5 March, 2022. These results are constant with the growth and yield contributing parameters including plant height (Figure 1), number of leaves (Figure 3), number of branches (Figure 5), fresh weight (Figure 7) and dry weight (Figure 7). These results are partially supported by with the finds of Hossain *et al*., (2009). Therefore, it suggest that sowing time of mungbean at 25 March gave better pods plant^{-1}.

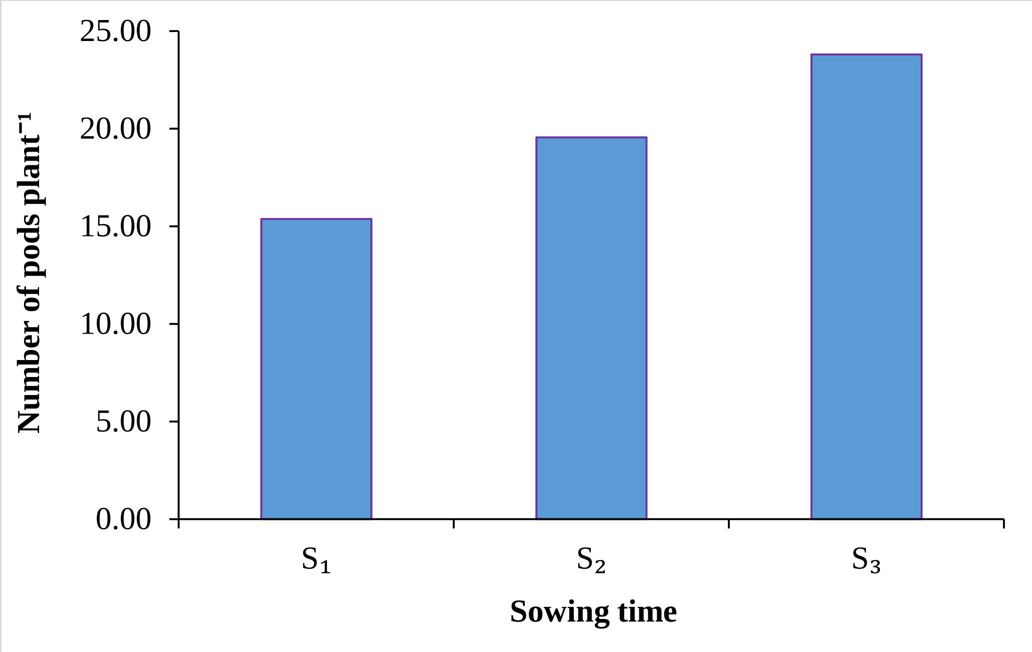

Figure 9. Effect of different sowing time on number of pods plant-^{1} of mungbean

(LSD value = 2.17, which is significant at 5% level of probability). Here, Sowing time S_1= 5 March, Sowing time S_2= 15 March and Sowing time S_3= 25 March.

Effect of auxin and gibberellic acid

The number of pods plant^{-1} of mungbean was significantly influenced by different concentrations of plant growth regulators at harvest (Figure 12 and Appendix VI). The results demonstrated that, G_3 (IAA 30 ppm + GA_3 30 ppm) was recorded with the highest number of pods plant^{-1} (23.00). On the other hand, G_0 (control) produced the lowest number of pods plant^{-1} (17.09). These results are constant with the growth and yield contributing parameters including plant height (Figure 2), number of leaves (Figure 4), number of branches (Figure 6), fresh weight (Figure 8) and dry weight (Figure 8). These results are partially supported by with the findings of Hossain *et al*., (2009) and Navya *et al*., (2021). Therefore, it suggest that plant growth regulators (IAA 30 ppm + GA_3 30 ppm) gave better pods plant^{-1}.

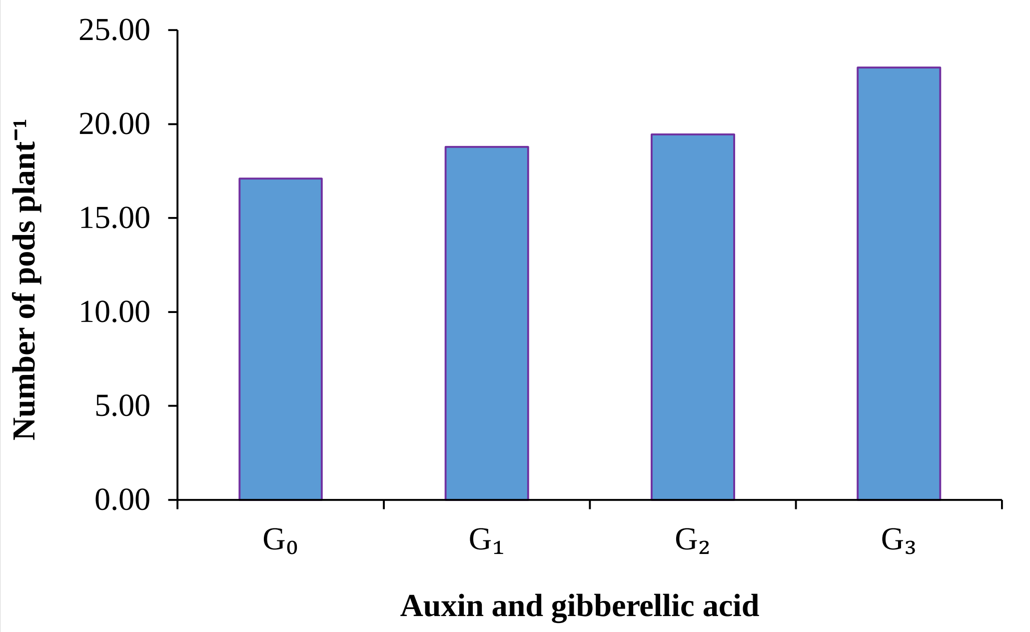

Figure 10. Effect of auxin and gibberellic acid on number of pods plant^{-1} of mungbean

(LSD value = 2.17, which is significant at 5% level of probability). Here, G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm

Interaction effect of different sowing time, auxin and gibberellic acid

Interaction of different times of seed sowing and plant growth regulators showed significant variation on number of pods plant^{-1} of mungbean at harvest (Table 5 and Appendix VI). The highest number of pods plant^{-1} (27.60) was observed from the S_3G_3 treatment combination and the lowest number of pods plant^{-1} (13.20) was observed from S_1G_0 treatment combination. In this study, Single application of IAA or GA_3 enhance the number of pods plant^{-1}. Application of both IAA and GA_3 in a same plant also promote the number of pods plant^{-1} compared to control.

4.7 Number of seeds pod^{-1}

Effect of different sowing time

Different time of seed sowing showed significant difference on the number of seeds pod^{-1} of mungbean at harvest (Figure 13 and Appendix VI). The result demonstrated that, the highest number of seeds pod^{-1} (10.41) were recorded from the third sowing date S_3, 25 March, 2022 and the lowest number of seeds pod^{-1} (8.93) were recorded from the first sowing S_1, 5 March, 2022. These results are constant with the growth and yield contributing parameters including plant height (Figure 1), number of leaves

(Figure 3), number of branches plant^{-1} (Figure 5), fresh weight (Figure 7), dry weight (Figure 7) and number of pods plant^{-1} (Figure 9). These results are partially supported with the findings of Mian *et al*., (2009). Therefore, it suggest that sowing time of mungbean at 25 March gave better seeds pod^{-1}.

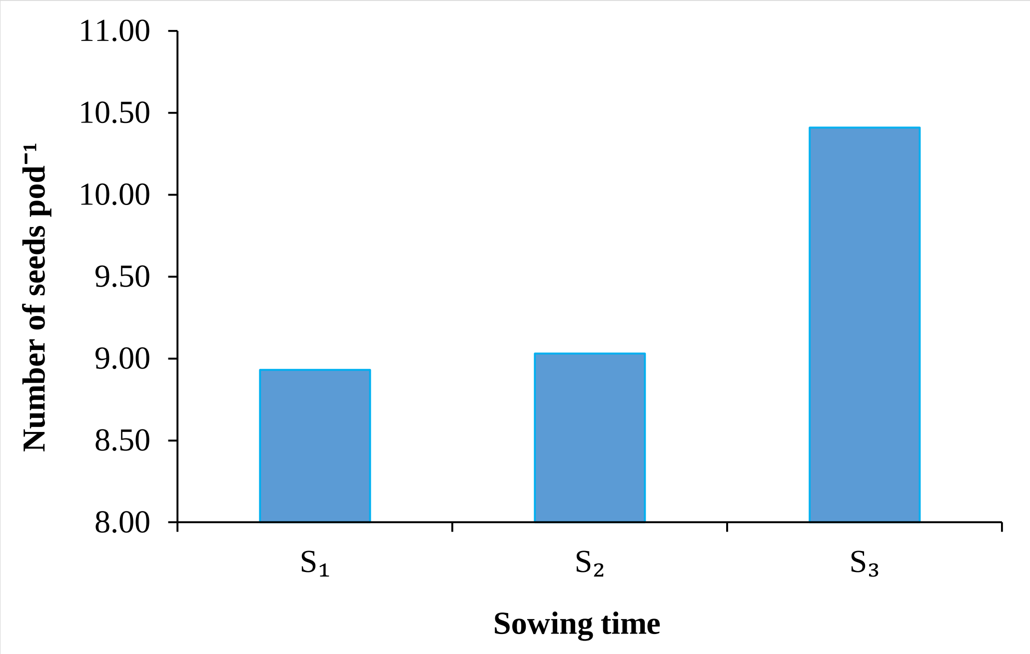

Figure 11. Effect of different sowing time on number of seeds pod-^{1} of mungbean

(LSD value = 1.39, which is significant at 5% level of probability). Here, Sowing time S_1= 5 March, Sowing time S_2= 15 March and Sowing time S_3= 25 March.

Effect of auxin and gibberellic acid

The number of seeds pod^{-1} of mungbean was significantly influenced by different concentrations of plant growth regulators at harvest (Figure 14 and Appendix VI). The results demonstrated that, G_3 (IAA 30 ppm + GA_3 30 ppm) was recorded with the highest number of seeds pod^{-1} (10.54). On the other hand, G_0 (control) showed the lowest number of seeds pod^{-1} (8.82). These results are constant with the growth and yield contributing parameters including plant height (Figure 2), number of leaves (Figure 4), number of branches plant^{-1} (Figure 6), fresh weight (Figure 8), dry weight (Figure 8) and number of pods plant^{-1} (Figure 10). These results are partially supported with the findings of Hossain *et al*., (2009) and Navya *et al*., (2021). Therefore, it suggest that plant growth regulators (IAA 30 ppm + GA_3 30 ppm) gave better seeds pod^{-1}.

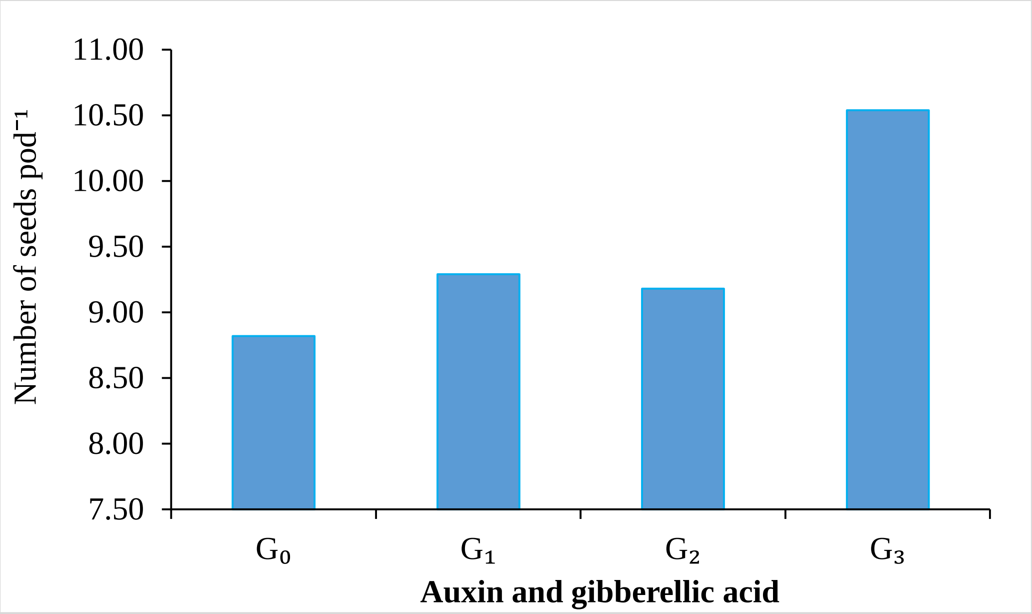

Figure 12. Effect of auxin and gibberellic acid on number of seeds pod-^{1} of mungbean

(LSD value = 1.39, which is significant at 5% level of probability). Here, G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm

Interaction effect of different sowing time, auxin and gibberellic acid

Interaction of different times of seed sowing and plant growth regulators showed significant variation on number of seeds pod^{-1} of mungbean at harvest (Table 5 and Appendix VI). The highest number of seeds pod^{-1} (12.23) was observed from the S_3G_3 treatment combination and the lowest number of seeds pod^{-1} (7.93) was observed from S_2G_1 treatment combination at harvest. In this study, single application of IAA or GA_3 enhance the number of seeds pod^{-1}. Application of both IAA and GA_3 in a same plant also promote the number of seeds pod^{-1} compared to control.

4.8 Pod length

Effect of different sowing time

Different time of seed sowing showed significant difference on the length of pod of mungbean at harvest (Figure 15 and Appendix VI). The result demonstrated that, the highest length of mungbean pod (7.82 cm) were recorded from the third sowing date S_3, 25 March, 2022 and the lowest length of mungbean pod (6.85 cm) were recorded from the first sowing date S_1, 5 March, 2022. These results are constant with the growth and yield contributing parameters including plant height (Figure 1), number of leaves

(Figure 3), number of branches plant^{-1} (Figure 5), fresh weight (Figure 7), dry weight (Figure 7), number of pods plant^{-1} (Figure 9) and number of seeds pod^{-1} (Figure 11). These results are partially supported with the findings of Hossain *et al*., (2009). Therefore, it suggest that sowing time of mungbean at 25 March gave better pod length.

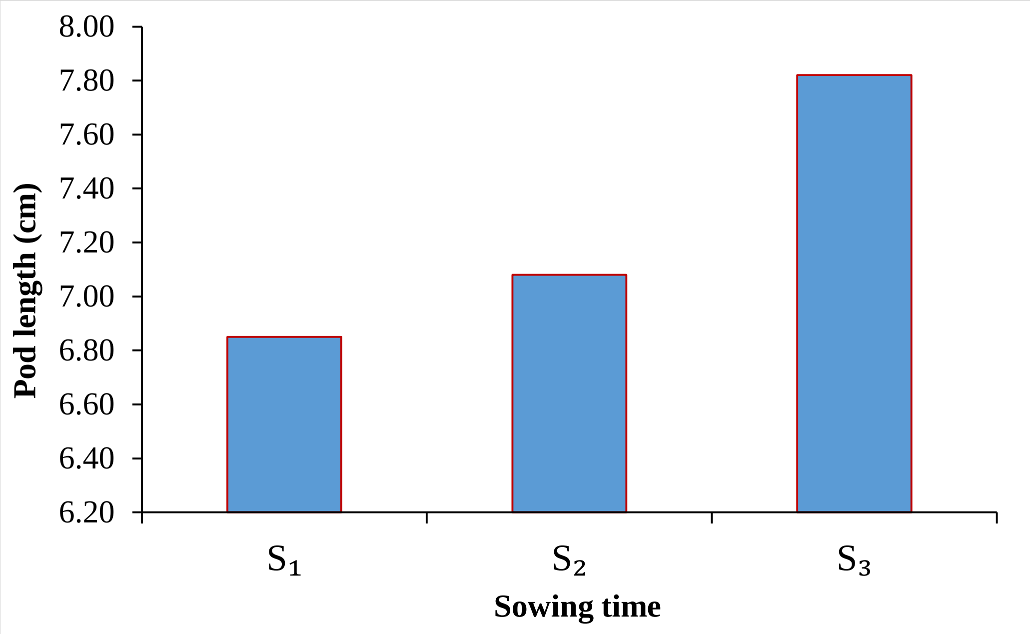

Figure 13. Effect of different sowing time on pod length of mungbean

(LSD value = 0.66, which is significant at 5% level of probability). Here, Sowing time S_1= 5 March, Sowing time S_2= 15 March and Sowing time S_3= 25 March.

Effect of auxin and gibberellic acid

The length of pod of mungbean was significantly influenced by different concentrations of plant growth regulators at harvest (Figure 16 and Appendix VI). The results demonstrated that, G_3 (IAA 30 ppm + GA_3 30 ppm) was recorded with the longest pod (7.98 cm). On the other hand, G_0 (control) showed the shortest pod (6.72 cm). These results are constant with the growth and yield contributing parameters including plant height (Figure 2), number of leaves (Figure 4), number of branches plant^{-1} (Figure 6), fresh weight (Figure 8), dry weight (Figure 8), number of pods plant^{-1} (Figure 10) and number of seeds pod^{-1} (Figure 12). These results are partially supported with the findings of Hossain *et al*., (2009). Therefore, it suggest that plant growth regulators (IAA 30 ppm + GA_3 30 ppm) gave better pod length.

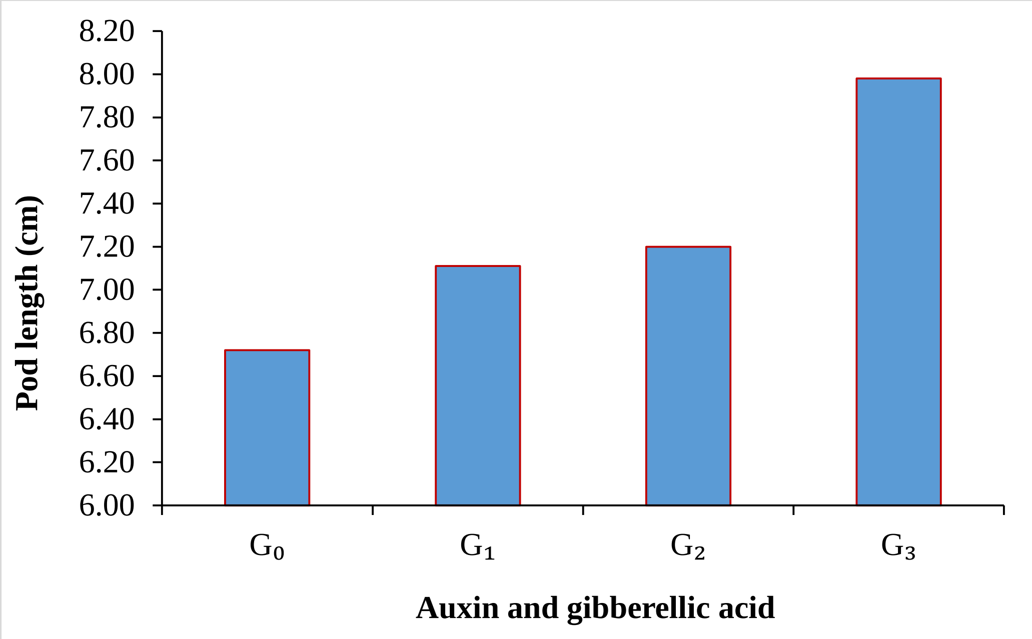

Figure 14. Effect of auxin and gibberellic acid on pod length of mungbean

(LSD value = 0.66, which is significant at 5% level of probability). Here, G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm

Interaction effect of sowing time, auxin and gibberellic acid

Interaction of different times of seed sowing and plant growth regulators showed significant variation on length of pod of mungbean at harvest (Table 5 and Appendix VI). The longest pod at harvest (9.13 cm) was observed from the S_3G_3 treatment combination and the shortest pod at harvest (6.35 cm) was observed from S_1G_0 treatment combination. In this study, single application of IAA or GA_3 enhance the pod length. Application of both IAA and GA_3 in a same plant also promote the pod length compared to control.

4.9 Weight of 1000-seeds

Effect of different sowing time

Different time of seed sowing showed significant difference on the weight of 1000-seeds of mungbean at harvest (Figure 17 and Appendix VI). The result demonstrated that, the highest weight of 1000-seeds (40.21 g) were recorded from the third sowing date S_3, 25 March, 2022 and the lowest weight of 1000-seeds (36.77 g) were recorded from the first sowing date S_1, 5 March, 2022. These results are constant with the growth and yield contributing parameters including plant height (Figure 1), number of leaves (Figure 3), number of branches plant^{-1} (Figure 5), fresh weight (Figure 7), dry weight

(Figure 7), number of pods plant^{-1} (Figure 9), number of seeds pod^{-1} (Figure 11) and pod length (Figure 13). Therefore, it suggest that sowing of mungbean at 25 March gave better seed weight.

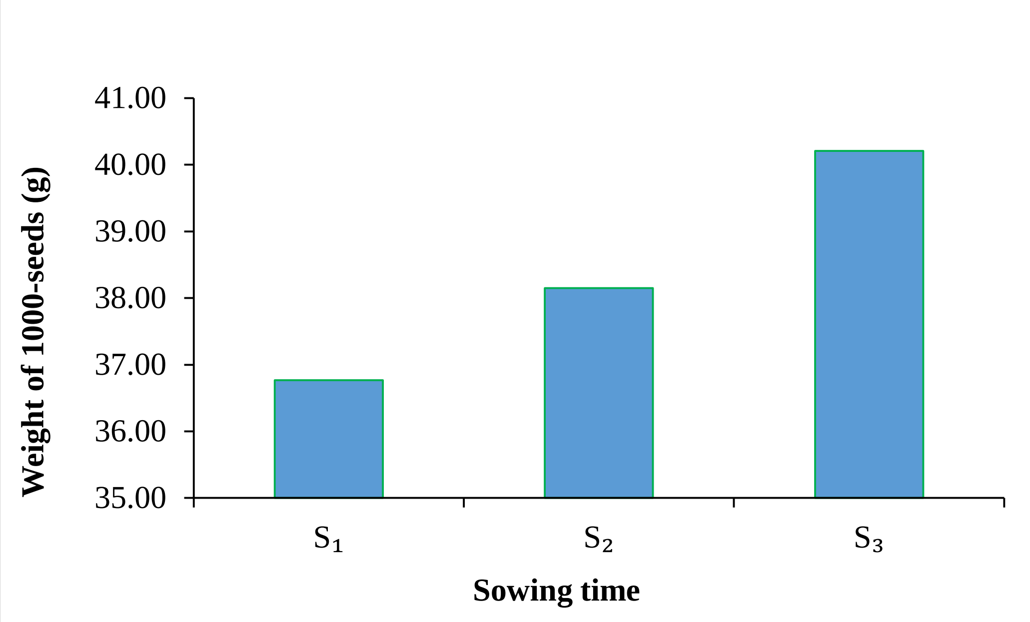

Figure 15. Effect of different sowing time on weight of 1000-seeds of mungbean

(LSD value = 2.33, which is significant at 5% level of probability.) Here, Sowing time S_1= 5 March, Sowing time S_2= 15 March and Sowing time S_3= 25 March.

Effect of auxin and gibberellic acid

The weight of 1000-seeds of mungbean was significantly influenced by different concentrations of plant growth regulators at harvest (Figure 18 and Appendix VI). The results demonstrated that at harvest, G_3 (IAA 30 ppm + GA_3 30 ppm) was recorded with the highest weight of 1000-seeds (44.26 g). On the other hand, G_0 (control) showed the lowest weight of 1000-seeds (34.28 g). These results are constant with the growth and yield contributing parameters including plant height (Figure 2), number of leaves (Figure 4), number of branches plant^{-1} (Figure 6), fresh weight (Figure 8), dry weight (Figure 8), number of pods plant^{-1} (Figure 10), number of seeds pod^{-1} (Figure 12) and pod length (Figure 14). Therefore, it suggest that plant growth regulators (IAA 30 ppm + GA_3 30 ppm) gave better seeds weight.

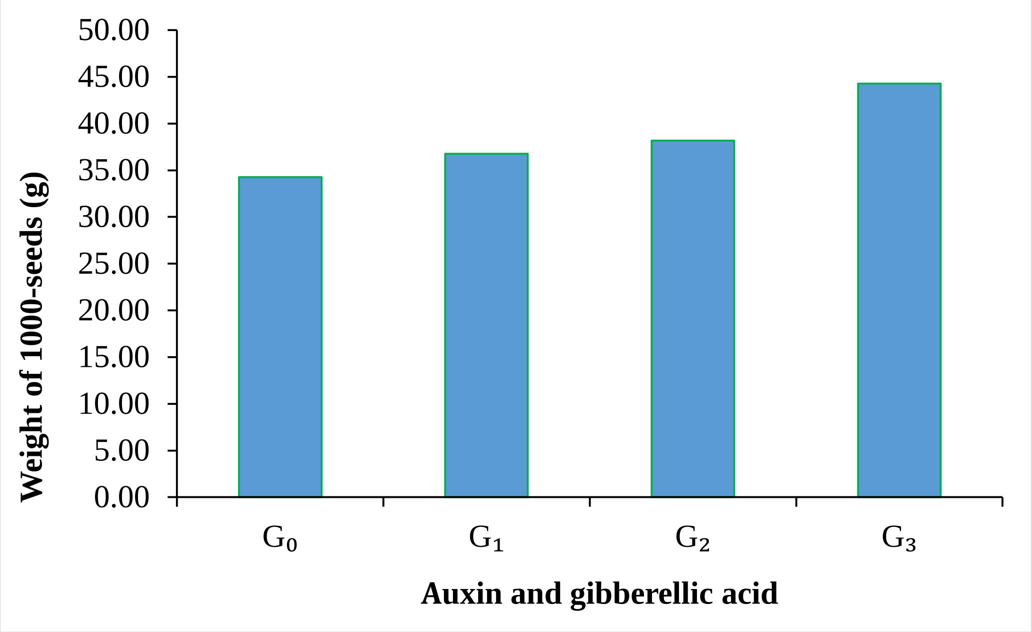

Figure 16. Effect of auxin and gibberellic acid on weight of 1000-seeds of mungbean

(LSD value = 2.33, which is significant at 5% level of probability). Here, G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm

Interaction effect of different sowing time, auxin and gibberellic acid

Interaction of different times of seed sowing and plant growth regulators showed significant variation on weight of 1000-seeds of mungbean at harvest (Table 5 and Appendix VI). The highest weight of 1000-seeds at harvest (46.54 g) was observed from the S_3G_3 treatment combination and the lowest weight of 1000-seeds at harvest (32.17 g) was observed from S_1G_0 treatment combination. In this study, single application of IAA or GA_3 enhance the seeds weight. Application of both IAA and GA_3 in a same plant also promote the seeds weight compared to control.

Table 6. Interaction effect of different sowing time, auxin and gibberellic acid on yield attributes of mungbean

Treatment Combination	Number of pods plant^{-1}	Number of seeds pod^{-1}	Pod length (cm)	Weight of 1000-seeds (gm)
S_1 G_0	13.20 g	8.07 efg	6.35 d	32.17 g
S_1 G_1	14.67 fg	9.47 bcde	6.77 cd	35.1 ef
S_1 G_2	15.93 ef	9.33 bcdef	7.07 bc	37.34 cde
S_1 G_3	17.73 de	8.87 cdefg	7.19 bc	42.47 b
S_2 G_0	17.40 de	9.67 bcd	6.65 cd	33.82 fg
S_2 G_1	18.73 cd	7.93 g	7.07 bc	37.17 cde
S_2 G_2	18.40 d	8.00 fg	6.98 bcd	37.83 cd
S_2 G_3	23.67 b	10.53 b	7.61 b	43.77 b
S_3 G_0	20.67 c	8.73 defg	7.15 bc	36.86 de
S_3 G_1	22.93 b	10.47 b	7.47 b	38.05 cd
S_3 G_2	24.00 b	10.20 bc	7.54 b	39.37 c
S_3 G_3	27.60 a	12.23 a	9.13 a	46.54 a
Level of significance	*	*	*	*
LSD (0.05)	**2.17**	**1.39**	**0.66**	**2.33**
CV (%)	**6.58**	**8.71**	**5.38**	**5.60**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, Sowing time S_1= 5 March, Sowing time S_2= 15 March and Sowing time S_3= 25 March.
G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm
* = Significant at 5% level

4.10 Seed yield plot^{-1}

Effect of different sowing time

Different time of seed sowing showed significant difference on the seed yield plot^{-1} of mungbean at harvest (Figure 21 and Appendix VII). The result demonstrated that, the highest seed yield plot^{-1} (192.16 g) were recorded from the third sowing date S_3, 25 March, 2022 and the lowest seed yield plot^{-1} (148.14 g) were recorded from the first sowing date S_1, 5 March, 2022. These results are constant with the growth and yield contributing parameters including plant height (Figure 1), number of leaves (Figure 3), number of branches plant^{-1} (Figure 5), fresh weight (Figure 7), dry weight (Figure 7), number of pods plant^{-1} (Figure 9), number of seeds pod^{-1} (Figure 11) and pod length (Figure 13). These results are partially supported by with the finds of Hossain *et al.*, (2009). Therefore, it suggest that sowing of mungbean at 25 March gave better seed yield plot^{-1}.

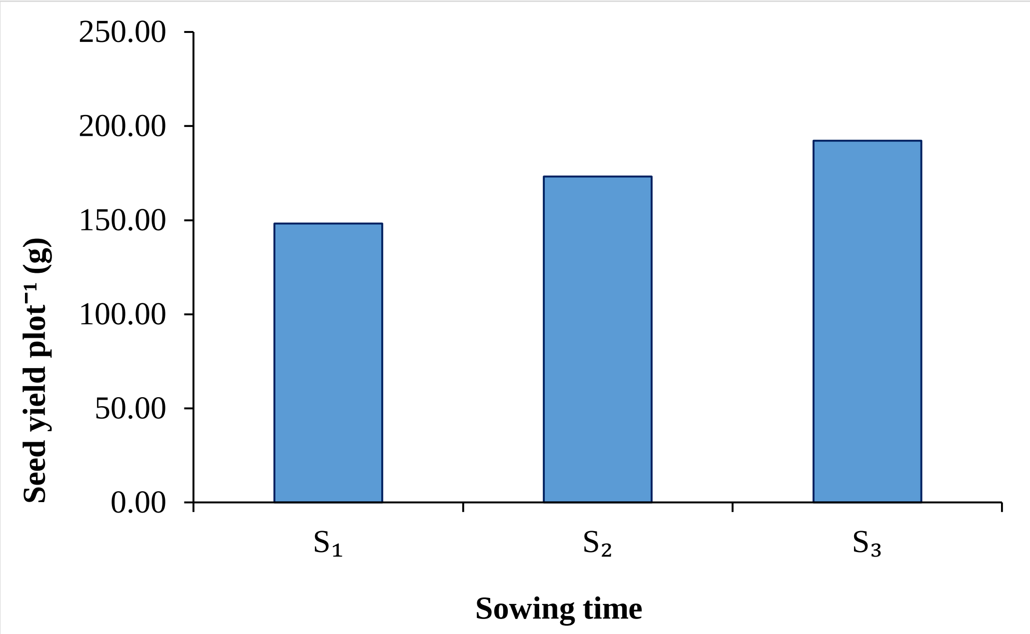

Figure 17. Effect of different sowing time on seed yield plot-^{1} of mungbean

(LSD value = 13.48, which is significant at 5% level of probability.) Here, Sowing time S_1= 5 March, Sowing time S_2= 15 March and Sowing time S_3= 25 March.

Effect of auxin and gibberellic acid

The seed yield plot^{-1} of mungbean was significantly influenced by different concentrations of plant growth regulators at harvest (Figure 22 and Appendix VII). The results demonstrated that, G_3 (IAA 30 ppm + GA_3 30 ppm) was recorded with the highest seed yield plot^{-1} (183.06 g). On the other hand, G_0 (control) showed the lowest seed yield plot^{-1} (163.79 g). These results are constant with the growth and yield contributing parameters including plant height (Figure 2), number of leaves (Figure 4), number of branches plant^{-1} (Figure 6), fresh weight (Figure 8), dry weight (Figure 8), number of pods plant^{-1} (Figure 10), number of seeds pod^{-1} (Figure 12) and pod length (Figure 14). These results are partially supported with the finds of Hossain *et al*., (2009). Therefore, it suggest that plant growth regulators (IAA 30 ppm + GA_3 30 ppm) gave better seed yield plot^{-1}.

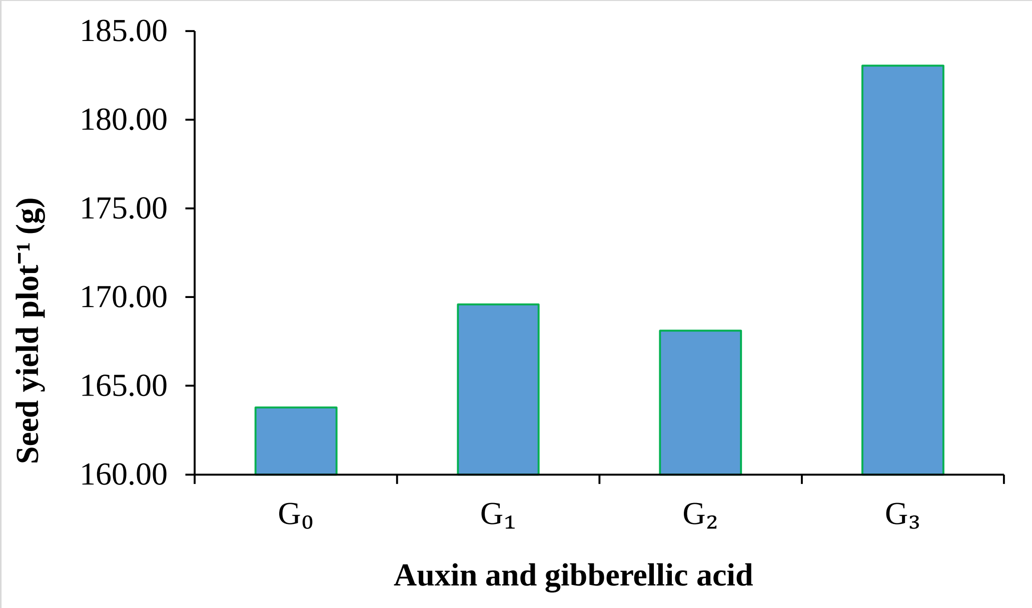

Figure 18. Effect of auxin and gibberellic acid on seed yield plot-[1] of mungbean

(LSD value = 13.48, which is significant at 5% level of probability). Here, G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm

Interaction effect of different sowing time, auxin and gibberellic acid

Interaction of different times of seed sowing and plant growth regulators showed significant variation on seed yield plot^{-1} of mungbean at harvest (Table 6 and Appendix VII). The highest seed yield plot^{-1} (205.84 g) was observed from the S_3G_3 treatment combination and the lowest seed yield plot^{-1} (138.81 g) was observed from S_1G_0 treatment combination. In this study, Single application of IAA or GA_3 enhance the seed yield plot^{-1}. Application of both IAA and GA_3 in a same plant also promote the seed yield plot^{-1} compared to control.

4.11 Yield ha^{-1}

Effect of different sowing time

Different time of seed sowing showed significant difference on the yield ha^{-1} of mungbean at harvest (Figure 23 and Appendix VII). The result demonstrated that, the highest yield ha^{-1} (0.67 t) were recorded from the first sowing date $S_{3,}$ 25 March, 2022 and the lowest yield ha^{-1} (0.52 t) were recorded from the S_1, 5 March, 2022. These results are constant with the growth and yield contributing parameters including plant height (Figure 1), number of leaves (Figure 3), number of branches plant^{-1} (Figure 5), fresh weight (Figure 7), dry weight (Figure 7), number of pods plant^{-1} (Figure 9), number of seeds pod^{-1} (Figure 11), pod length (Figure 13) and seed yield plot^{-1} (Figure 17). These results are partially supported with the findings of Mian *et al*., (2009). Therefore, it suggest that sowing of mungbean at 25 March gave better seed yield.

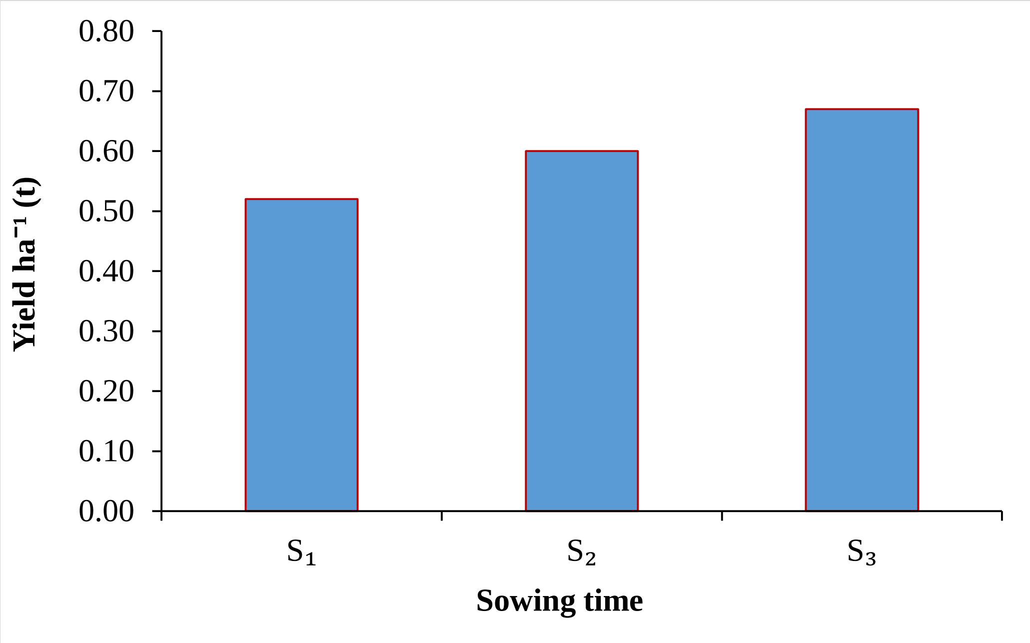

Figure 19. Effect of different sowing time on yield ha-^{1} of mungbean

(LSD value = 0.05, which is significant at 5% level of probability). Here, Sowing time S_1= 5 March, Sowing time S_2= 15 March and Sowing time S_3= 25 March.

Effect of auxin and gibberellic acid

The yield ha^{-1} of mungbean was significantly influenced by different concentrations of plant growth regulators at harvest (Figure 24 and Appendix VII). The results demonstrated that, G_3 (IAA 30 ppm + GA_3 30 ppm) was recorded with the highest yield ha^{-1} (0.64 t). On the other hand, G_0 (control) showed the lowest yield ha^{-1} (0.57 t). These results are constant with the growth and yield contributing parameters including plant height (Figure 2), number of leaves (Figure 4), number of branches plant^{-1} (Figure 6), fresh weight (Figure 8), dry weight (Figure 8), number of pods plant^{-1} (Figure 10), number of seeds pod^{-1} (Figure 12), pod length (Figure 14) and seed yield plot^{-1} (Figure 18). These results are partially supported with the findings of Hossain *et al*., (2009) and Navya *et al*., (2021). Therefore, it suggest that plant growth regulators (IAA 30 ppm + GA_3 30 ppm) gave better yield ha^{-1}.

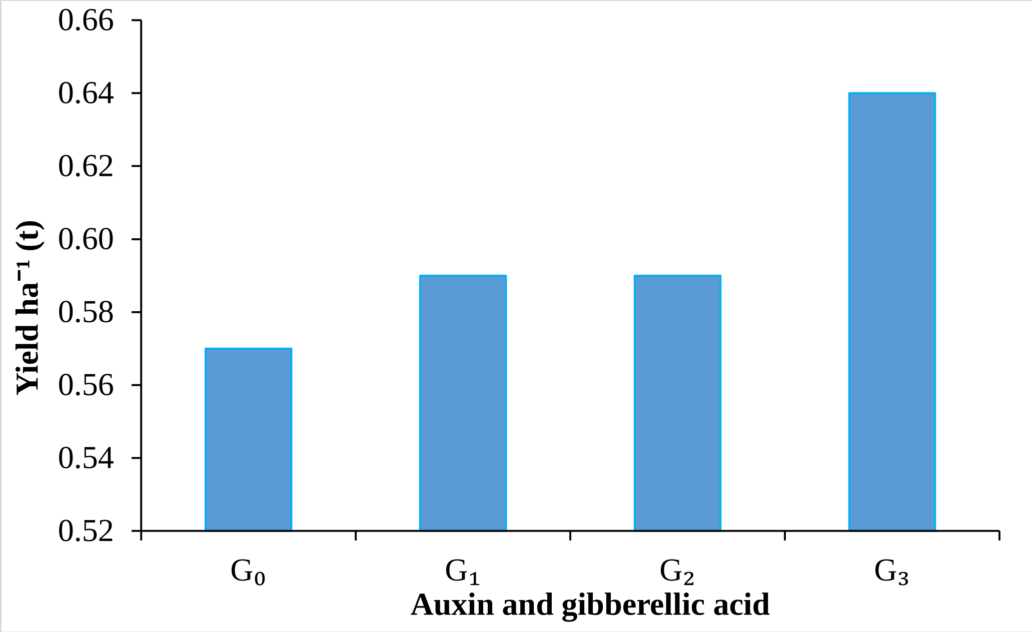

Figure 20. Effect of auxin and gibberellic acid on yield ha-^{1} of mungbean

(LSD value = 0.05, which is significant at 5% level of probability). Here, G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm

Interaction effect of different sowing time, auxin and gibberellic acid

Interaction of different times of seed sowing and plant growth regulators showed significant variation on yield ha^{-1} of mungbean at harvest (Table 6 and Appendix VII). The highest yield ha^{-1} (0.72 t) was observed from the S_3G_3 treatment combination and the lowest yield ha^{-1} (0.48 t) was observed from S_1G_0 treatment combination. In this study, Single application of IAA or GA_3 enhance the yield ha^{-1}. Application of both IAA and GA_3 in a same plant also promote the yield ha^{-1} compared to control.

Table 7. Interaction effect of different sowing time, auxin and gibberellic acid on seed yield of mungbean

Treatment Combination	Seed yield plot^{-1} (g)	Yield ha^{-1} (t)
S_1 G_0	138.81 f	0.48 f
S_1 G_1	149.78 ef	0.52 ef
S_1 G_2	145.27 ef	0.51 ef
S_1 G_3	158.70 de	0.55 de
S_2 G_0	169.35 d	0.59 cd
S_2 G_1	170.69 cd	0.59 cd
S_2 G_2	167.80 d	0.59 cd
S_2 G_3	184.64 b	0.64 bc
S_3 G_0	183.21 bc	0.64 bc
S_3 G_1	188.34 b	0.66 b
S_3 G_2	191.26 b	0.67 ab
S_3 G_3	205.84 a	0.72 a
Level of significance	*	*
LSD (0.05)	**13.48**	**0.05**
CV (%)	**5.13**	**5.11**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, Sowing time S_1= 5 March, Sowing time S_2= 15 March and Sowing time S_3= 25 March.
G_0= Control, G_1= IAA 30 ppm, G_2= GA_3 30 ppm and G_3= IAA 30 ppm + GA_3 30 ppm
* = Significant at 5% level

CHAPTER V

SUMMARY AND CONCLUSIONS

The field experiment was conducted at the Research Farm of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, during the period from February to June 2022 to identify the suitable time of sowing and the effect of auxin and gibberellin on growth and yield of mungbean. The experiment comprised of two factors *viz*., Factor A: Sowing time (3), i) S_1 = 5 March, ii) S_2 = 15 March and iii) S_3 = 25 March; factor B: Plant growth regulators (4), i) G_0 = Control, ii) G_1 = IAA 30 ppm, iii) G_2 = GA_3 30 ppm and iv) G_3 = IAA 30 ppm + GA_3 30 ppm. BARI Mung-6 was used as planting material. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data were collected on different aspects of growth, yield attributes and yield of mung bean.

The result revealed that S_3 treatment (sowing at 25 March) exhibited its superiority to other sowing time of 5 March and 15 March in terms of seed yield. S_3 out-yielded over S_2 by 11.67% higher yield. S_3 also showed the highest number of branches plant^{-1} (3.08), the highest fresh weight plant^{-1} of mungbean (10.87 g), the highest dry weight plant^{-1} of mungbean (1.94 g), the highest number of seeds pod^{-1} (10.41), highest pod length (7.82 cm), the highest weight of 1000-seeds (40.21 g) and the highest seed yield plot^{-1} (192.16 g) than other sowing time in the experiment. On the other hand, the S_1 treatment (sowing at 5 March) returned with 28.85% lower yield than S_3 which was significantly the lowest compare with other sowing times under study.

Significant differences existed among different plant growth regulator treatments with respect to yield and yield attributing parameters of mungbean. A yield advantages of 0.05 t ha^{-1}, 0.05 t ha^{-1} and 0.07 t ha^{-1} was observed from G_3 treatment (IAA 30 ppm + GA_3 30 ppm) over G_2 , G_1 and G_0 treated plot, respectively. The higher amount of yield from G_3 treatment was possibly aided by the highest number of branches plant^{-1} (3.22), the highest fresh weight plant^{-1} of mungbean (10.69 g), the highest dry weight plant^{-1} of mungbean (1.78 g), the highest number of pods plant^{-1} (23.00), the highest number of seeds pod^{-1} (10.54), highest pod length (7.98 cm), the highest weight of 1000-seeds (44.26 g) and the highest seed yield plot^{-1} (183.06 g). On the other hand, treatment G_2 (GA_3 30 ppm) gave significantly better result compared with other treatment in some parameters like—plant height, number of leaves plant^{-1}, number of branches plant^{-1}, pod length, weight of 1000-seeds and seed yield plot^{-1}.

Interaction results of sowing time and plant growth regulators indicated that all the studied parameters were influenced significantly. Significantly the highest seed yield ha^{-1} (0.72 t ha^{-1}) was recorded from S_3G_3 [25 March × (IAA 30 ppm + GA_3 30 ppm)] interaction due to the highest number of seeds pod^{-1} (12.23), pod length (9.13 cm), the highest weight of 1000-seeds (46.54 g) and the highest seed yield plot^{-1} (205.84 g). It was also observed that S_3G_2 combination (25 March × GA_3 30 ppm) showed the second highest seed yield (0.67 t ha^{-1}).

CONCLUSION

From the above result it was revealed that S_3 treatment (sowing at 25 March) gave higher yield along with higher values in most of the yield attribute parameters. Among the plant growth regulator treatments, G_3 treatment (IAA 30 ppm + GA_3 30 ppm) was high yielder than other concentrations of plant growth regulators. Among the interactions, S_3G_3 and S_3G_2 were superior in most of the growth and yield attributing parameters along with seed yield. Mungbean seed sown at 25 March and applied with IAA 30 ppm + GA_3 30 ppm seems promising for producing significantly higher yield of mungbean.

RECOMMENDATION

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

- More number of sowing times for mungbean may be used with different level of plant growth regulators for getting proper sowing time specific plant growth regulators recommendation.
- Studies of similar nature could be carried out in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of zonal adaptability.

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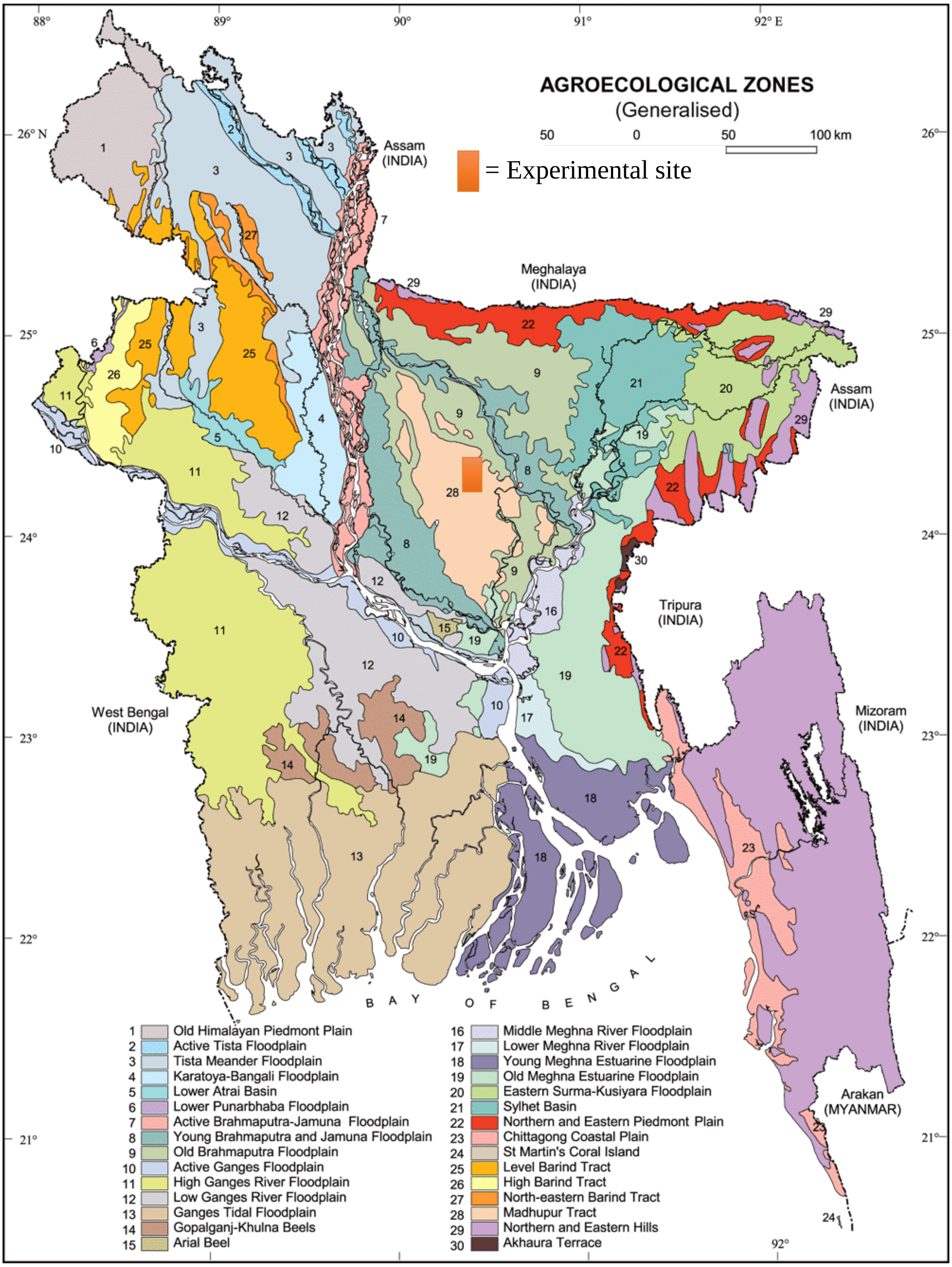
APPENDICES

Appendix I. The map of the experimental site



Appendix II. Analysis of variance (mean square) of Plant height of mungbean

Source of variation	Degrees of freedom	Mean Square value of		
		Plant height at 30 DAS	Plant height at 40 DAS	Plant height at 50 DAS
Sowing time	2	346.84*	356.28*	412.45*
Plant growth regulators	3	57.81*	9.67	19.59
Sowing time × Plant growth regulators	6	9.08*	1.54*	2.90*
Error	24	7.74	9.70	6.77
Total	35	31.64	28.10	30.39
* indicates significant at 5% level of probability				

Appendix III. Analysis of variance (mean square) of Number of leaves plant^{-1} of mungbean

Source of variation	Degrees of freedom	Mean Square value of		
		Number of leaves plant^{-1} at 30 DAS	Number of leaves plant^{-1} at 40 DAS	Number of leaves plant^{-1} at 50 DAS
Sowing time	2	0.67*	0.92*	0.80*
Plant growth regulators	3	0.21*	0.40*	0.42*
Sowing time × Plant growth regulators	6	0.07*	0.37*	0.69*
Error	24	0.24	0.73	1.57
Total	35	0.23	0.65	1.28
* indicates significant at 5% level of probability				

Appendix IV. Analysis of variance (mean square) of Number of branches plant^{-1} of mungbean

Source of variation	Degrees of freedom	Mean Square value of		
		Number of branches plant^{-1} at 30 DAS	Number of branches plant^{-1} at 40 DAS	Number of branches plant^{-1} at 50 DAS
Sowing time	2	0.27^{NS}	3.61*	2.68*
Plant growth regulators	3	0.07^{NS}	0.18*	0.54*
Sowing time × Plant growth regulators	6	0.06^{NS}	0.15*	0.53*
Error	24	0.11	0.33	0.43
Total	35	0.11	0.48	0.59
* indicates significant at 5% level of probability				

Appendix V. Analysis of variance (mean square) of plant fresh and dry weight of mungbean

Source of variation	Degrees of freedom	Mean Square value of	
		Fresh weight at 40 DAS	Dry weight at 40 DAS
Sowing time	2	10.51*	0.52*
Plant growth regulators	3	10.39*	0.40*
Sowing time × Plant growth regulators	6	6.86*	0.30*
Error	24	2.20	0.15
Total	35	4.18	0.22
* indicates significant at 5% level of probability			

Appendix VI. Analysis of variance (mean square) of yield attributes of mungbean

Source of variation	Degrees of freedom	Mean Square value of			
		Number of pods $plant^{-1}$	Number of seeds pod^{-1}	Pod length	Weight of 1000-seeds
Sowing time	2	212.53*	8.15*	3.12*	35.90*
Plant growth regulators	3	55.69*	5.08*	2.49*	161.98*
Sowing time × Plant growth regulators	6	2.01*	3.62*	0.38*	1.44*
Error	24	1.66	0.68	0.15	1.91
Total	35	18.40	1.99	0.56	17.49
* indicates significant at 5% level of probability					

Appendix VII. Analysis of variance (mean square) of yield of mungbean

Source of variation	Degrees of freedom	Mean Square value of	
		Seed yield $plot^{-1}$	Yield ha^{-1}
Sowing time	2	5849.89*	0.07*
Plant growth regulators	3	623.00*	0.01*
Sowing time × Plant growth regulators	6	25.15*	0.0003*
Error	24	64.01	0.001
Total	35	435.89	0.01
* indicates significant at 5% level of probability			