FLOWER AND POD DROPPING, GROWTH AND BIOLOGICAL YIELD OF MUNGBEAN AS AFFECTED BY IAA AND PLANT DENSITY

NARGIS AKTAR

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JUNE, 2015

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By

NARGIS AKTAR
REGISTRATION NO. 09-03653

A Thesis
Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE
IN
AGRONOMY

SEMESTER: **JANUARY–JUNE, 2015**

Approved by:

……………….……………. ………..……………………….
Prof. Dr. Md. Shahidul Islam **Prof. Dr. Parimal Kanti Biswas**
Supervisor **Co-supervisor**

…………………………….……………….
Prof. Dr. Md. Fazlul Karim
Chariman
Examination Committee

Department of Agronomy

Sher-e Bangla Agricultural University
Sher-e-Bangla Nagar
Dhaka-1207

CERTIFICATE

*This is to certify that thesis entitled, "**FLOWER AND POD DROPPING, GROWTH AND BIOLOGICAL YIELD OF MUNGBEAN AS AFFECTED BY IAA AND PLANT DENSITY**"submitted to the Faculty of Agriculture, Sher-e-BanglaAgricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (MS) IN AGRONOMY, embodies the result of a piece of bona-fide research work carried out by NARGIS AKTAR, Registration no. 09-03653 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

……………………………………
Prof. Dr. Md. Shahidul Islam
Department of Agronomy
Sher-e-Bangla Agricultural University
Dhaka-1207

Date:
Place: Dhaka, Bangladesh

ACKNOWLEDGEMENTS

All praises are laid upon the almighty Allah who is the Supreme Creator and given the author His kind blessing to complete her piece of study.

The author is much pleased to express her sincere appreciation and profound gratitude to her supervisor Prof. Dr. Md. Shahidul Islam, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his dynamic guidance, constant encouragement, constructive criticism and valuable suggestions not only during the preparation of the thesis but also during the entire period of the work.

It is a great pleasure to express her deep sense of gratitude and sincere regard to the research co-supervisor, Prof. Dr. Parimal Kanti Biswas, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his adept guidance, supervision, kind co-operation, and valuable suggestions in preparation of the thesis.

The author is highly grateful to Prof. Dr. Md. Fazlul Karim, Chairman, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka along with all the teachers and staff members of the Department of Agronomy, Sher-e-Bangla Agricultural University for their co-operation during the period of the study

The author wishes to extend her special thanks to her class mates Md. Hasib Abdullah, Negar Sultana, Atia Khatun, Chandra Sekhar Bhowmik, Faiz Muhammad Al-Noman, Pavel Khan for their keen help as well as heartiest co-operation and encouragement.

She also express her heartfelt thanks to her mother, father, brother, sister, uncles, aunts, grandmother and other relatives who continuously prayed for her success and without whose love, affection, inspiration and sacrifice ther work would not have been completed.

May Allah bless and protect them all.

The Author

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ABSTRACT

A field experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka, during March to June, 2014 to study the response of BARI Mung 6 under different planting density and foliar application of IAA (Indole-3-Acetisc Acid). The experiment was consisted of three spacings viz. i) 20cm x 10 cm (S_1) ii) 30cm x 10 cm (S_2) and iii) 40cm x10cm (S_3) and four levels of foliar spray with IAA application viz. i) Control (A_1) ii) Spraying IAA @ 50 ppm at 25 DAS (A_2) iii) Spraying IAA @ 100 ppm at 25 DAS (A_3) and iv) Spraying IAA @ 150 ppm at 25 DAS (A_4). The experiment was laid out in randomized complete block design (RCBD) (factorial) with three replications. The results showed that growth, flower and pod dropping and biological yield of BARI Mung 6 significantly responded to the different levels of IAA application, plant density and their interaction effects. Significant effect of plant density was found on growth and biological yield. The plant with 30 cm x 10 cm spacing gave the highest biological yield ha^{-1} (5.41 t), stover yield ha^{-1} (0.884 t). Flower and pod dropping $plant^{-1}$ was minimum (17.95) in $S_{1.}$ Foliar application of IAA also had significant effect on different growth, flower and pod dropping and biological yield. The highest stover yield ha^{-1} (0.91 t), biological yield ha^{-1} (5.33 t) and harvest index (40.33%) were observed from 100 ppm of IAA application. However, the lowest flower and pod dropping $plant^{-1}$ (16.99) was observed in 150 ppm IAA application. The combination effect of 100 ppm IAA application and 30 cm row to row distance showed maximum biological yield ha^{-1} (5.38 t) and 100 ppm IAA with 20 cm row to row distance gave lowest flower and pod dropping $plant^{-1}$ (16.28)

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LIST OF ABBREVIATIONS

AEZ	Agro-Ecological Zone
Anon.	Anonymous
AIS	Agriculture Information Service
BARC	Bangladesh Agricultural Research Council
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
BNNC	Bangladesh National Nutrition Council
BARI	Bangladesh Agriculture Research Institute
CRRI	Central Rice Research Institute
CV %	Percent Coefficient of Variance
cv.	Cultivar (s)
DAT	Days After Transplanting
DRR	Directorate of Rice Research
eds.	Editors
et al.	et alii (and others)
etc.	et cetera (and other similar things)
FAO	Food and Agricultural Organization
IAA	Indole-3-Acetic Acid
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
IRRI	International Rice Research Institute
L.	Linnaeus
LSD	Least Significant Difference

i.e.	id est (that is)
MoP	Muriate of Potash
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TDM	Total Dry Matter
TSP	Triple Super Phosphate
UNDP	United Nations Development Programme
var.	Variety
viz.	Namely

CHAPTER 1

INTRODUCTION

Mungbean (*Vigna radiata L.*) is an important pulse crop of Bangladesh, which contains high graded vegetable proteins and satisfactory level of minerals and vitamins. This pulse plays a significant role as supplement of low protein diet of poor people in Bangladesh but its production and acreage is declining day by day with an average yield of 0.69 ton ha^{-1} (BBS, 2008). After 1970s, the production area of pulses is in decreasing trend in Asia due to increasing cultivation of cereals and vegetable crops (FAO, 2011; Munir *et al.*, 2012). Among the pulse area, only 8.10% lands in Bangladesh are used for the cultivation of mungbean (Kabir, 2001). According to World Health Organization (WHO), per capita per day requirement of pulse is 45 g. However, in Bangladesh, only 12g pulse is available per capita per day. About 6.01 million tons of pulse is required to meet the present per capita requirement of our country. Seed yield is strongly correlated with the number of opened flowers and number of produced mature pods (Mondal *et al*., 2011b). High yielding genotypes of mungbean have higher number of flowers (Fakir *et al.*, 2011). In legume crops, many flowers are produced but only a few pods are set and result in low yield (Pigeaire *et al.*, 1992; Fakir *et al.*, 1998; Saitoh *et al.*, 2004; Mondal, 2007; Islam *et al.*, 2010). The extent of abscission has been put at more than 50% in most cases (Izquierdo & Hosfield, 1981). The abscissions of flowers and young pods of mungbean varied from 14.4 to 36.8% and 12.3 to 38.5%, respectively (Ter and Ugese, 2009). Approximately 55 to 85% of mungbean flowers do not develop into mature pods thereby showing low yield potential (Fakir *et al.*, 2011). Degree of flower shedding varies between 60–92% in soybean (Nahar & Ikeda, 2002; Saitoh *et al.*, 2004), 70-90% in mungbean (Kumari & Verma, 1983; Mondal *et al.*, 2011a), 80–91% in *Vigna unguiculata* (Hossain *et al.*, 2006) and 80–95% in *Cajanus cajan* (Fakir *et al.*, 1997; Begum *et al.*, 2007). The high proportion of reproductive abscission occurs because of the flowers and pods of the raceme may not receive enough assimilates from the leaf due to inadequate phloem tissue development in distal (top) part of the raceme (Wiebold & Panciera, 1990; Begum *et al.*, 2007; Mondal *et al.*, 2011a) resulting abscission of flowers and immature pods in legumes (Nahar & Ikeda, 2002; Hossain *et al.*, 2006).

The abscission of organs takes place at discrete sites and at specific times during the life cycle of a plant. Successful reproduction relies on careful timing and coordination of tissue development, which requires constant communication between these tissues. Optimum supply of required nutrient to the reproductive organs from the leaf could nourish it and enhance its life. IAA, a naturally synthesized growth hormone, plays a very important role to enhance crop growth and development, which could increase the availability of food to the growing plant when required. Auxin regulates many physiological processes related to flower and pod dropping. Plant hormones ethylene, abscisic acid and jasmonates induce senescence; and auxin, cytokinin and gibberellins play a role in its suppression (Lim *et al.*, 2003). Classical studies have correlated auxin levels with senescence and abscission (Addicott, 1982; Nooden and Leopold, 1988; Sexton and Roberts, 1982). The activity of hydrolytic enzymes involved in cell separation in the dehiscence zone is regulated by auxin activity (Chauvaux *et al.*, 1997). In bean leaves, a gradient of auxin levels was detected between the leaf blade and the stalk. Auxin levels declined with leaf age and senescence occurred when auxin levels between the leaf and stalk were approximately equal (Shoji *et al.*, 1951). Auxin plays a key role that mediates its function in flowers and fruits through an integrated process of biosynthesis, transport, and signaling, as well as interaction with other hormonal pathways. With increasing plant density, competition between plants increases which could result lower nutrient uptake as well as food production of individual plant that could hamper flower and pod set. Artificial applied auxin could increase root and shoot growth which could help to harvest more light, water, nutrients etc. to produce more food by individual plant.

Therefore, artificially applied auxin might have a positive effect to reduce flower and pod dropping and increasing yield under different plant density.

Taking the above mentioned points in view, the present study was undertaken with the following objectives:

- To study the role of different level of IAA on flower and pod dropping of BARI Mung 6 in kharif –II under different plant density.
- To study the growth pattern of BARI Mung 6 under different levels of IAA and different plant density.
- To find out the proper dose of IAA for higher yield of mungbean under different plant density.

CHAPTER 2

REVIEW OF LITERATURE

The growth and development of mungbean are influenced due to different level of IAA foliar application and plant density. Experimental results are available from home and abroad to reveal that IAA and plant density may influence growth and yield to a great extent. Relevant reviews on the above aspects have been presented and discussed in this chapter.

2.1. Role of IAA

2.1.1. Plant height

Total length of plant from ground level to the top of the leaf is a good indicator for overall development of any crop. Plant growth regulator like IAA can modify the plant height.

Abel and Theologis (2010) conducted an experiment and found that auxin is involved in mitotic activity in sub-apical tissues, resulting in increased plant growth. In a pot experiment Rastogi *et al.* (2013) found that auxin and gibberellic acid enhanced vegetative growth of linseed. They concluded that 0.5 mg L^{-1} dose of auxin is recommended for the enhancement of vegetative growth. However, it was observed that IAA had more promotory effects than GA in the enhancement of vegetative growth. Among PGRs, auxin and gibberellin play vital role in regulating developmental processes within plant bodies (Gou *et al.*, 2010). A higher concentration of gibberellins increases plant growth (Bora and Sarma 2006) while higher concentration of auxin inhibits it (Hussain *et al.*, 2010)

Muthulakshmi and Pandiyarajan (2015) conducted an experiment to study the IAA foliar spray on vegetative growth, physiological and biochemical constituents of *Chataranthus roseus* (L).G.Don. Significant increase of vegetative growth characters such as shoot and root length, shoot and root fresh weights and dry weights, photosynthetic pigment, non-photosynthetic pigment composition and total soluble protein, total soluble glucose, free amino acid, starch, leaf nitrate, NRA and peroxidase activity were recorded after IAA treatment.

Reena *et al.* (1999) conducted an experiment on soybean at 25, 50, 75, 100, 125 and 150 ppm solution of IAA and concluded that 100 ppm was the most effective concentration in increasing plant height. However, Sontakey *et al*. (1991) sprayed IAA at pre- flowering stage with 100, 250 or 500 ppm. and reported increased plant height of sesame after IAA application. Rahman *et al*. (1989) found similar results of increased plant height at 50 mg IAA/ L of foliar application, in a pot ecperiment with grasspea.

Quaderi *et al.* (2006) and Mathur (1971) found that plant height increased effectively by IAA application in mungbean and onion respectively. Saha *et al.* (1996) reported that IAA concentration of 600 and 900 ppm applied at the beginning of the tillering stage in Kanchan variety of wheat increased plant height compared to control and 300 ppm IAA.

Mirhadi *et al*. (1979) reported about higher plant height of sorghum hybrid Hazara-728 sprayed with 100 ppm of IAA. Garg and Kumar (1987) sprayed aqueous solution of 10 ppm IAA four-week old *Euphoria lathyrus* L. plants at weekly intervals for four weeks and found increased plant height compared to the control.

Lee (1990) reported longer main stems of groundnut after soaking groundnut seed in 50, 100, and 200 ppm solution of IAA prior to sowing. In cowpeas, stem length increased only when IAA was applied at 10 or 50 mg/L at 25-65% water holding capacity (Khalil and Mandurah, 1989). Manikandan and Hakin (1998) reported increased shoot length of groundnut when they applied IAA at 30 ppm as foliar spray and parthenium root extract in groundnut (arachis hypogaea cv. Co-02)

2.1.2. Number of leaves plant^{-1}

Gurdev and Saxena (1991) conducted and experiment on wheat and reported that IAA applied at 10^{-4}M increased number of leaves plant^{-1}. Mathur (1971) also mentioned about similar increase in leaf number in onion treated with IAA at 100-300 ppm.

Khalil and Mandurah (1989) conducted 2 year pot trails on cowpea and found that at 15, 25, 45 of 65% of water holding capacity of soil and sprayed with 0, 10, 50 or 100 ppm IAA at 4, 6 and 9 weeks after sowing, IAA increased the number of leaves only when applied at 10 of 50 ppm at 25-65% water holding capacity.

2.1.3. Number of branches plant^{-1}

Lee (1990) observed higher number of branches after soaking groundnut seed in solution of 50, 100 and 200 ppm IAA before sowing. IAA at 300, 600 and 900 ppm increased number of tiller plant^{-1} in wheat when IAA is applied at the beginning of tillering stage (Saha *et al.*, 1996). Awan and Alizai (1989) also mentioned about similar results of higher number of tiller in rice after the application of 100 ppm IAA at panicle emergence stage of rice cv. IR6.

Rahman *et al*. (1989) reported that 500 ppm IAA produced maximum number of plant branches in grasspea. Sontakey *et al.* (1991) reported that pre-flowering spray of sesame cv. 128 with 100, 250 of 500 ppm IAA increased branch number per plant.

2.1.4. Root

Fukaki *et al.* (2007) studied on the developmental mechanisms of lateral root development and found that auxin has emerged as a central regulator of lateral root development. However, few scientists said that correct auxin localisation and subsequent auxin response are crucial for lateral root development (Casimiro *et al.*, 2003; De Smet *et al.*, 2006).

Auxin is found directly involved in activating the cell cycle during lateral root initiation (Himanen *et al.,* 2004) and the expression of genes downstream (Himanen *et al.,* 2004; Vanneste *et al.*, 2005).

Casimiro *et al.* (2003) in an experiment found that auxin is the major regulator of lateral root initiation, differentiation and meristem specification. Manikandan and Hakin (1998) reported increased root length when IAA was applied at 30 ppm as foliar spray in groundnut.

Mutants which overproduce auxin, like the *Arabidopsis superroot* mutant, have increased numbers of lateral roots (Boerjan *et al.*,1995) and similarly exogenous application of auxin increases lateral root numbers (Wightman *et al.,*1980; Laskowski *et al.,* 1995). In contrast, mutants resistant to auxin show reduced numbers of lateral roots (De Smet *et al.*, 2006).

2.1.5. Flower and pod dropping

Mondal *et al*. (2011b) reported that seed yield is strongly correlated with the number of opened flowers and number of produced mature pods.

Lim *et al.* (2003) said that plant hormones like ethylene, abscisic acid and jasmonates induce senescence; and auxin, cytokinin and gibberellins play a role in suppressing flower and pod dropping. However, classical studies have correlated auxin levels with senescence and abscission (reviewed in Addicott, 1982; Nooden and Leopold, 1988; Sexton and Roberts, 1982).

Fakir *et al.* (2011) conducted an experiment on mungbean and concluded that high yielding genotypes of mungbean have higher number of flowers. However, in legume crops, many flowers are produced but only a few set pods are formed and result the low yield (Pigeaire *et al.*, 1992; Fakir *et al.*, 1998; Saitoh *et al.*, 2004; Mondal, 2007; Islam *et al.*, 2010). The extent of abscission has been put at more than 50% in most cases (Izquierdo & Hosfield, 1981).

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2.1.6. Stover yield

Elshorbagi *et al.* (2008) mentioned about the role of IAA on the anatomical characteristics, stover and fiber yield and quality of Flax.

2.1.7. Biological yield

Sadak *et al.* (2013) conducted and experiment and found that that IAA treatments caused significant increases in seed yield/plant (g), yield attributes (number of pods/plant, pods yield/plant (g), 100-seed weight (g) and biological yield/plant) of the two fababean cultivars.

2.1.8. Harvest index (%)

Quaderi *et al.* (2006) conducted an experiment and mentioned that seed treatment with 200 ppm IAA resulted the highest relative growth rate (RGR), crop growth rate (CGR), net assimilation rate (NAR), higher yield, harvest index (38.48) of mungbean.

2.2. Role of plant density

2.2.1. Plant height

Rafiei, (2009) mentioned that, optimum plant density is a pre-requisite for obtaining higher productivity. Maboko and Plooy (2009) found a significant interaction of plant density on plant height. Jahan and Hamid, (2005) said that plant density affects plant growth.

Significant influence of plant density on plant height of mungbean was reported by Ihsanullah*et al.*, (2002). However, reports of several researches (Narayanan and Narayanan, 1987; Chimanshette and Dhoble, 1992 and Hosssain & Salauddin, 1994) showed that narrow plant density increased plant height and reduced the number of branches plant^{-1}.

Baloch (2004) conducted an experiment on different plant density (30 cm, 45 cm, and 60 cm row distance) and found that plant density plays significant role on plant height, monopodial branches, pod length, number of pods plant^{-1}, number of seeds pod^{-1}, seed weight plant^{-1} and seed yield.

2.2.2. Number of leaves palnt^{-1}

Streck *et al.* (2014) carried out an experiment in a subtropical environment of Brazil. The objective of the experiment was to study the influence of different planting densities on the growth, development yield of cassava. They found that, the final leaf size and number of lateral shoots increases with the decrease of plant density. The maximum leaf area index and phyllochron increases as plant density increases.

Maboko and Plooy (2009) found a significant interaction of plant density on plant height, fresh and dry leaf mass, leaf number m^{-2}, leaf area. The results indicate that, increase in plant population significantly increases yield and yield components of leafy lettuce.

Islam *et al.* (2011) conducted a field experiment at the Horticultural farm of the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, during September 2006 to April 2007 on sweet pepper to study role of plant density on growth and yield of sweet pepper. They found significant influence of plant density on that number of leaves plant^{-1}.

To find out the optimum plant density and suitable cabbage variety(s), Moniruzzaman (2011) conducted an experiment on cabbage at the Agricultural Research Station, Raikhali, Rangamati. He concluded his research that, wider plant density (60 × 45 cm) resulted in significantly maximum number of folded leaves and head weight (without unfolded leaves) in comparison to closer plant density (60 × 30 cm)'

2.2.3. Number of branches plant^{-1}

Narayanan & Narayanan, (1987) mentioned that, narrow spacing of pigeonpea reduced the number of branches plant^{-1} and increased plant height.

2.2.4. Root

Kabir *et al.* (2013) conducted an experiment at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2005 to April 2006. The objective of the study was to determine the influence of different sowing dates and plant density on growth and yield of carrot. They found significant influence of different plant density on leaf length, root length, leaf fresh weight, root fresh weight, root diameter, leaf dry weight and root dry weight under different sowing time. However, Streck *et al*. (2014) reported higher tuber root yield of cassava under higher plant densities.

Jiang *et al*. (2013) conducted an investigation on maize to investigation the effects of plant density on grain yield and root competition in summer maize (*Zea mays* L.). Less root biomass was reported at narrow plant density. Slightly reduced dry root weight was recorded in the 20–40 cm and 40–70 cm zones at the mid-grain filling stage. However, variation was observed in the 70–100 cm zone during the whole growth period for dry weight of roots. 5.0% and 8.4%

lower grain yield and above-ground biomass were recorded in the narrow plant density than with normal plant density.

Desuki *et al. (*2005) conducted a field trial on radish (*Raphanus sativus* L.) in 2002 and 2003 growth seasons to investigate the effect of different plant densities and N fertiliser rates on yield and quality attributes of radish. They found that, decreasing plant density markedly enhanced root quality but significantly reduced the total yield. It was concluded that the reduction in yield for lower plant density can be compensated by the higher prices of high quality root.

2.2.5. Leaf dry weight

Khazaei *et al.*, (2013) mentioned about the role of plant density on leaf dry weight of lettuce. Kabir *et al.* (2013) also found the role of plant density on leaf dry weight of carrot under differed sowing times.

Amaglo *et al.* (2006) carried out an experiment at the Department of Horticulture of the Kwame Nkrumah University of Science and Technology, Kumasi, to investigate the role of plant density and harvest frequency on the growth, leaf yield and quality of Moringa oleifera Lam. The wider plant density produced a greater number of leaves and higher shoot yield plant^{-1} than the closer plant densities ($P<0.05$). However, in the close plant density the number increased steadily but declined 8.49 to 7.84 in the 8th week.

Abubakari *et al.* (2011) mentioned almost two fold increased weight of lettuce under 15x15 cm plant density compared to 20x20 and 30x30 cm.

2.2.6. Stem dry weight

Khazaei *et al.* (2013) carried out an experiment on lettuce to investigate the effects of plant density, mulch and organic fertilizer on the growth and yield of lettuce. According to findings of the experiment, significant effects of plant density was found on stem diameter, stem weight, stem dry matter, stem fresh weight, leaf number, stem dry weight, leaf dry weight, total yield. Significant influence of plant density on dry weight of plant was also reported by Streck *et al.* (2014) in subtropical environment of Rio Grande do Sul, Brazil.

2.2.7. Inflorescence

Mozumder *et al.* (2012) conducted an experiment at the Horticulture Field Laboratory of Bangabandhu Sheikh Mujibur Rahman Agricultural University during December 2007 to July 2008 of *Eryngium foetidum* at different plant density. Individual plant performance, flower stalk size, number of inflorescence, seeds/inflorescence and thousand seed weight were higher in wider plant density but marketable fresh yield and seed yield per unit area was better in medium (10 cm×10 cm) plant density. Ramamneh *et al.* (2013) also mentioned the role of plant density on inflorescence of Stoverberry.

Chomtee and Ruamrungsri (2012) conducted an experiment to know the effects of fertilizer rates, plant density and rhizome sizes on growth and inflorescence quality on Globba winitii, a flower bulb. They found that the plant density factor did not significantly affect on growth and inflorescence quality of Gobba winitii.

2.2.8. Stover yield

Bozorgi *et al.* (2011) mentioned the role of plant density on seed yield and stover yield of rice variety Hashemi. The interaction effect of plant density and number of seedling per hill was found significant on stover yield, grain yield and harvest index at 1% and on biological yield at 5% probability level. Zamir *et al.* (2011) also mention about similar result.

Kumar and Sharma (1989) reported higher biological yield at narrow row plant density. However, Soni *et al.* (1991) reported non-significant effect of row plant density on biological yield.

2.2.9. Biological yield

Kumar and Sharma (1989) reported about higher biological yield at higher plant density. Ihsanullah *et al.* (2002) also mentioned that spacings influence plant yield, yield attributes and yields of mungbean. However, soni *et al.* (1991) reported about non-significant effect of plant density on biological yield.

2.2.10. Harvest index (%)

Foysalkabir *et al.* (2016) conducted and experiment in sher-e-bangla agricultural university and found that 30cm × 10cm plant spacing gave the highest 1000-seeds weights, seed yield and harvest index of mungbean.

CHAPTER 3

MATERIALS AND METHODS

This chapter consists of the materials and methods of the experiment along with a brief description of the experimental site, experimental design, soil, climate, land preparation, fertilizer application, planting materials, transplanting, intercultural operation, irrigation and drainage, data collection, data recording and their analysis. The details of investigation for achieving stated objectives are described below.

3.1. Site description

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from March 2014 to June 2014. The experimental site was located at 23°77′ N latitude and 90°37′ E longitudes with an altitude of 9 m.

3.2. Agro-ecological region

The experimental site belongs to the agro-ecological zone of “Madhupur Tract”, AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Madhupur clay, where floodplain sediments buried the dissected edges of the Madhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain (Anon., 1988b).For better understanding, the experimental site is shown in the AEZ Map of Bangladesh in Appendix I.

3.3. Climate and weather

The geographical location of the experimental site was under the sub-tropical climate characterized by three distinct seasons. The monsoon or rainy season extending from May to October, which is associated with high temperature, high humidity and heavy rainfall; the winter or dry season from November to

February, which is associated with moderately low temperature and the pre-monsoon period or hot season from March to April, which is associated with some rainfall and occasional gusty winds. Information regarding monthly average maximum and minimum temperature, total rainfall and average relative humidity and sunshine during the period of study of the experimental site was collected from Bangladesh Meteorological Department, Agargaon, Dhaka and is presented in Appendix II.

3.4. Soil

The soil on which the experiment was conducted is Madhupur Tract, a typical rice growing soil. Top soil was silty clay in texture, red brown terrace soil type, olive–gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and had organic carbon 0.45%. The land was well drained with good irrigation facilities. The experimental site was a medium high land. The experimental site was above flood level and sufficient sunshine was available during the experimental period. The morphological characters of soil of the experimental plots are as following - Soil series: Tejgaon, General soil: Non-calcareous dark grey (Appendix III). The physicochemical properties of the soil are presented in Appendix III.

3.5. Crop / Planting materials

BARI Mung-6 was used as planting material. The seeds of BARI Mung 6 was collected from Bangladesh Agricultural Research Inistitute, 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 60-65 days after sowing (DAS) and average yield is 1400-1600 kg ha^{-1}

3.6. Treatments under investigation

Factor A: Indole-3-acetic acid with 4 levels designated

A_1 = Control (Foliar spray of water at 25 DAS)

A_2 = Foliar spray of Indol-3-Acetic Acid (IAA) @ 50 ppm at 25 DAS

A_3 = Foliar spray of Indol-3-Acetic Acid (IAA) @ 100 ppm at 25 DAS

A_4 = Foliar spray of Indol-3-Acetic Acid (IAA) @ 150 ppm at 25 DAS

Factor B: Spacing with 3 levels designated

S_1 = Row to row 20 cm and plant to plant 10 cm

S_2 = Row to row 30 cm and plant to plant 10 cm

S_3 = Row to row 40 cm and plant to plant 10 cm

3.7. Details of the experiment:

3.7.1. Experimental treatments:

Two factor experiments were conducted to evaluate the effect of IAA on flower & pod dropping, growth and biological yield of mungbean under different plant density and IAA application.

3.7.2. Experimental design

The experiment was laid out in randomized complete block design (RCBD) with three replications. The layout of the experiment was prepared for distributing the treatments. The experimental field was divided into 3 blocks. Each block was again divided into 12 plots. The total numbers of unit plots of the experiment were 36 (12 × 3). The size of the unit plot was 3.75 m × 1.78 m (6.675 m^2).There were 0.50 m width and 10 cm depth for drains between the blocks. Each treatment was again separated by drainage channel of 0.4 m width and 10 cm depth. The treatments were randomly distributed to each block following the experimental design (Figure 1).

3.8. Growing of crops

3.8.1. Land preparation

The land was irrigated before ploughing. After having field capacity, land was allowed to attain at joo condition. On 08 March, 2014, the first ploughing was done and final land ploughing was done on 10 March, 2014. According to experimental layout the experimental field was divided and arranged. On 10 March, 2014, the basal fertilizer doses were applied. The experimental layout is presented in Figure 1.

3.8.2. Fertilizer application

Urea, Triple Super Phosphate (TSP) and Murate of Potash (MoP) were used as sources of nitrogen, phosphorus and potash. BARI recommended doses were applied. During final land preparation, all the fertilizers were applied as a basal dose.

Nutrient	**Source**	**Dose (kg ha^{-1})**
N (Nitrogen)	Urea (46% N)	30
P (phosphorus)	TSP (48% P_2O_5)	48
K (potassium)	MoP (60% K_2O)	30

3.8.3. Seed sowing

Seeds were sown @ 30 kg ha^{-1} on 11 March, 2014. Seeds were treated with fungicide Provex to protect them from seed born diseases. Seeds were placed in

2-3 cm depth in rows having different distances of 20 cm, 30 cm and 40 cm. Emergences of seedling: Seed germination occurred on 14 March, 2014 and 50% seed germination was recorded on 16 March, 2014.

3.9. Intercultural operation

3.9.1.Weeding and thining

Weeding was done as per requirement. Thining were done to maintain 10 cm plant to plant distance. The first thinning was done at 8 DAS and second one was done at 15 DAS.

3.9.2. Irrigation and drainage

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

3.9.3. Insect control

At the time of 50% pod formation stage, insecticide Malathion 57EC was sprayed @ 1.5 t ha^{-1} to control pod borer.

3.10. General observation

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

3.11. Determination of maturity

At the time when 80% of the pods turned blakish in colour, the crops were assessed to attain maturity.

3.12. Harvesting and sampling

The crops were harvested from central 1.0 m^2 area of each plot for biological yield data on different dates as they attained maturity. Five randomly selected plants from each plot were marked for recording data on plant height, leaves number, inflorescence number, flower and pod dropping. Pods were collected thrice throughout the growing period.

3.13. Threshing

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

3.14 Drying, cleaning and weighing

The collected seeds were dried in the sun for 1-3 days to reduc the moisture to about nearly12% level. The dried seeds and stover were cleaned and weight of seeds plot^{-1} was recorded.

3.15 Recording of data

Data were recorded on the following characters

i. Plant height at 35, 45, 55 & 65 DAS
ii. Number of leaves plant^{-1} at 35, 45, 55 & 65 DAS
iii. Dry weight of leaves plant^{-1} at 35, 45, 55 & 65 DAS
iv. Dry weight of roots plant^{-1} at 35, 45, 55 & 65 DAS
v. Dry weight of stem plant^{-1} at 35, 45, 55 & 65 DAS
vi. Number of inflorescence plant^{-1}
vii. Dry weight of inflorescence plant^{-1}
viii. Flower and pod dropping plant^{-1}
ix. Flower and pod dropping percentage plant^{-1}
x. Biological yield ha^{-1}
xi. Stover yield ha^{-1}
xii. Harvest index (%)

3.16 Outline of data recording

A brief outline of data recording procedure is given below:

i) Days to seedling emergence

It was taken by an overview to measure first germination of crops took places.

ii) Days to 50% seedling emergence

It was observed on 17 March, 2014 when 50% seed were germinated.

iii) Plant height plant^{-1} (cm)

The height of plant was recorded in centimeter (cm) at 35, 45, 55 and 65 DAS. Data were recorded from 5 plants selected at random from the outer side rows (started after 2 rows from outside) of each plot. The height of the plant was determined by measuring the distance from the soil surface to the tip of the top leaf.

iv) Number of leaves plant^{-1}

Numbers of leaves per plant were recorded at 35, 45, 55 and 65 DAS. Data were recorded from 5 plant selected at random from the outer side rows (started after 2 rows from outside) of each plot.

v) Dry weight of leaves plant^{-1}(g)

Total Dry matter weight of leaves plant^{-1} was recorded at 35, 45, 55 and 65 DAS by uprooting three random plant samples and separating the leaves carefully. The leaf samples were oven dried at 72 °C temperature until a constant weight was raised. Data were recorded as the average of 3 sample plants plot^{-1} selected at random from the outer rows of each plot leaving the border line and expressed in gram.

vi) Dry weight of roots plant^{-1}(g)

Total Dry matter weight of roots plant^{-1} was recorded at 35, 45, 55 and 65 DAS by uprooting three random plant samples and separating the root carefully. The root samples were oven dried at 72°C temperature until a constant weight. Data were recorded as the average of 3 sample plants plot^{-1} selected at random from the outer rows of each plot leaving the border line and expressed in gram.

vii) Dry weight of stem plant^{-1}(g)

Total Dry matter weight of stem plant^{-1} was recorded at 35, 45, 55 and 65 DAS by uprooting three random plant samples and separating the stem carefully. The stem samples were oven dried at 72 °C temperature until a constant weight was found. Data were recorded as the average of 3 sample plants plot^{-1} selected at random from the outer rows of each plot leaving the border line and expressed in gram.

viii) Number of inflorescence plant^{-1}

Numbers of inflorescence plant^{-1} were recorded at 45, 55 and 65 DAS. Data were recorded from 5 plant selected at random from the outer side rows (started after 2 rows from outside) of each plot.

ix) Dry weight of inflorescence plant^{-1}(g)

Total Dry matter weight of inflorescence plant^{-1} was recorded at 45, 55 and 65 DAS by uprooting three random plant samples and separating the inflorescence carefully. The stem samples were oven dried at 72 °C temperature until a constant weight was found. Data were recorded as the average of 3 sample plants plot^{-1} selected at random from the outer rows of each plot leaving the border line and expressed in gram.

x) Flower and pod dropping

Aborted flower and pods were collected everyday at very first hour of the morning from five pre-selected plants. Soil areas of the plots were kept clean. Data were recorded as the average of flower and pods aborted from five sample plants plot^{-1} selected at random from the outer rows of each plot leaving the border line.

xi) Flower and pod dropping percentage

Flower and pod dropping percentage were calculated by the following formula.

$$\text{Flower and pod dropping(\%)} = \frac{\text{Harvested pod number}}{\text{Harvested pod number} + \text{totel dropping}} \times 100$$

xii) Days to harvesting

Days to harvesting was considered when the 80% pod of the plants within a plot becomes blackish in color. The number of days to maturity was recorded from the date of sowing.

xiii) Biological yield

Biological yield was calculated using the following formula:

Biological yield = Grain yield + Stover yield.

xiv) Harvest index (%)

Harvest index was calculated with the help of following formula and it was calculated on dry weight basis.

$$\text{Harvest Index (\%)} = \frac{\text{Economic Yield (Seed weight)}}{\text{Biological Yield (Total dry weight)}} \times 100$$

3.17 Statistical analysis

The data obtained for different characters were statistically analyzed following the analysis of variance techniques to obtain the level of significance by using MSTAT-C computer package program (Fred, 1986). The significant differences among the treatment means were compared by Least Significant Difference (LSD) at 5% levels of probability.

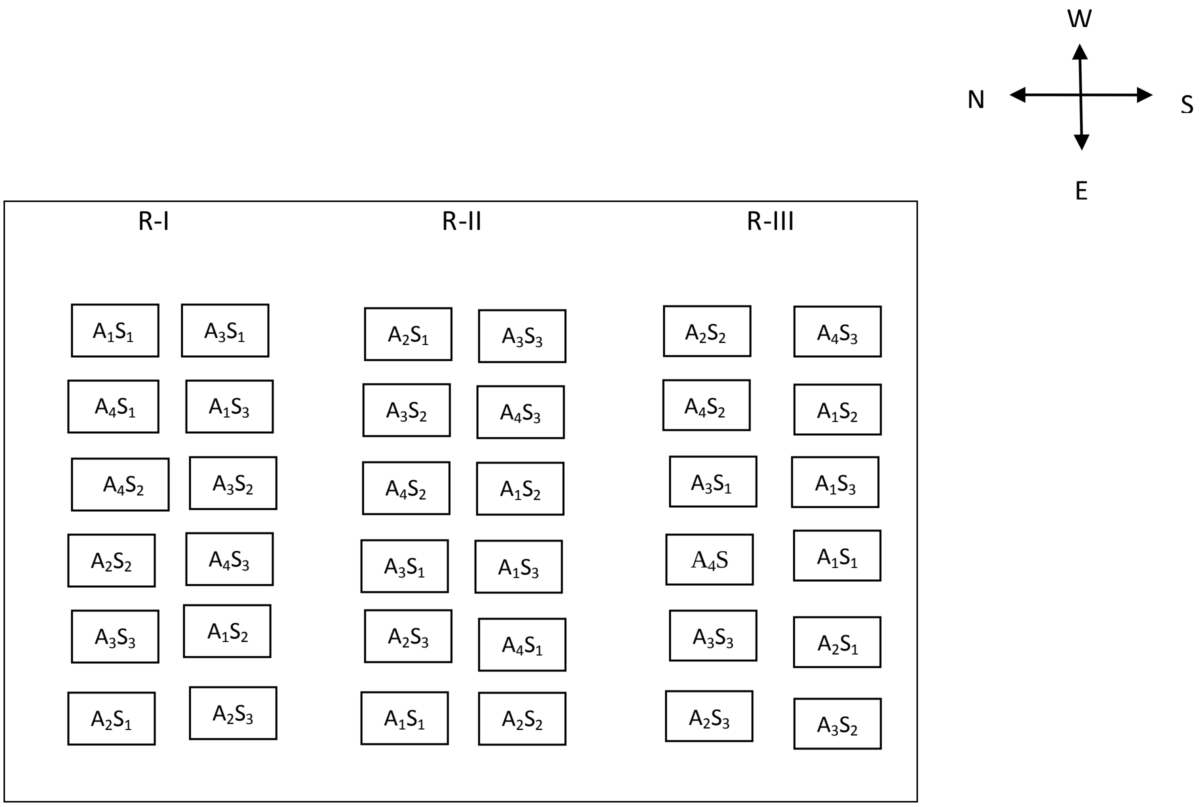


Figure 1: Experimental layout

Here,

S_1 = 20cm x 10cm plant density

S_2 = 30cm x 10cm plant density

S_3= 40cm x 10cm plant density

A_1 = Control (Foliar spray of water at 25 DAS)

A_2 = Foliar spray of Indol-3-Acetic Acid (IAA) @ 50 ppm at 25 DAS

A_3 = Foliar spray of Indol-3-Acetic Acid (IAA) @ 100 ppm at 25 DAS

A_4 = Foliar spray of Indol-3-Acetic Acid (IAA) @ 150 ppm at 25 DAS

Number of treatment: 12

Plot to plot = 0.4 m

Block to block -= 0.5 m

Plot Area: 3.75 x 1.8= 6.75 m^2

CHAPTER 4

RESULTS AND DISCUSSION

This chapter contains the presentation and discussion of the results obtained from the present study. Results have been presented, discussed and possible interpretations were made through tables and graphs. The results obtained from this experiment have been presented under separate headings and sub-headings as follows:

4.1. Crop growth parameters

4.1.1. Plant height

4.1.1.1. Effect of IAA

Application of IAA with different concentrations showed significant influence on plant height of BARI Mung 6 (Appendix-IV). Plant height was increased with increasing IAA concentration. The tallest plant of BARI Mung 6 was found in A_4 (150 ppm IAA foliar application) treatment at 35, 45, 55 and 65 DAS (33.88 cm, 41.52 cm, 45.30 cm and 44.45 cm respectively) (Fig. 2a). However, A_3 (100 ppm IAA foliar application) treatment showed statistically similar plant height of BARI Mung 6 at 45 and 65 DAS (39.46 cm and 41.98 cm respectively). On the other hand, control treatment (A_1**:** No IAA foliar application) showed the lowest plant height of BARI Mung 6 at different growth stage (29.36 cm at 35 DAS, 37.96 cm at 45 DAS, 39.87 cm at 55 DAS and 39.01 cm at 65 DAS) (Fig. 2a).

Auxin appears to be a pattern-determining global regulator, as well as a player in cell division, cell elongation and vascular tissue differentiation. So, foliar application of IAA may enhance the physiological process of plant which could be the reason for higher plant height of IAA treated plants in this experiment.

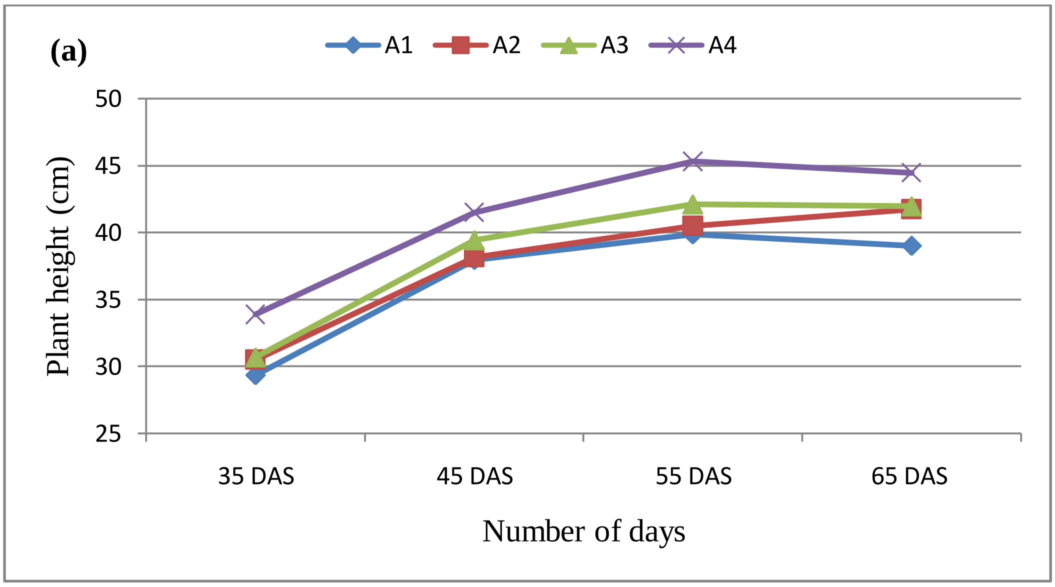
Abel and Theologis (2010) reported that exogenous application of auxin increased the plant growth. Rastogi *et al.* (2013); Sontakey *et al.* (1991) and Rahman *et al.* (1989) also mentioned higher plant height after IAA application.

4.1.1.2. Effect of plant density

Significant influence of plant density on plant height of BARI Mung 6 (Fig. 2b and Appendix- IV) was found at different days after sowing (DAS). Results showed that S_2 (30 cm row to row distances) treatment produced the tallest plant at 35, 45, 55 and 65 DAS (31.89 cm, 40.63 cm, 43.76 cm and 42.85 cm respectively). However, statistically similar results were found in S_3 (40 cm row to row distance) treatment at 45 and 55 DAS (39.33 cm and 41.01 cm respectively) (Fig. 2b). Closest plant density (S_1: 20 cm row to row distance) showed lowest plant height of BARI Mung 6 throughout the growing period (28.31 cm at 35 DAS, 37.87 cm at 45 DAS, 40.69 cm at 55 DAS and 39.32 cm at 65 DAS) (Fig. 2b).

At lower plant density, plants might have received more light, nutrients and other resources to ensure optimum growth and development. On the other hand, there is always higher competition for light, nutrients and moisture at higher plant density. However, plant density over optimum level could expose the plants to climatic hazards under changing microclimate. This may be the reason why plants with lower plant density (S_3: 40 cm row to row distance) failed to show better performance.

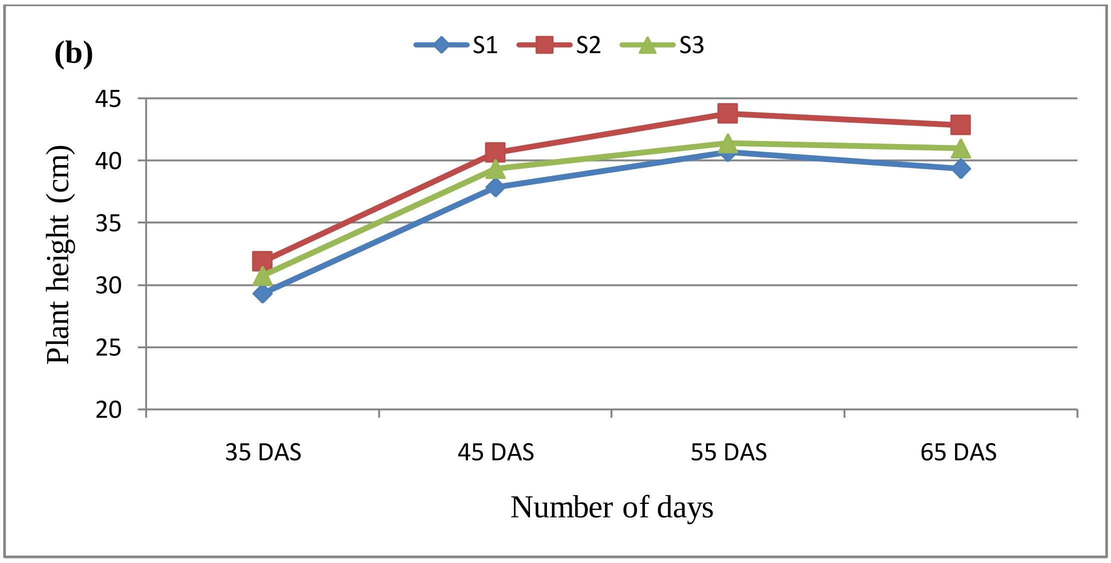
Rafiei, (2009) mentioned that optimum plant density is pre-requisite to ensure higher productivity of plant. Similar results were also mentioned by Baloch (2004), Ihsanullah*et al.* (2002) and Jahan and Hamid (2005) who reported that plant density affects the plant growth.



Note: A_1 : No IAA A_3 : 100 ppm IAA

A_2 : 50 ppm IAA A_4 : 150 ppm IAA

LSD values were 2.54, 2.28, 2.43 and 3.03 at 35, 45, 55 and 65 DAS respectively



Note: S_1 : 20 cm ×10 cm,
S_2 : 30 cm ×10 cm
S_3 : 40 cm ×10 cm
LSD values were 2.20, 1.98, 2.11 and 2.63 at 35, 45, 55 and 65 DAS respectively

Figure 2. Effect of IAA (a) and plant density (b) on plant height of BARI Mung 6

4.1.1.3. Interaction effect of IAA and plant density

In this experiment significant interaction effect of IAA and plant density was observed for BARI Mung 6 (Appendix-IV and Table 1). The highest plant height was recorded in A_4S_2 (150 ppm IAA foliar application + 30cm row to row distance) treatment combination at 35, 45, 55 and 65 DAS (37.36 cm, 44.38 cm, 50.04 cm and 46.72 cm respectively) (Table 1). On the other hand, the lowest plant height was recorded in A_1S_1 (No IAA foliar application + 20 cm row to row distance) treatment combination at all the growth stage of plant (26.30 cm at 35 DAS, 34.02 cm at 45 DAS, 39.50 cm at 55 DAS and 38.68 cm at 65 DAS).

4.1.2. Number of leaves plant^{-1}

4.1.2.1. Effect of IAA

Significant influence of IAA was found on the number of leaves plant^{-1} of BARI Mung 6 (Fig. 3a and Appendix V). The highest number of leaves plant^{-1} was recorded from higher concentration of IAA treated plants (A_4: 150 ppm IAA application) throughout the plant growth period. The number of leaves in A_4 (150 ppm IAA application) treatment at 35, 45, 55 and 65 DAS were 21.55, 22.95, 23.89 and 23.40 respectively (Fig. 3a). At 55 DAS and 65 DAS, A_3 (100 ppm IAA application) treatment showed statistically similar results (22.90, 22.42 respectively) to A_4 (150 ppm IAA application) treatment. IAA treated plant showed significantly better performance than the plants in control throughout the growing period. The lowest number of leaves was recorded from control treatment (A_1: No IAA application) throughout the growth period of BARI Mung 6 (19.56 at 35 DAS, 20.99 at 45 DAS, 21.93 at 45 DAS and 21.24 at 65 DAS).

Gurdev and Saxena (1991) mentioned that 10^{-4} M of IAA increased leaves number plant^{-1} of wheat. Khalil and Mandurah (1989) reported that IAA application increased the number of leaves plant^{-1}. Similar increase in leaf number was also reported with 100–300 ppm of IAA (Mathur, 1971) in onion.

Table 1. Interaction effects of IAA and plant density on plant height plant^{-1} of BARI Mung 6

Treatments	Plant height plant^{-1} (cm)			
	35 DAS	**45 DAS**	**55 DAS**	**65 DAS**
A_1S_1	26.30 d	34.02 d	39.50 d	38.68 c
A_1S_2	30.84 bc	40.38 bc	43.87 bc	43.58 abc
A_1S_3	30.93 bc	39.48 bc	42.24 bcd	40.75 bc
A_2S_1	30.95 bc	37.82 cd	41.10 cd	40.78 bc
A_2S_2	30.47 bcd	39.52 bc	42.84 bcd	41.70 abc
A_2S_3	30.13 bcd	37.15 cd	49.57 cd	42.72 abc
A_3S_1	31.43 bc	36.75 cd	40.64 cd	39.14 bc
A_3S_2	28.90 cd	38.22 c	39.30 bcd	43.42 abc
A_3S_3	31.80 bc	37.28 cd	39.44 bcd	43.38 abc
A_4S_1	34.13 ab	42.88 ab	41.50 b	42.67 abc
A_4S_2	37.36 a	44.38 a	50.04 a	46.72 a
A_4S_3	30.13 bcd	42.78 ab	43.37 bcd	43.97 ab
LSD $_{(0.05)}$	**4.407**	**3.957**	**4.215**	**5.255**
CV (%)	**8.37**	**8.95**	**6.08**	**7.17**

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

S_1 : 20 cm x 10 cm
S_2 : 30 cm x 10 cm
S_3 : 40 cm x 10 cm

A_1 : Control (No IAA)
A_2 : 50 ppm IAA
A_3 : 100 ppm IAA
A_4 : 150 ppm IAA

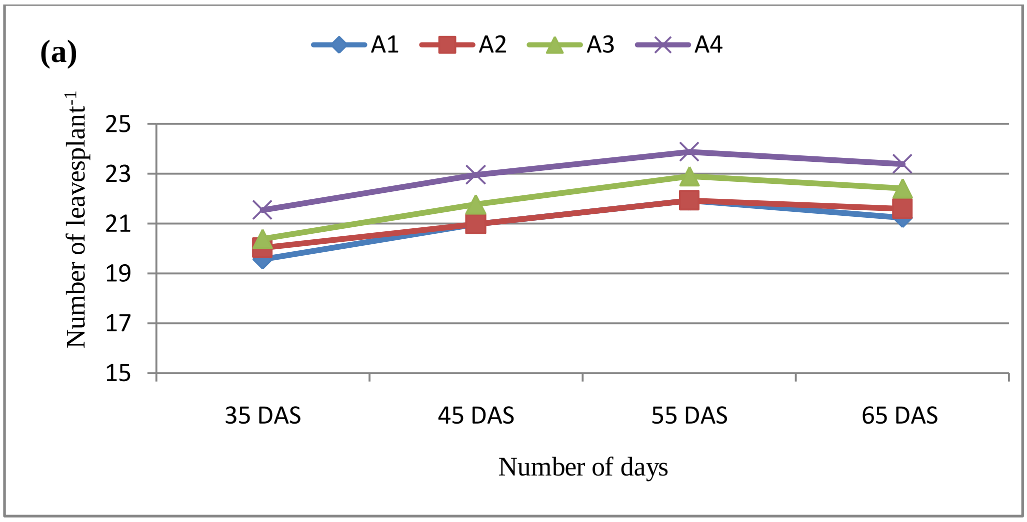
4.1.2.2. Effect of plant density

The number of leaves plant^{-1} of BARI Mung 6 was found to be significantly influenced by different plant density (Fig. 3b and Appendix V). The maximum number of leaves was found in S_2 (30 cm row to row distance) treatment at 35, 45, 55 and 65 DAS (21.23, 22.74, 23.98 and 23.40 respectively) (Fig. 3b). However, at 35 DAS, S_3 (40 cm row to row distance) treatment showed statistically similar results to S_1 (20 cm row to row distance) treatment. On the contrary, closer plant density (S_1: 20 cm row to row distance) showed significantly lower performance, especially at the maturity stage of plant (21.01 at 55 DAS and 20.92 at 65 DAS) (Fig. 3b).

Streck *et al*. (2014) mentioned about the significant influence of plant density on number of leaves plant^{-1}. Baloch (2004) found that row plant density influenced monopodial branches of mungbean.. M. Moniruzzaman (2011) also mentioned about similar results for cabbage.

4.1.2.3. Interaction effect of IAA and plant density

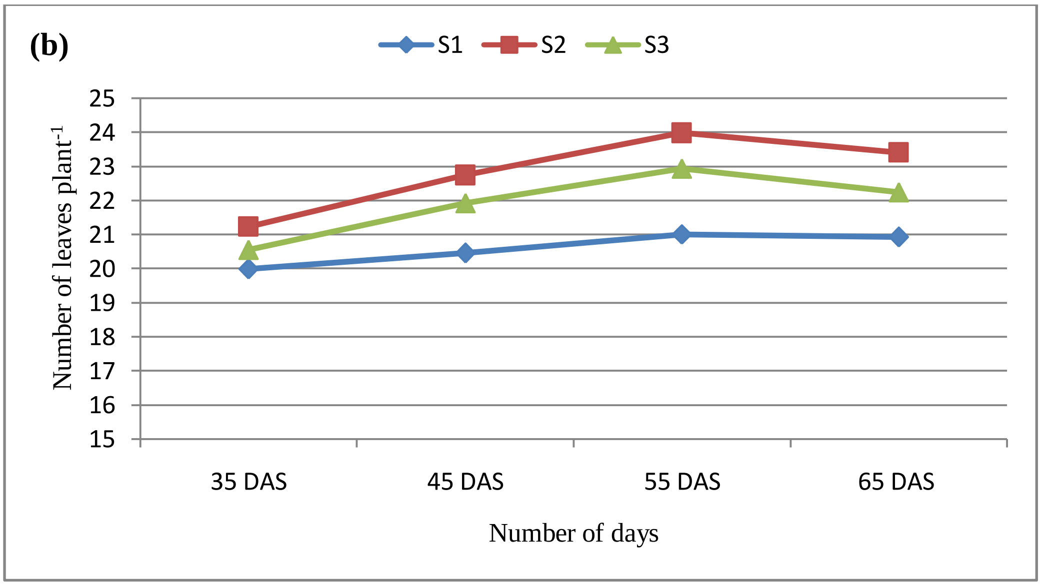
In the case of combined effect of IAA and plant density had significant influence on number of leaves plant^{-1} of BARI Mung 6 (Appendix V). A_4S_2 (150 ppm IAA + 30 cm row to row distance) treatment combination showed better performance than all the other treatments (Table 2). The number of leaves plant^{-1} in A_4S_2 (150 ppm IAA + 30 cm row to row distance) treatment combination at 35, 45, 55 and 65 DAS was 23.23, 24.90, 26.07 and 25.50, respectively (Table 2). Whereas, the lowest number of leaves plant^{-1} was found from A_1S_1 (No IAA application + 20 cm row to row distance) treatment combination at 35, 45, 55 and 65 DAS (18.20, 19.35, 20.48 and 20.35 respectively) (Table 2).



Note: A1 : No IAA A3 : 100 ppm IAA

A2 : 50 ppm IAA A4 : 150 ppm IAA

LSD values were 0.75, .70, 1.10 and 1.07 at 35, 45, 55 and 65 DAS respectively



Note: S_1 : 20 cm ×10 cm , S_2 : 30 cm ×10 cm

S_3 : 40 cm ×10 cm

LSD values were 0.65, 0.68, 0.95 and 0.90 at 35, 45, 55 and 65 DAS respectively

Figure 3. Effect of IAA (a) and plant density (b) on number of leaves plant^{-1} of BARI Mung 6

Table 2. Interaction effects of IAA and plant density on number of leaves plant^{-1} of BARI Mung 6

Treatments	Number of leaves plant^{-1}			
	35 DAS	**45 DAS**	**55 DAS**	**65 DAS**
A_1S_1	18.20 d	19.35 d	20.48 e	20.35 e
A_1S_2	20.37 bc	21.68 bc	22.90 bcd	22.24 bcde
A_1S_3	19.40 cd	21.11 bcd	21.84 cde	21.26 de
A_2S_1	20.18 bc	21.20 bc	21.88 cde	21.40 cde
A_2S_2	20.37 bc	21.50 bc	22.34 bcde	21.37 cde
A_2S_3	19.94 bc	20.88 bcd	21.97 cde	21.35 cde
A_3S_1	19.60 c	20.46 cd	21.48 de	21.07 de
A_3S_2	20.63 b	22.30 b	23.98 b	23.20 bc
A_3S_3	20.98 b	22.13 b	23.67 bc	22.95 bcd
A_4S_1	20.88 b	21.23 bc	21.47 de	20.58 e
A_4S_2	23.23 a	24.90 a	26.07 a	25.50 a
A_4S_3	20.60 bc	22.56 b	23.45 bc	23.60 ab
LSD $_{(0.05)}$	**1.23**	**1.78**	**1.90**	**1.92**
CV (%)	**7.12**	**3.70**	**5.15**	**5.34**

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

S_1 : 20 cm x 10 cm
S_2 : 30 cm x 10 cm
S_3 : 40 cm x 10 cm

A_1 : Control (No IAA)
A_2 : 50 ppm IAA
A_3 : 100 ppm IAA
A_4 : 150 ppm IAA

4.1.3. Dry weight of leaves plant^{-1}

4.1.3.1. Effect of IAA

In this experiment, dry weight of leaves plant^{-1} of BARI Mung 6 was increased with exogenous application of IAA foliar. Foliar application of IAA played significant role to increase dry weight of leaves plant^{-1} (Fig. 4a and Appendix VIII). The highest dry weight of leaves plant^{-1} of BARI Mung 6 was found in A_3 (100 ppm IAA foliar application) treatment (8.02 g at 35 DAS, 10.21g at 45 DAS, 12.88g at 55 DAS and 13.31g at 65 DAS) (Fig. 4a) compared to other treatments. However, little decrease of dry weight of leaves plant^{-1} was found in A_4 (150 ppm IAA foliar application). Although, it was statistically similar to A_3 (100 ppm IAA foliar application) (Fig. 4a). On the other hand, control treatment (A_1: No IAA foliar application) gave the lowest dry weight of leaf plant^{-1} of BARI Mung 6 (6.73g at 35 DAS, 8.90g at 45 DAS, 10.92g at 55 DAS and 11.65g at 65 DAS) (Fig. 4a)

Muthulakshmi and Pandiyarajan (2015) reported about increased vegetative growth characters like leaf dry weight, length of root and shoot, fresh and dry weight of shoot and root. Exogenous IAA application increased the leaf dry weight in onion at 100-300 ppm (Mathur, 1971) and in wheat treated with 10^{-4} M IAA (Gurdev and Saxena, 1991). Similar results were also reported by Khalil and Mandurah (1989).

4.1.3.2. Effect of plant density

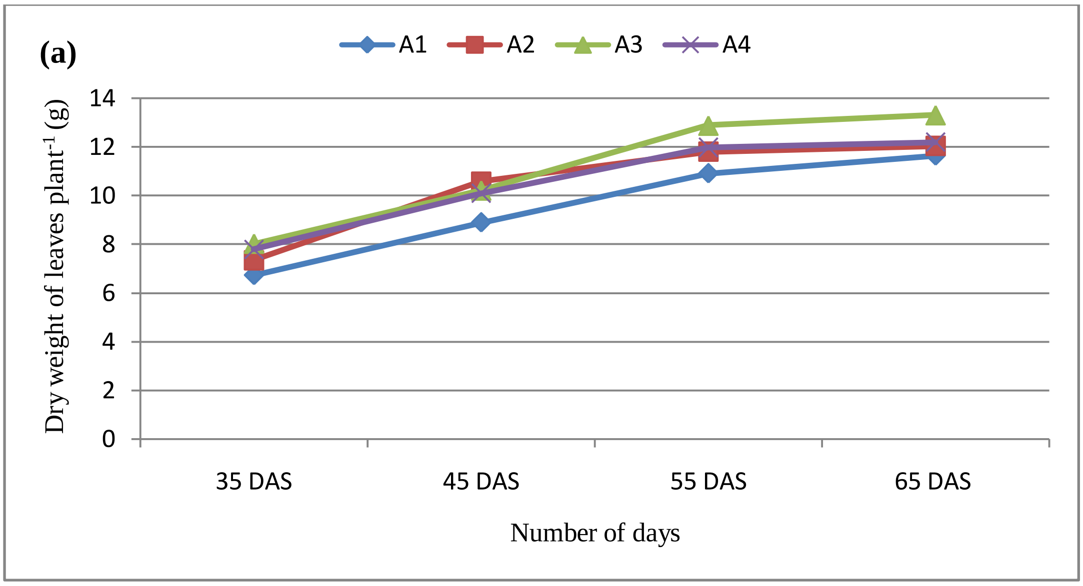
In this experiment, dry weight of leaves plant^{-1} of BARI Mung 6 was influenced significantly due to different plant density (Fig. 4b and Appendix VIII). The highest dry weight of leaves plant^{-1} was observed in S_2 (30 cm row to row distance) treatment (7.75 g at 35 DAS, 10.65 g at 45 DAS, 12.03 g at 55 DAS and 13.40 g at 65 DAS) (Fig. 4b). However, statistically similar dry weight of leaves plant^{-1} of BARI Mung 6 was found in S_3 (40 cm row to row distance) treatment. On the contrary, the lowest dry weight of leaves plant^{-1}

was found in S_1 (20 cm row to row distance) treatment (6.76 g at 35 DAS, 9.60 g at 45 DAS, 10.89 g at 55 DAS and 11.56 g at 65 DAS) (Fig. 4b).

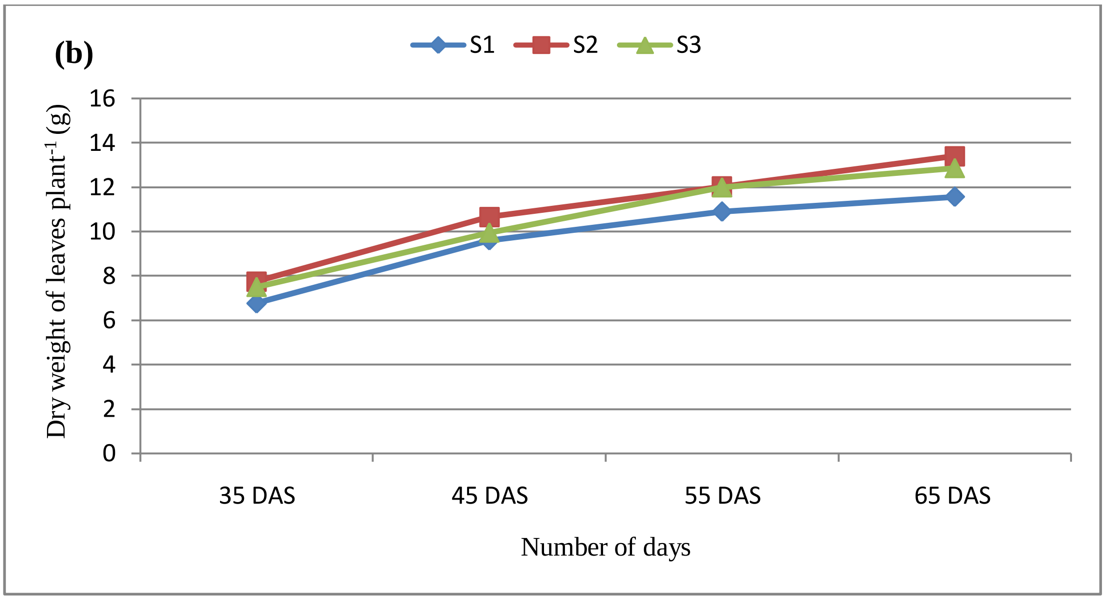
Kabir *et al.* (2013) found that leaf dry weight was significantly differed among the sowing times at different plant density. Khazaei *et al.* (2013) also mentioned about the role of plant density on leaf dry weight of lettuce. Amaglo *et al.* (2006) and Abubakari*et al.* (2011) also mentioned about similar results.

4.1.3.3. Interaction effect of IAA and plant density

Dry weight of leaves plant^{-1} of BARI Mung 6 was significantly influenced due to the interaction effect of IAA foliar application and different plant density (Table 3 and Appendix VIII). The highest dry weight of leaves plant^{-1} was recorded in A_3S_2 (100 ppm IAA foliar application + 30 cm row to row distance) treatment combination (8.03g at 35 DAS, 12.67 g at 45 DAS, 15.20 g at 55 DAS and 14.96 g at 65 DAS) that was statistically similar to A_3S_3 (150 ppm IAA foliar application + 40 cm row to row distance), A_3S_1 (150 ppm IAA foliar application + 20 cm row to row distance), A_2S_2 (50 ppm IAA foliar application + 30 cm row to row distance), A_4S_2 (150 ppm IAA foliar application + 30 cm row to row distance) and A_4S_3 (150 ppm IAA foliar application + 40 cm row to row distance) treatment combination at 35 DAS (Table 3). On the other hand, control treatment combination A_1S_1 (No IAA foliar application + 20 cm row to row distance) gave the lowest dry weight of leaves plant^{-1} (4.02 g at 35 DAS, 7.80 g at 45 DAS, 9.68 g at 55 DAS and 10.71 g at 65 DAS) (Table 3).



Note: A1 : No IAA A3 : 100 ppm IAA
A2 : 50 ppm IAA A4 : 150 ppm IAA
LSD values were 0.83, 1.10, 1.59 and 1.20 at 35, 45, 55 and 65 DAS respectively



Note: S_1 : 20 cm ×10 cm , S_2 : 30 cm ×10 cm
S_3 : 40 cm ×10 cm
LSD values were 0.782, 0.950, 1.351 and 1.380 at 35, 45, 55 and 65 DAS respectively

Figure 4. Effect of IAA (a) and plant density (b) on dry weight of leaves plant^{-1} of BARI Mung 6

Table 3. Interaction effects of IAA and plant density on dry weight of leaves plant^{-1} of BARI Mung 6

Treatments	Dry weight (g) of leaves plant^{-1}			
	35 DAS	45 DAS	55 DAS	65 DAS
A_1S_1	4.02 e	7.80 c	9.68 d	10.70 c
A_1S_2	6.12 bcd	9.23 bc	11.40 bcd	11.94 abc
A_1S_3	5.91 cd	10.28 b	11.80 bcd	12.04 bc
A_2S_1	5.50 de	9.92 bc	11.40 bcd	11.33 bc
A_2S_2	7.14 abc	10.46 b	13.75 ab	12.04 bc
A_2S_3	6.86 abcd	10.71 ab	12.30 bc	12.21 abc
A_3S_1	7.68 a	9.97 bc	10.25 cd	10.98 bc
A_3S_2	8.03 a	12.67 a	15.20 a	14.96 a
A_3S_3	7.48 ab	10.94 ab	12.18 bc	13.50 ab
A_4S_1	6.88 abcd	10.96 ab	11.80 bcd	11.72 bc
A_4S_2	6.52 abcd	10.68 ab	10.99 cd	11.50 bc
A_4S_3	6.89 abcd	9.97 bc	11.92 bcd	12.50 abc
LSD $_{(0.05)}$	**1.55**	**2.24**	**2.47**	**2.78**
CV (%)	**17.55**	**15.20**	**13.24**	**13.70**

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

S_1 : 20 cm x 10 cm
S_2 : 30 cm x 10 cm
S_3 : 40 cm x 10 cm

A_1 : Control (No IAA)
A_2 : 50 ppm IAA
A_3 : 100 ppm IAA
A_4 : 150 ppm IAA

4.1.4. Dry weight of stem plant^{-1}

4.1.4.1. Effect of IAA

Different levels of IAA application caused significant increase of dry weight of stem of BARI Mung 6 compared to control treatment (Fig. 5a). It was found that (Appendix VII) A_3 (100 ppm IAA application) treatment showed the highest dry weight of stem plant^{-1} (3.983 g, 7.451 g, 10.436 g and 10.768 g at 35, 45, 55 and 65 DAS respectively) (Fig. 5a). However, at 45, 55 and 65 DAS, A_4 (150 ppm IAA foliar application) treatment showed statistically similar results to A_3 (100 ppm IAA foliar application) treatment. On the other hand, plants treated with water (A_1: No IAA foliar application) showed the lowest dry weight of stem plant^{-1} (2.126 g at 35 DAS, 5.712 g at 45 DAS, 7.310 g at 55 DAS and 7.766 g at 65 DAS) (Fig. 5a) compared to plants treated with different concentration of IAA.

Gou *et al.* (2010) found in an experiment that auxin and gibberellin play key role to regulate developmental processes of plant. Quaderi *et al.* (2006) and Rastogi *et al.* (2013) also mentioned about similar results about the role of IAA. On the contrary, Hussain *et al.,* (2010) found negative effect of auxin if it is applied at higher concentration.

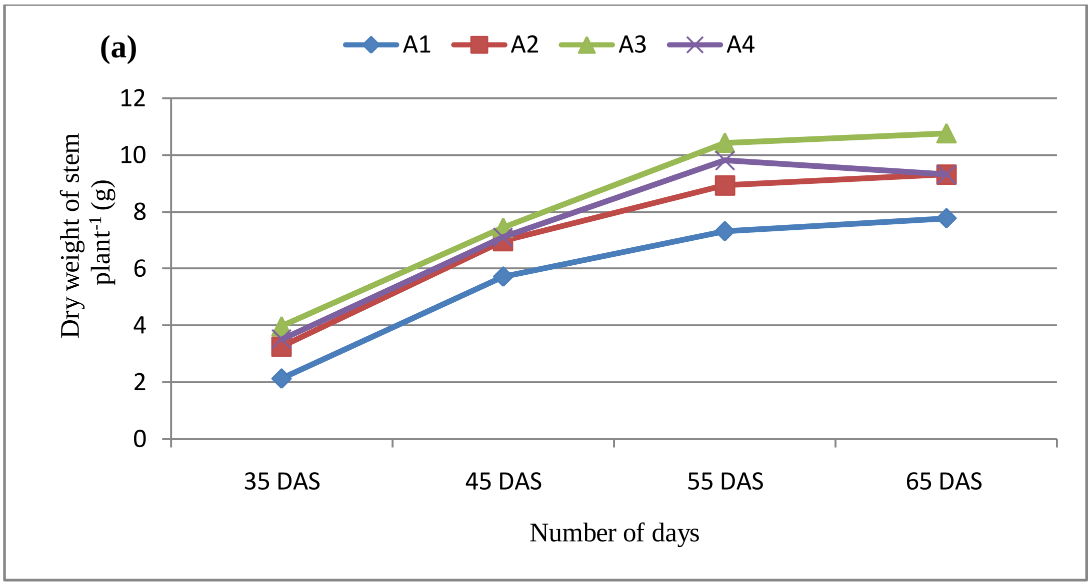
4.1.4.2. Effect of plant density

Significant differences were found on dry weight of stem plant^{-1} because of the variation of plant density (Appendix. VII and Fig. 5b). The highest dry weight of stem plant^{-1} was recorded in S_2 (30 cm row to row distances) treatment (3.417 g, 7.781 g, 9.561 g and 9.891 g at 35, 45, 55 and 65 DAS respectively) (Fig. 5b). However, statistically similar results were found in S_3 (40 cm row to row distance) treatment at 35, 45, 55 and 65 DAS. On the contrary, closer plant density (S_1: 20 cm row to row distances) gave the lowest dry weight of stem plant^{-1} throughout the growth period of the crop.

Khazaei *et al.* (2013) mentioned about the significant influence of plant density on stem diameter, stem dry and fresh weight. Streck *et al.* (2014) and Taleie *et al.* (2012) also found similar results about the role of plant density on dry weight of stem plant^{-1}.

4.1.4.3. Interaction effect of IAA and plant density

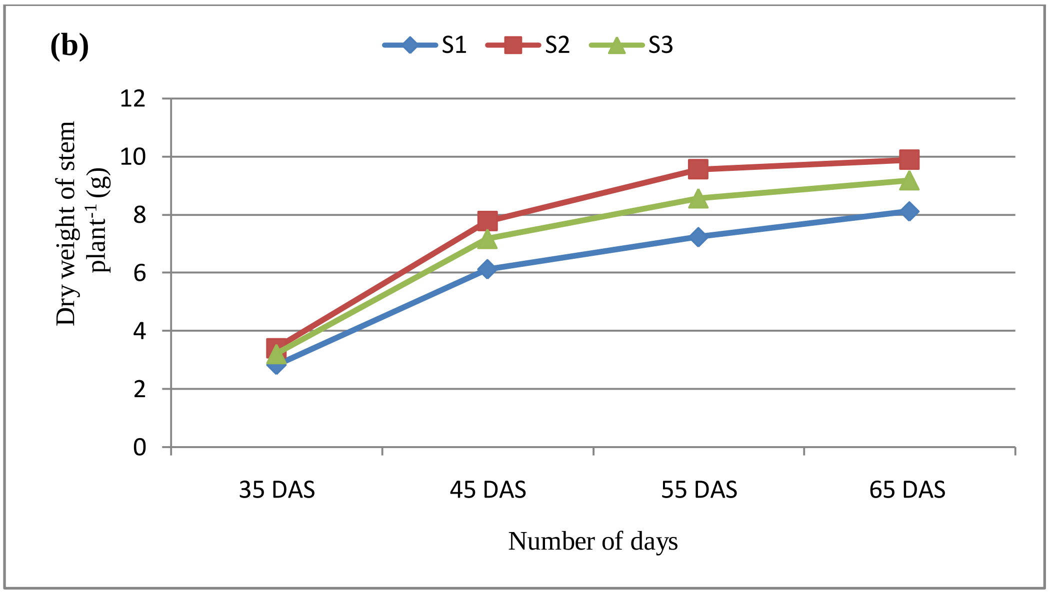
Different concentration of IAA and different plant density had significant influence on dry weight of stem plant^{-1} of BARI Mung 6 (Appendix VII). The highest dry weight of stem plant^{-1} was recorded from A_3S_2 (100 ppm IAA foliar application + 30 cm row to row distance) treatment combination (4.892g at 35 DAS, 9.135g at 45 DAS, 11.901g at 55 DAS and 13.107g at 65 DAS) (Table 4). However, A_4S_1 (150 ppm IAA foliar application + 20 cm row to row distance) and A_3S_3 (100 ppm IAA foliar application + 40 cm row to row distance) treatment combination showed statistically similar result to A_3S_2 (100 ppm IAA application + 30 cm row to row distance) treatment combination at 35, 45 and 55 DAS. On the contrary, closer plant density with no exogenous foliar application of IAA (A_1S_1: No IAA foliar application + 20 cm row to row distance) showed the lowest dry weight of stem plant^{-1} (2.134g, 4.762g, 5.981g and 7.512g at 35, 45, 55 and 65 DAS respectively) (Table 4).



Note: A_1 : No IAA A_3 : 100 ppm IAA

A_2 : 50 ppm IAA A_4 : 150 ppm IAA

LSD values were 0.316, 1.324, 2.019 and 1.657 at 35, 45, 55 and 65 DAS respectively



Note: S_1 : 20 cm ×10 cm , S_2 : 30 cm ×10 cm

S_3 : 40 cm ×10 cm

LSD values were 0.450, 1.413, 1.630 and 1.813 at 35, 45, 55 and 65 DAS respectively

Figure 5. Effect of IAA (a) and plant density (b) on dry weight of stem plant^{-1} of BARI Mung 6

Table 4. Interaction effects of IAA and plant density on dry weight of stem plant^{-1} of BARI Mung 6

Treatments	Dry weight (g) of stem plant^{-1}			
	35 DAS	45 DAS	55 DAS	65 DAS
A_1S_1	2.134 d	4.762 c	5.981 c	7.512 c
A_1S_2	3.067 bcd	6.210 abc	8.109 bc	8.451 bc
A_1S_3	2.879 cd	5.985 bc	7.890 bc	8.352 bc
A_2S_1	2.781 cd	5.819 bc	8.201 bc	8.751 bc
A_2S_2	4.103 ab	6.319 abc	9.013 abc	8.810 bc
A_2S_3	3.981 abc	6.127 abc	9.120 abc	9.346 bc
A_3S_1	3.879 abc	7.012 abc	9.121 abc	8.791 bc
A_3S_2	4.892 a	9.135 a	11.901 a	13.107 a
A_3S_3	4.091 ab	7.792 abc	9.467 ab	10.215 b
A_4S_1	4.132 ab	8.370 ab	9.768 ab	11.012 ab
A_4S_2	4.440 a	9.139 a	8.091 bc	9.157 bc
A_4S_3	4.173 ab	7.681 abc	7.910 bc	9.120 bc
LSD $_{(0.05)}$	**1.201**	**3.112**	**3.343**	**3.451**
CV (%)	**11.23**	**10.23**	**11.65**	**19.56**

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

S_1 : 20 cm x 10 cm
S_2 : 30 cm x 10 cm
S_3 : 40 cm x 10 cm

A_1 : Control (No IAA)
A_2 : 50 ppm IAA
A_3 : 100 ppm IAA
A_4 : 150 ppm IAA

4.1.5. Dry weight of root plant^{-1}

4.1.5.1. Effect of IAA

Significant variation was also observed in dry weight of root due to different IAA treatments (Appendix VI and Fig. 6a). At 25 DAS dry weight of root was increased compared to control treatment. However, A_3 (100 ppm IAA foliar application) treatment showed highest dry weight of root throughout the growth stage (1.167 g at 35 DAS, 1.743 g at 45 DAS, 2.104 g at 55 DAS and 2.140g at 65 DAS) (Fig. 6a). In the case of higher IAA concetration , A_4 (150 ppm IAA foliar application) treatment was found statistically simillar to A_3 (100 ppm IAA foliar application) at 35 and 45 DAS. Control (No IAA foliar application) treatment showed minimum dry weight of root plant $^{-1}$ at all the growth stages (0.875 g at 35 DAS,1.340 g at 45 DAS, 1.756 g at 55 DAS, 1.749 g at 65 DAS) (Fig. 6a).

Casimiro *et al*. (2003) and Fukaki *et al*. (2007) found that auxin is the major regulator of lateral root initiation, differentiation and meristem specification. Exogenous application of auxin increases lateral development of root (Wightman *et al*., 1980; Laskowski *et al*., 1995). Auxin is directly involved in activating the cell cycle during lateral root initiation (Himanen *et al*., 2004) and the expression of downstream genes (Himanen *et al*., 2004; Vanneste *et al*., 2005).

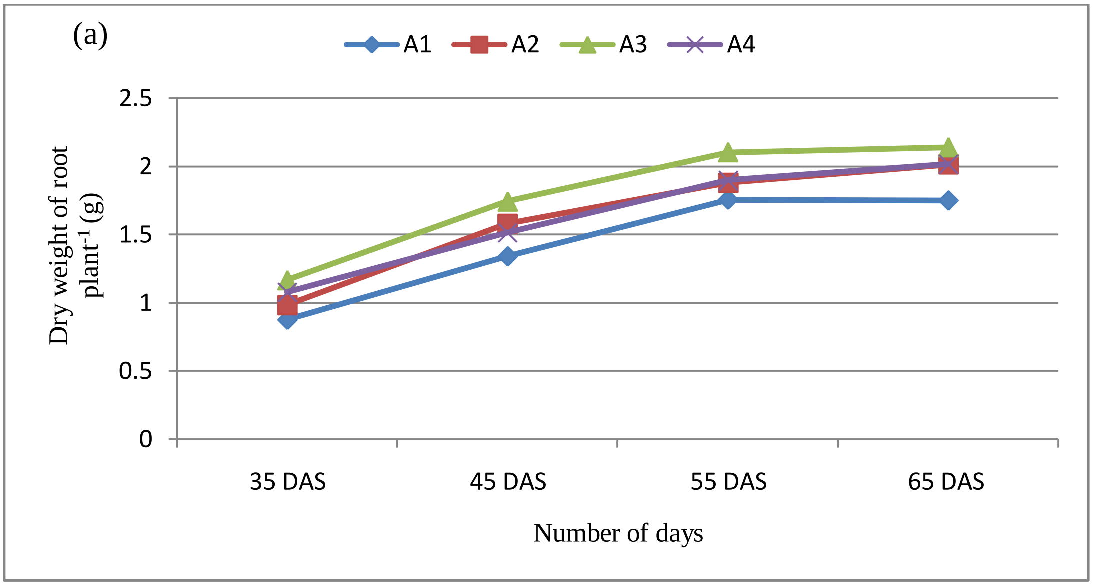
4.1.5.2. Effect of plant density

Plant density had significant effect on the dry weight of roots plant^{-1} in this experiment (Appendix VI). Dry weight of plant roots was significantly influenced by different level of plant density over time. The highest dry weight of root was found in S_2 (30 cm row to row distance) (1.54 g at 45 DAS, 1.98 g at 55 DAS and 2.14 g at 65 DAS) (Fig. 6b) compared to other treatments. However, S_3 (40 cm row to row distance) showed statistically similar results to S_2 (30 cm row to row distance) throughout the crop growth period.

Streck *et al.* (2014) mentioned that tuber root yield was higher at higher densities of plant population of cassava. However, Jiang *et al.* (2013) found reduced activity of maize roots that were significantly decreased under narrow plant density conditions, as a result lower root biomass and yield reduction at maturity. Desuki*et al.* (2005) and Kabir *et al.* (2013) also found similar results for radish and carrot respectively.

4.1.5.2. Interaction effect of IAA and plant density

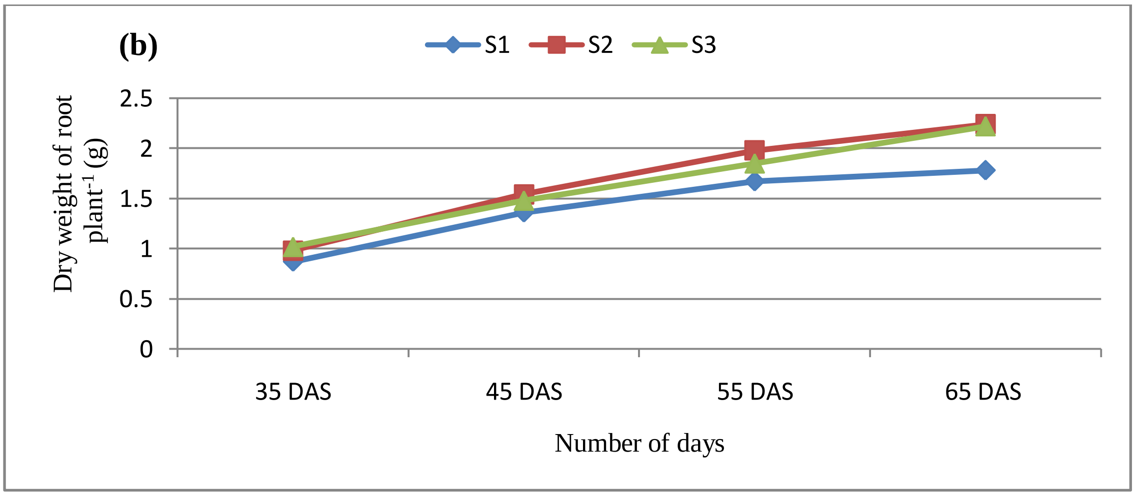
The data in Table 5 showed interaction effect of IAA and plant density on dry weight of root of BARI Mung 6. Root dry weight was found to increase with plant age and interaction effect of IAA and plant density on dry weight of roots plant^{-1}were found significant in this experiment (Appendix VI). However, among all the combinations of treatment, the highest dry weight of root was recorded in A_3S_2 (100 ppm IAA foliar application + 30 cm row to row distance) treatment combination (1.245 g at 35 DAS, 1.829 g at 45 DAS, 2.457g at 55 DAS and 2.871 g at 65 DAS) (Table 5). On the other hand, the control treatment combination (A_1S_1: No IAA foliar application + 20 cm row to row distance) resulted the lowest dry weight of root of BARI Mung 6.



Note: A_1 : No IAA A_3 : 100 ppm IAA

A_2 : 50 ppm IAA A_4 : 150 ppm IAA

LSD values were 0.125, 0.176, 0.221 and 0.298 at 35, 45, 55 and 65 DAS respectively



Note: S_1 : 20 cm ×10 cm , S_2 : 30 cm ×10 cm

S_3 : 40 cm ×10 cm

LSD values were 0.120, 0.142, 0.213 and 0.267at 35, 45, 55 and 65 DAS respectively

Figure 6. Effect of IAA (a) and plant density (b) on dry weight of root plant^{-1} of BARI mung 6

Table 5: Interaction effects of IAA and plant density on dry weight of root plant^{-1} of BARI Mung 6

Treatments	Dry weight (g) of root plant^{-1}			
	35 DAS	45 DAS	55 DAS	65 DAS
A_1S_1	0.663 e	1.187 e	1.713 d	1.989 cd
A_1S_2	0.867 de	1.520 cd	1.912 bcd	2.105 bcd
A_1S_3	0.986 bcd	1.611 bcd	1.780 cd	1.925 d
A_2S_1	0.904 cde	1.598 bcd	1.745 cd	1.989 cd
A_2S_2	1.017 abcd	1.561 bcd	1.882 bcd	2.109 bcd
A_2S_3	0.987 bcd	1.467 de	1.970 bcd	2.445 abc
A_3S_1	1.172 a	1.781 abc	1.870 cd	2.584 ab
A_3S_2	1.245 a	1.829 abc	2.457 a	2.871 a
A_3S_3	1.148 abc	1.651 bcd	2.314 ab	2.341 bcd
A_4S_1	1.034 abcd	1.637 bcd	1.890 bcd	2.067 cd
A_4S_2	1.050 abc	1.865 ab	1.980 bc	2.134 bcd
A_4S_3	1.167 ab	1.982 a	2.165 abc	2.001 cd
LSD $_{(0.05)}$	**0.250**	**0.312**	**0.439**	**0.498**
CV (%)	**18.10**	**15.25**	**14.89**	**14.54**

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

S_1 : 20 cm x 10 cm
S_2 : 30 cm x 10 cm
S_3 : 40 cm x 10 cm

A_1 : Control (No IAA)
A_2 : 50 ppm IAA
A_3 : 100 ppm IAA
A_4 : 150 ppm IAA

4.2. Reproductive parameters

4.2.1. Number of inflorescence plant^{-1}

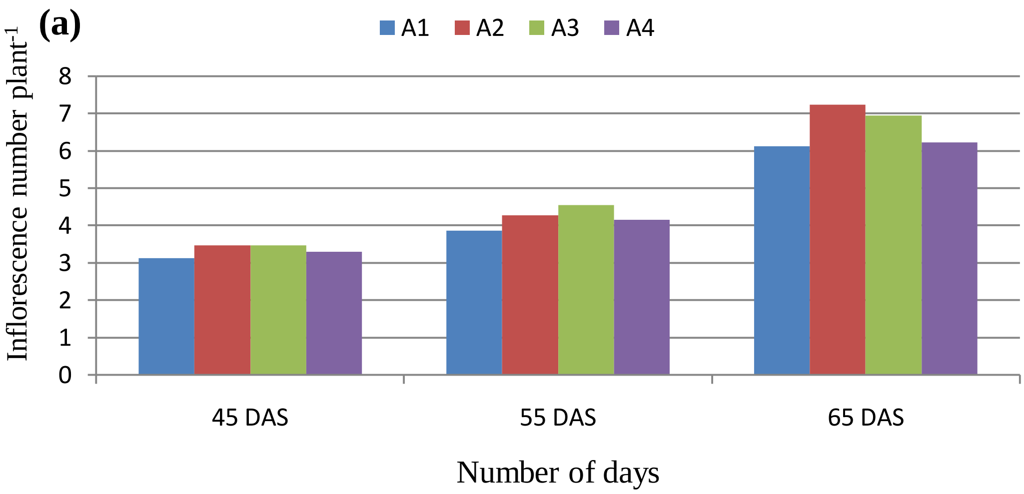
4.2.1.1. Effect of IAA

The growth regulator (IAA) had stimulatory effect on number of inflorescence per plant (Appendix IX) as was recorded at 45 DAS, 55 DAS and 65 DAS (Fig. 7a). Inflorescence number gradually increased with the advancement of crop growth in all concentration of IAA. It reveals from the figure that both A_2 (50 ppm IAA application) and A_3 (100 ppm IAA application) treatments were found effective equally to increase inflorescence number (Fig. 7a). A_2 (50 ppm IAA application) produced maximum inflorescence at 45 and 65 DAS (3.48 and 7.24 respectively).Whereas, A_3 (100 ppm IAA application) (4.71) produced maximum number of inflorescence at 55 DAS. However, maximum IAA treatment (A_4) (150 ppm IAA application) produced statistically similar inflorescence with control (A_1) (No IAA application) that indicates 150 ppm IAA was toxic concentration.

4.2.1. 2. Effect of plant density

There was a significant variation observed in number of inflorescence due to different plant density treatments (Appendix IX). Lower plant density reduced inflorescence number and sometime extra plant density did same (Fig. 7b). The number of inflorescence was higher in S_2 (30 cm row to row distance) at 45, 55 and 65 DAS (3.6, 4.71 and 7.29 respectively) (Fig. 7b). Statistically identical inflorescence number was found for S_3 (40 cm row to row distance) at 45 DAS and 65 DAS that were 3.45 and 6.65 respectively (Fig. 7b). On the other hand, lowest inflorescence number was recorded for S_1 (20 cm row to row distance) that were 2.98 g at 45 DAS, 3.76g at 55 DAS and 5.98 g at 65 DAS.

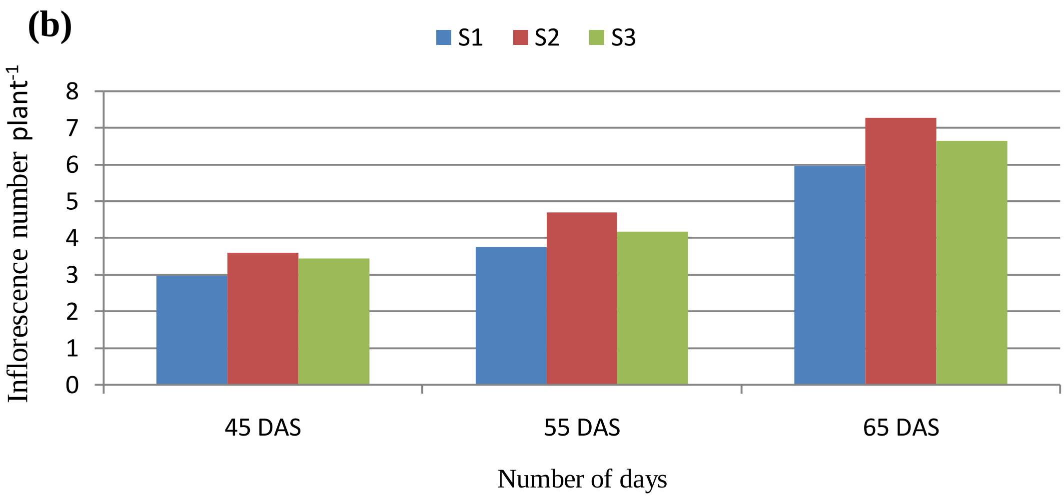
Mozumder *et al.* (2012) found that flower stalk size, number of inflorescence, seeds/inflorescence and thousand seed weight of *Eryngium foetidum* were higher in wider plant density. Ramamneh *et al.* (2013) also mentioned the role of plant density on inflorescence of strawberry.



Note: A_1 : No IAA A_3 : 100 ppm IAA

A_2 : 50 ppm IAA A_4 : 150 ppm IAA

LSD values were 0.31, 0.44 and 0.77 at 45, 55 and 65 DAS respectively



Note: S_1 : 20 cm ×10 cm , S_2 : 30 cm ×10 cm

S_3 : 40 cm ×10 cm

LSD values were 0.27, 0.38 and 0.67at 45, 55 and 65 DAS respectively

Figure 7. Effect of IAA (a) and plant density (b) on number of inflorescence plant^{-1} of BARI Mung 6

4.2.1.3. Interaction effect of IAA and plant density on number of inflorescence plant^{-1} of BARI Mung 6

The number of inflorescence was found to increase in this experiment due to the effect of IAA and plant density (Appendix. IX and Table 6). Inflorescence number of BARI Mung 6 increased with the IAA application. Highest number of inflorescence was recorded in A_3S_2 (100 ppm IAA application + 30 cm row to row distance) (4.16 at 40 DAS, 5.66 at 50 DAS, 8.16 at 60 DAS) (Table 6). However, statistically similar result was found for A_2S_3 (50 ppm IAA application + 40 cm row to row distance) at 40 DAS and A_2S_2 at 60 DAS. On the other hand, control treatment (A_1S_1) (No IAA application + 20 cm row to row distance) gave lowest inflorescence number all the time.

4.2.2. Inflorescence dry weight plant^{-1}

4.2.2.1. Effect of IAA

No significant influence of IAA on inflorescence dry weight plant^{-1}at 65 DAS (Appendix X). However, at 45 and 55 DAS, IAA was found to have significant influence on dry weight of inflorescence plant^{-1} (Appendix. X). Highest values of inflorescence dry weigh were recorded for at 55 DAS and 65 DAS in A_3 (100 ppm IAA application) treatment (18.33g at 55 DAS and 11.39g at 65 DAS). Statistically identical result was found for A_2 (50 ppm IAA application) at 65 DAS (10.78g) (Fig. 8a) and similar results at 55 DAS (14.73g). On the other hand, the lowest inflorescence dry weight of BARI Mung 6 was recorded for control treatment (A_1) (No IAA application) (0.44g, 13.03 g and 6.33g at 45, 55 and 65 DAS respectively) (Fig. 8a).

Table 6. Interaction effects of IAA and plant density on number of inflorescence plant^{-1} of BARI Mung 6

Treatments	Number of inflorescence plant^{-1}		
	45 DAS	55 DAS	65 DAS
A_1S_1	2.53 d	3.33 d	4.93 d
A_1S_2	3.53 b	4.33 b	7.00 abc
A_1S_3	3.33 bc	4.00 bcd	6.46 bc
A_2S_1	3.26 bc	4.06 bcd	6.73 bc
A_2S_2	3.53 b	4.66 b	7.80 ab
A_2S_3	3.66 ab	4.13 bc	7.20 abc
A_3S_1	2.86 cd	3.53 cd	6.33 c
A_3S_2	4.16 a	5.66 a	8.16 a
A_3S_3	3.40 bc	4.46 b	6.40 c
A_4S_1	3.26 bc	4.13 bc	5.93 cd
A_4S_2	3.20 bc	4.20 bc	6.20 cd
A_4S_3	3.43 b	4.16 bc	6.56 bc
LSD $_{(0.05)}$	**0.54**	**0.77**	**1.34**
CV (%)	**9.59**	**10.87**	**12.01**

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

S_1 : 20 cm x 10 cm
S_2 : 30 cm x 10 cm
S_3 : 40 cm x 10 cm

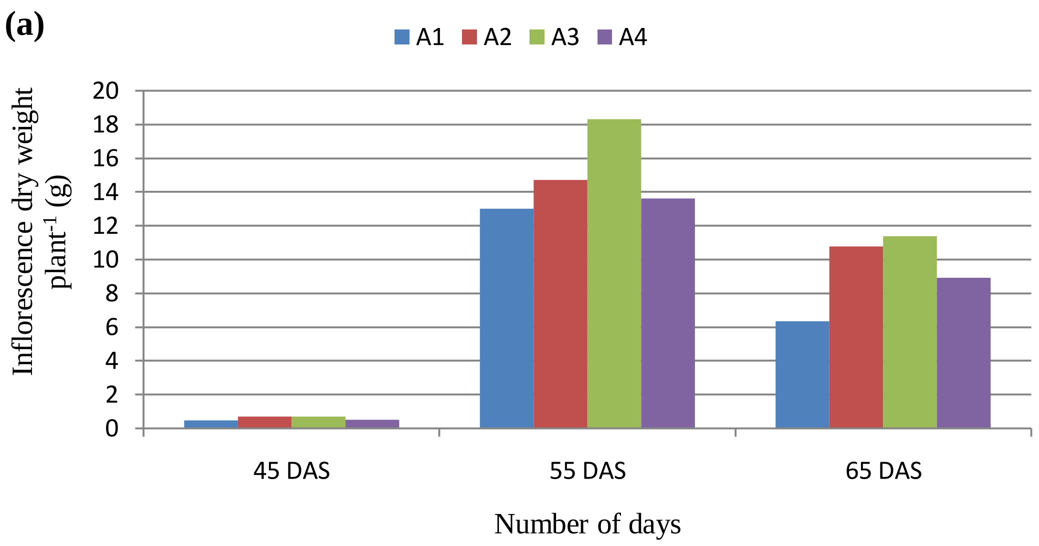
A_1 : Control (No IAA)
A_2 : 50 ppm IAA
A_3 : 100 ppm IAA
A_4 : 150 ppm IAA

4.2.2. 2. Effect of plant density

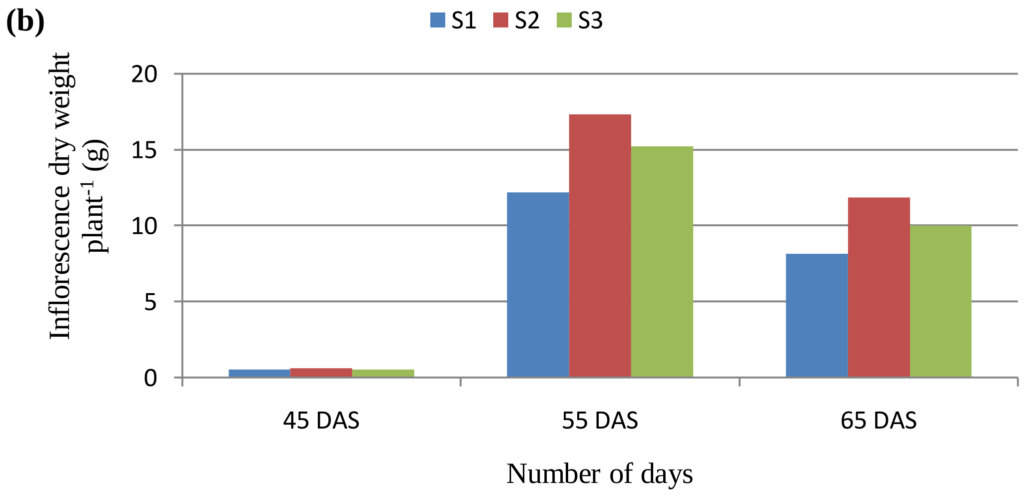
The dry weight of inflorescence plant^{-1}was found to have no significant influence of plant density at 55 DAS (Appendix X). However, at 45 and 65 DAS different plant density was found to influence the dry weight of inflorescence plant^{-1} (Appendix-X). Maximum inflorescence dry weight plant^{-1} was recorded in S_2 (30 cm row to row distance) treatment (0.63 g, 17.35 g and 11.89 g at 45, 55 and 65 DAS respectively) which was statistically similar to S_3 (40 cm row to row distance) at 45, 55 and 65 DAS (0.54 g, 15.24 g and 10.01 g at 45, 55 and 65 DAS respectively) (Fig. 8b). On the other hand, minimum inflorescence dry weights of BARI Mung 6 were recorded for S_1 (20 cm row to row distance) and that was 0.53 g, 12.2 g and 8.16 g at 45, 55 and 65 DAS respectively.

4.2.2.3. Interaction effect of IAA and plant density

Dry weight of inflorescence of BARI Mung 6 was influenced by the interaction of IAA and plant density. Significant interaction effect was found at 45 and 55 DAS (Appendix X). However, interaction effect of IAA and plant density was found non-significant at 65 DAS (Appendix X). Highest inflorescence dry weight was recorded in A_3S_2 (100 ppm IAA application + 30 cm row to row distance) treatment (0.90 g at 45 DAS, 27.30 g at 55 DAS, 14.36 g at 65 DAS) (Table 7). However, at 65 DAS several treatments A_2S_2 (50 ppm IAA application + 30 cm row to row distance) (10.72 g), A_2S_3 (100 ppm IAA application + 40 cm row to row distance) (11.97 g), A_3S_1 (100 ppm IAA application + 20 cm row to row distance) (10.69g) showed statistically identical results to A_3S_2 (100 ppm IAA application + 30 cm row to row distance) (14.36 g). On the contrary, control treatment combination (A_1S_1) (No IAA application + 20 cm row to row distance) always gave lowest inflorescence dry weight compared to other treatments (0.31 g, 8.13 g and 3.27 g at 45, 55 and 65 DAS respectively) (Table 7).



Note: A_1 : No IAA — A_3 : 100 ppm IAA
A_2 : 50 ppm IAA — A_4 : 150 ppm IAA
LSD values were 0.243, 5.005 and 4.250 at 45, 55 and 65 DAS respectively



Note: S_1 : 20 cm ×10 cm , — S_2 : 30 cm ×10 cm
S_3 : 40 cm ×10 cm
LSD values were 0.210, 4.33 and 2.680 at 45, 55 and 65 DAS respectively

Figure 8. Effect of IAA (a) and plant density (b) on inflorescence dry weight plant^{-1} of BARI Mung 6

Table 7. Interaction effects of IAA and plant density on inflorescence dry weight plant^{-1} of BARI Mung 6

Treatments	Dry weight (g) of inflorescence plant^{-1}		
	45 DAS	55 DAS	65 DAS
A_1S_1	0.31 c	8.13 c	3.27b
A_1S_2	0.47 bc	12.56 bc	8.20ab
A_1S_3	0.54 abc	18.40 ab	7.52ab
A_2S_1	0.75 ab	12.44 bc	9.07ab
A_2S_2	0.73 abc	15.80 bc	10.72 a
A_2S_3	0.56 abc	15.95 bc	11.97 a
A_3S_1	0.56 abc	14.42 bc	10.69 a
A_3S_2	0.90 a	26.30 a	14.36 a
A_3S_3	0.54 abc	14.27 bc	9.68ab
A_4S_1	0.50 abc	13.80 bc	9.63ab
A_4S_2	0.43 bc	14.72 bc	8.67ab
A_4S_3	0.53 abc	12.35 bc	8.47ab
LSD $_{(0.05)}$	**0.42**	**8.66**	**7.36**
CV (%)	**13.72**	**16.46**	**14.29**

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

S_1 : 20 cm x 10 cm
S_2 : 30 cm x 10 cm
S_3 : 40 cm x 10 cm

A_1 : Control (No IAA)
A_2 : 50 ppm IAA
A_3 : 100 ppm IAA
A_4 : 150 ppm IAA

4.2.3. Number of flower and pod dropping plant^{-1}

4.2.3.1. Effect of IAA

The effect of IAA on flower and pod dropping plant^{-1} of BARI Mung 6 was found significant (Appendix XI). Number of flower and pod dropping was decreased due to the foliar application of IAA. The highest value was recorded at A_1 (No IAA application) (21.42) and the lowest in A_4 (150 ppm IAA application) (16.99). However, statistically similar result was detected for A_2 (50 ppm IAA application) and in A_3 (150 ppm IAA application) (20.16) (Fig. 9a).

Lim *et al.* (2003) said that plant hormones like auxin, cytokinin and gibberellins play a role in suppressing flower and pod dropping.

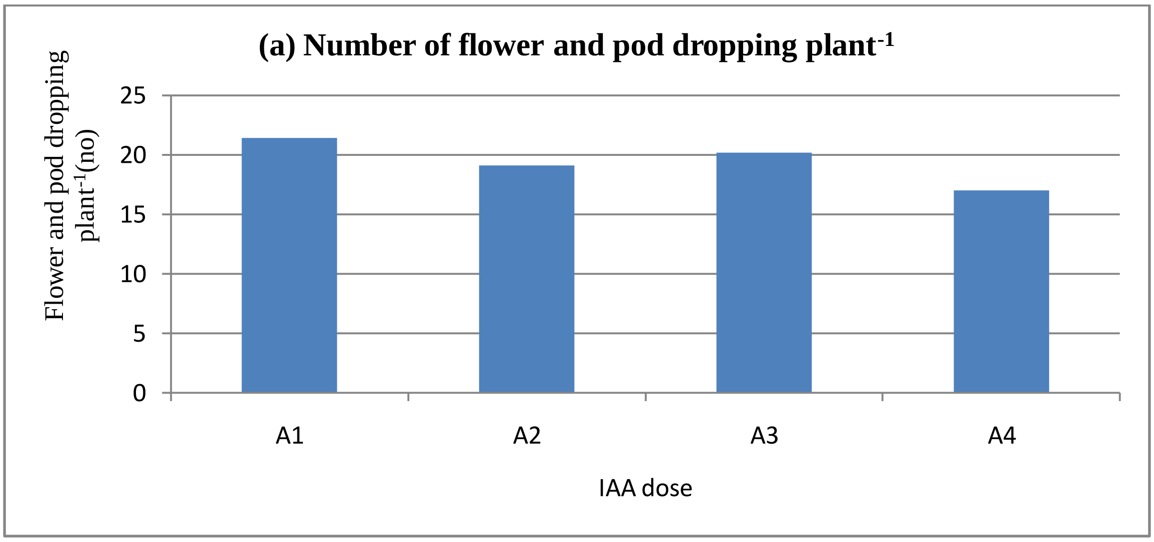
4.2.3.2. Effect of plant density

The influence of plant density on number of flower and pod dropping of BARI Mung 6 was found significant (Appendix. XI). Number of flower and pod dropping increased with decreasing plant density. The highest number of flower and pod dropping was recorded in S_3 (40 cm row to row distance) (20.22) which were statistically identical to S_2 (30 cm row to row distance) (19.88) (Fig. 9b). On the other hand, lowest flower and pod dropping was recorded at closer plant density S_1 (20 cm row to row distance) (17.95) (Fig. 9b)

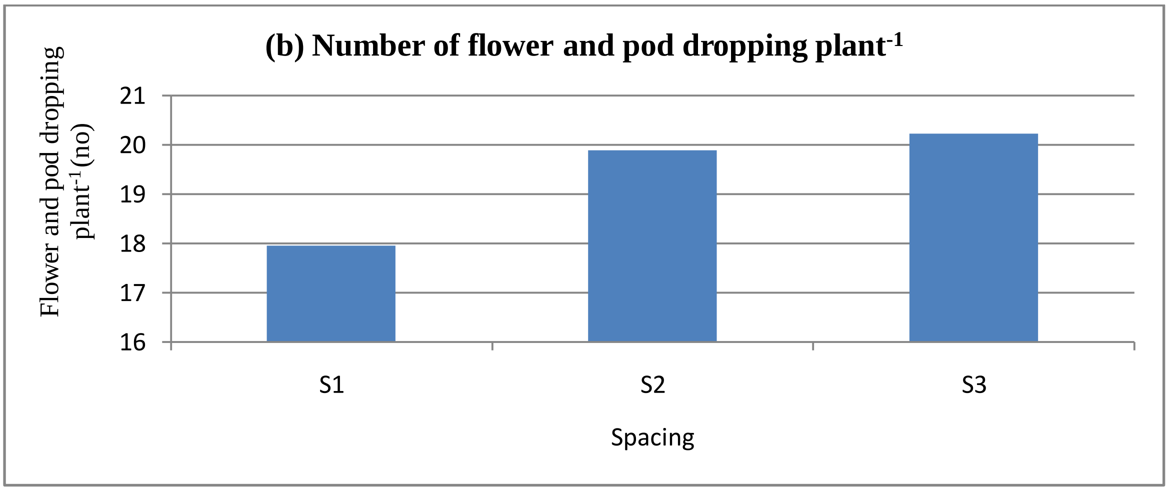
4.2.3.3. Interaction effect of plant density and IAA

Interaction effect of foliar IAA application and plant density influenced the flower and pod dropping of BARI Mung 6 (Appendix XI). Highest flower and pod dropping of BARI Mung 6 was recorded at A_1S_3 (No IAA application + 40 cm row to row distance) (23.8) (Table 8). However, statistically similar results was found for A_1S_2(No IAA application + 30 cm row to row distance), A_2S_2 (50 ppm IAA application + 30 cm row to row distance), A_2S_3 (50 ppm IAA application + 40 cm row to row distance) and A_3S_2 (100 ppm IAA application +

30 cm row to row distance) that were 20.22, 23.06, 22.46 and 20.74 respectively. On the other hand, lowest flower and pod dropping of BARI Mung 6 was recorded at A_3S_1 (100 ppm IAA application + 20 cm row to row distance) (16.28) (Table. 8).



Note: A_1 : No IAA A_3 : 100 ppm IAA
A_2 : 50 ppm IAA A_4 : 150 ppm IAA
LSD value was 2.14



Note: S_1 : 20 cm ×10 cm , S_2 : 30 cm ×10 cm
S_3 : 40 cm ×10 cm
LSD value was 1.85

Figure 9. Effect of IAA (a) and plant density (b) on number of flower and pod dropping plant^{-1} of BARI mung 6

4.2.4. Flower and pod dropping percentage

4.2.4.1. Effect of IAA

In this experiment the effect of IAA on flower and pod dropping percent of BARI Mung 6 was found significant (Appendix XI). Flower and pod dropping percent per plant was decreased due to the foliar application of IAA. The highest flower and pod dropping percent was recorded at A_1 (No IAA application) (60.17 %) and lowest in A_4 (150 ppm IAA application) (47.47) (Fig. 10a). However, all IAA treated plants showed statistically identical results that were 52.34 % in A_2 (50 ppm IAA application), 49.78 % in A_3 (50 ppm IAA application) and 47.47A_4 (150 ppm IAA application).

4.2.4.2. Effect of plant density

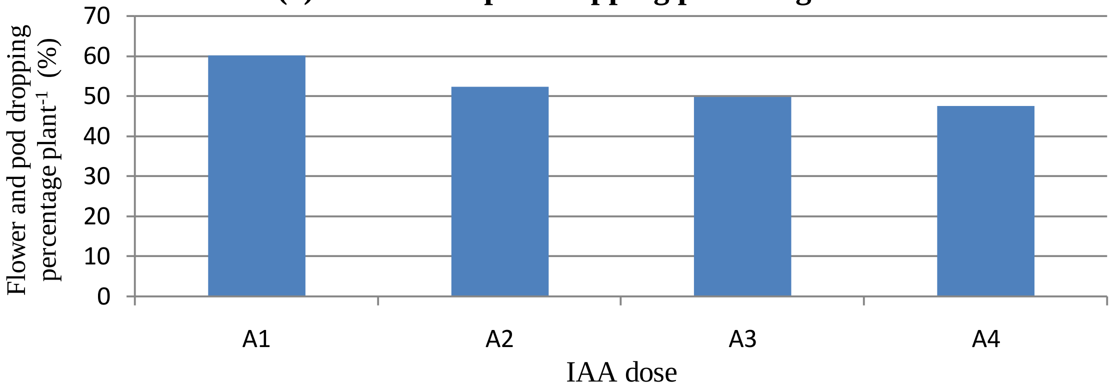
In this experiment the influence of plant density on flower and pod dropping percent of BARI Mung 6 was found significant (Appendix XI). Flower and pod dropping percent per plant decreased after increasing row to row distance. The highest flower and pod dropping percent was recorded in S_1 (20 cm row to row distance) (56.98 %). On the other hand, lowest flower and pod dropping was recorded at S_2 (30 cm row to row distance) (48.98 %) which was statistically identical to S_3 (40 cm row to row distance) (51.88 %) (Fig. 10b)

4.2.4.3. Interaction effect of plant density and IAA

In this experiment the effect of foliar IAA application with plant density was found significant to the flower and pod dropping percent plant^{-1} of BARI Mung 6 (Appendix XI). Highest flower and pod dropping percent plant^{-1} of BARI Mung 6 was recorded at A_1S_1 (No IAA application + 20 cm row to row distance) (63.28 %) (Table. 8). However, statistically similar results was found in A_1S_2 (No IAA application + 30 cm row to row distance) (56.87 %) and A_1S_3 (No IAA application + 40 cm row to row distance) (58.62 %) (Table 8). On the other hand, lowest flower and pod dropping percent plant^{-1} of BARI Mung 6 was recorded at A_3S_2 (100 ppm IAA application + 30 cm row to row distance)

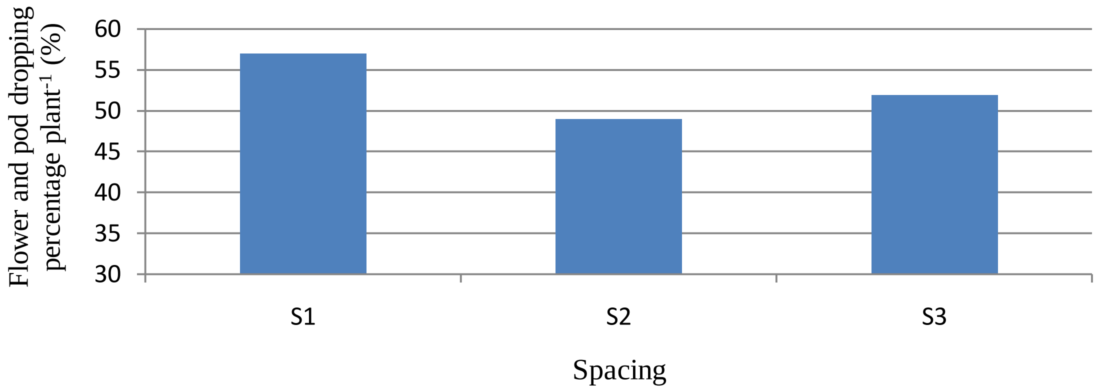
(44.76%) which was statistically similar to A_3S_3 (100 ppm IAA application + 40 cm row to row distance) (47.28%), A_4S_2 (150 ppm IAA application + 30 cm row to row distance) (45.92%), A_4S_3 (150 ppm IAA application + 40 cm row to row distance) (49.79%),A_2S_2 (100 ppm IAA application + 30 cm row to row distance) (51.63%)and A_2S_1 (100 ppm IAA application + 20 cm row to row distance) (51.77%).

(a) Flower and pod dropping percentage



Note: A_1 : No IAA
A_2 : 50 ppm IAA
LSD value was 2.14
A_3 : 100 ppm IAA
A_4 : 150 ppm IAA

(b) Flower and pod dropping percentage



Note: S_1 : 20 cm ×10 cm ,
S_3 : 40 cm ×10 cm
LSD value was 5.07
S_2 : 30 cm ×10 cm

Figure 10. Effect of IAA (a) and plant density (b) on flower and pod dropping percentage plant^{-1} of BARI Mung 6

Table 8. Interaction effect of IAA and plant density on flower & pod dropping $plant^{-1}$ and flower & pod dropping percentage $plant^{-1}$ of BARI Mung 6

Treatments	Flower & pod dropping $plant^{-1}$ (no.)	Flower & pod dropping percentage $plant^{-1}$ (%)
A_1S_1	17.92 cd	63.28 a
A_1S_2	20.22 abc	56.87 abc
A_1S_3	23.8 a	58.62 ab
A_2S_1	18 cd	51.77 bcde
A_2S_2	23.06 ab	51.63 bcde
A_2S_3	22.46 ab	56.35 abc
A_3S_1	16.28 d	52.60 bcd
A_3S_2	20.74 abc	44.76 e
A_3S_3	18.6 cd	47.28 de
A_4S_1	19.47 bcd	54.78 bc
A_4S_2	17.2 cd	45.92 de
A_4S_3	19.89 bcd	49.79 cde
LSD $_{(0.05)}$	**3.79**	**7.46**
CV(%)	**12.90**	**17.57**

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

S_1 : 20 cm x 10 cm
S_2 : 30 cm x 10 cm
S_3 : 40 cm x 10 cm

A_1 : Control (No IAA)
A_2 : 50 ppm IAA
A_3 : 100 ppm IAA
A_4 : 150 ppm IAA

4.3. Yield parameters

4.3.1. Stover yield ha^{-1}

4.3.1.1. Effect of IAA

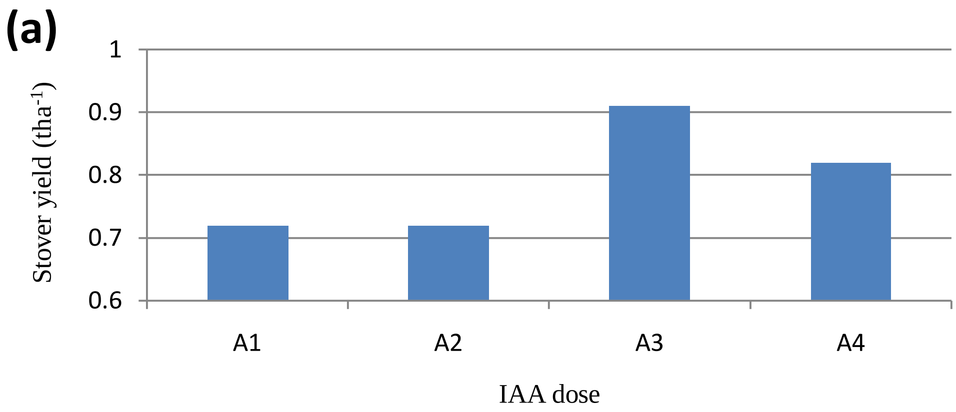
Effect of IAA on stover yield ha^{-1} of BARI Mung 6 was found significant in this experiment (Appendix - XII). Stover yield ha^{-1} was increased due to the foliar application of IAA. The highest stover yield ha-1was recorded at A_3 (100 ppm IAA application) (0.91 t ha^{-1}) and lowest in control treatment A_1 No IAA application) (0.72 t ha^{-1}). However, statistically similar result to A_3 (100 ppm IAA application) was observed in A_4 (150 ppm IAA application) (0.82 t ha^{-1}) (Fig. 11a).

Elshorbagi *et al.* (2008) mentioned about the role of IAA on the anatomical characteristics, stover and fiber yield and quality of Flax.

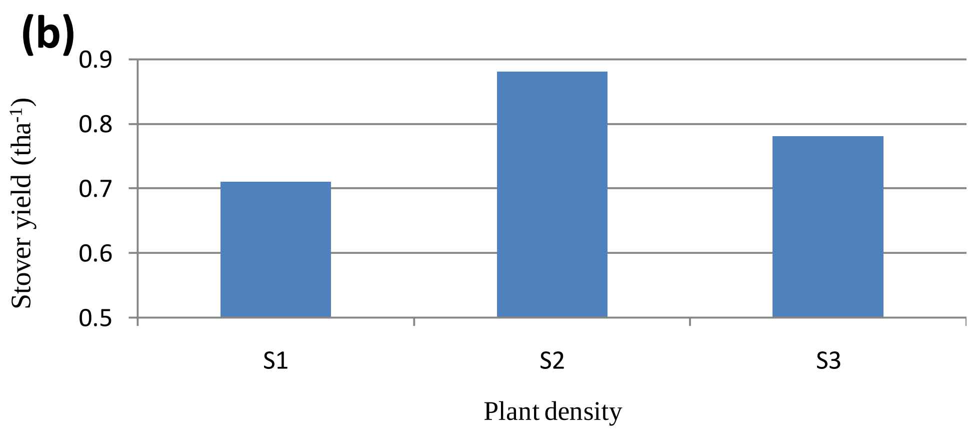
4.3.1.2. Effect of plant density

The influence of spacing on stover yield ha^{-1} of BARI Mung 6 was found significant (Appendix-XII) in this experiment. Stover yield ha^{-1} increased after decreasing plant density. However, at maximum spacing (S_3: 40 cm row to row distance) stover yield ha^{-1}was decreased a bit. The highest stover yield ha^{-1} was recorded in S_2 (30 cm row to row distance) (0.88 t ha^{-1}) which was statistically similar to S_3 (40 cm row to row distance) (0.78 t ha^{-1}) (Fig. 11b). On the other hand, lowest stover yield ha^{-1} was recorded at closer spacing S_1 (20 cm row to row distance) (0.71 t ha^{-1}) (Fig. 11b).

Bozorgi *et al.* (2011) conducted an experiment to study the effect of plant density on yield and yield components of rice variety Hashemi. They concluded that interaction effect of plant spacing and number of seedling per hill on grain yield, stover yield and harvest index was significant in 1% and on biological yield in 5% probability level. Zamir *et al.* (2011) also mentioned about similar result.



Note: A_1 : No IAA A_3 : 100 ppm IAA
A_2 : 50 ppm IAA A_4 : 150 ppm IAA
LSD value = 0.145



Note: S_1 : 20 cm ×10 cm , S_2 : 30 cm ×10 cm
S_3 : 40 cm ×10 cm
LSD value = 0.126

Figure 11. Effect of IAA (a) and plant density (b) on stover yield ha^{-1} of BARI Mung 6.

4.3.1.3. Interaction effect to IAA and row spacing

Foliar application of IAA and plant density influenced the stover yield ha^{-1} of BARI Mung 6 (Appendix-XII). The highest stray yield ha^{-1} was recorded at A_3S_2 (100 ppm IAA application + 30 cm row to row distance) (1.12 t ha^{-1}) (Table 9). However, statistically similar results was found for A_3S_3 (100 ppm IAA application + 40 cm row to row distance), A_4S_1 (150 ppm IAA application + 20 cm row to row distance) and A_4S_2 (150 ppm IAA application + 30 cm row to row distance) that were 0.88 t ha^{-1}, 0.92 t/ha and 0.88 t ha^{-1} respectively. On the other hand, the lowest stray yield m^{-2} was recorded at A_1S_1 (No IAA application + 20 cm row to row distance) (0.55 t ha^{-1}) (Table 9).

4.3.2. Biological yield

4.3.2.1. Effect of IAA

Effect of IAA on biological yield $ha^{-1}$of BARI Mung 6 was found significant in this experiment (Appendix-XII). Biological yield $ha^{-1}$of BARI Mung 6 was increased due to the foliar application of IAA. The highest biological yield ha^{-1} of BARI Mung 6 was recorded at A_3 (100 ppm IAA application) (5.33 t ha^{-1}). However, statistically similar result was found for A_2 (50 ppm IAA application) (5.25 t ha^{-1}). On the contrary, lowest biological yield $ha^{-1}$of BARI Mung 6 was recorded in control treatment A_1 (No IAA application) (4.91 t ha^{-1}) which was statistically similar to A_4 (150 ppm IAA application) (5.08 t ha^{-1}) (Fig. 12a).

Sadak *et al*. (2013) mentioned about higher biological yield of the two fababean cultivars after IAA treatment.

4.3.2.2. Effect of row spacing

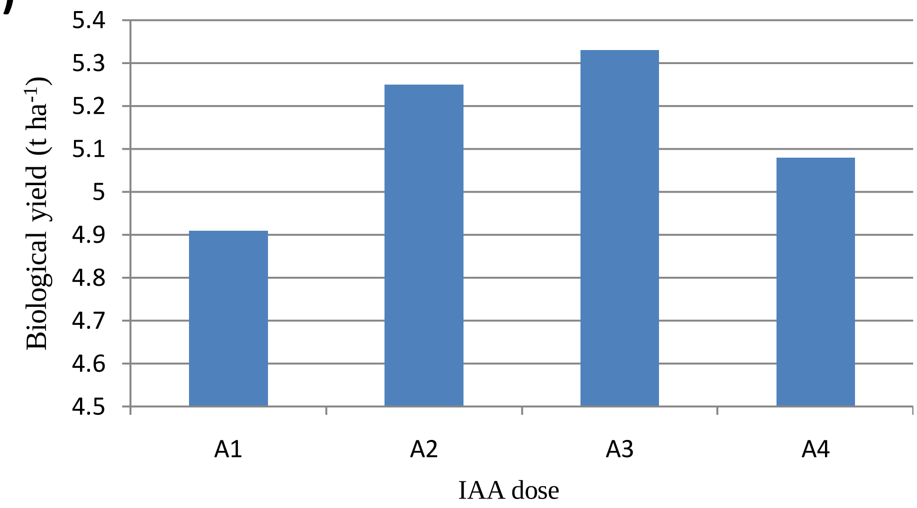
The influence of spacing on biological yield ha^{-1} of BARI Mung 6 was found significant (Appendix-XII) in this experiment. Biological yield increased with decreasing plant density. However, at maximum spacing (S_3: 40 cm row to row distance) biological yield ha^{-1} was decreased a bit. The highest biological yield ha^{-1} was recorded in S_2 (30 cm row to row distance) (5.41 t/ha) (Fig 12a). On the other hand, lowest stover yield ha^{-1} was recorded at closer spacing S_1 (20 cm row to row distance) (4.81 t ha^{-1}) which was statistically identical to S_3 (40 cm row to row distance) (5.06 t ha^{-1}).

Kumar and Sharma (1989) reported about higher biological yield at higher plant density. Ihsanullah *et al.* (2002) also mentioned about similar type or results.

4.3.2.3. Interaction effect to IAA and spacing

Foliar application of IAA and plant density influenced the biological yield ha^{-1} of BARI Mung 6 (Appendix-XII). Highest biological yield ha^{-1} was recorded at A_3S_2 (100 ppm IAA application + 30 cm row to row distance) (5.38 t ha^{-1}) (Table 9). However, statistically similar results (5.11 t ha^{-1}) was found for A_3S_3 (100 ppm IAA application + 40 cm row to row distance), treatment combination. On the other hand, lowest biological yield ha^{-1} was recorded at A_1S_1 (No IAA application + 20 cm row to row distance) (4.28 t ha^{-1}) (Table 9).

(a)

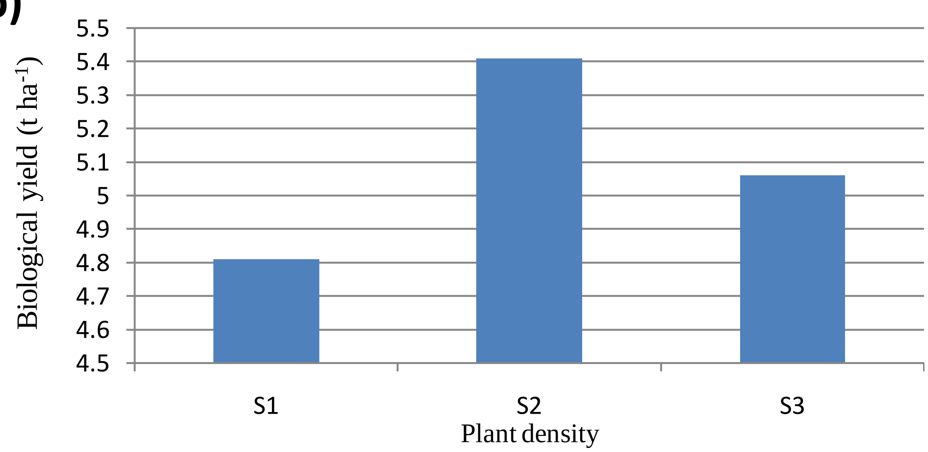


Note: A_1 : No IAA A_3 : 100 ppm IAA

A_2 : 50 ppm IAA A_4 : 150 ppm IAA

LSD value = 0.185

(b)



Note: S_1 : 20 cm ×10 cm , S_2 : 30 cm ×10 cm

S_3 : 40 cm ×10 cm

LSD value = 0.252

Figure 12. Effect of IAA (a) and plant density (b) on biological yield ha^{-1} of BARI Mung 6.

4.3.3. Harvest index (%)

4.3.3.1. Effect of IAA

Harvest index percent was found different due to different doses of IAA foliar application in this experiment. The highest harvest index percent was recorded in A_3 (100 ppm IAA application) and the lowest harvest index percent was found in A_4 (150 ppm IAA application) that was 40.33 and 38.75 respectively (Fig. 13a).

Quaderi *et al.* (2006) mentioned that seed treatment with 200 ppm IAA resulted the highest harvest index (38.48) of mungbean.

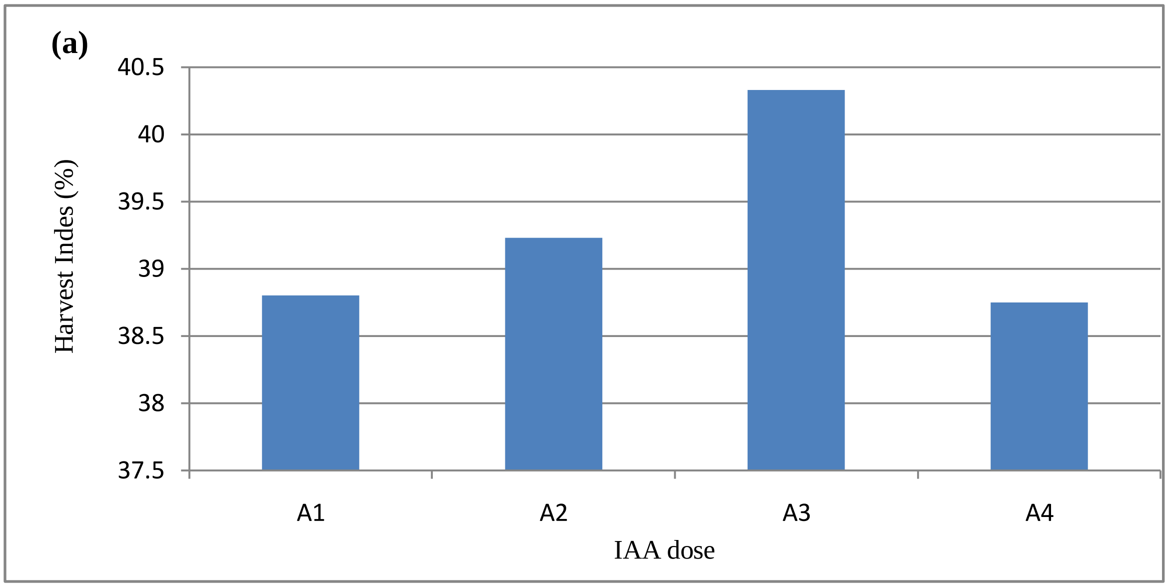
4.3.3.2. Effect of row spacing

In this experiment harvest index percent was found different due to different planting density. The highest harvest index percent was recorded in S_2 (30 cm row to row distance) that was 40.11 (Fig. 13b). On the contrary, the lowest harvest index percent was found in S_1 (20 cm row to row distance) (37.82) (Fig. 13b)

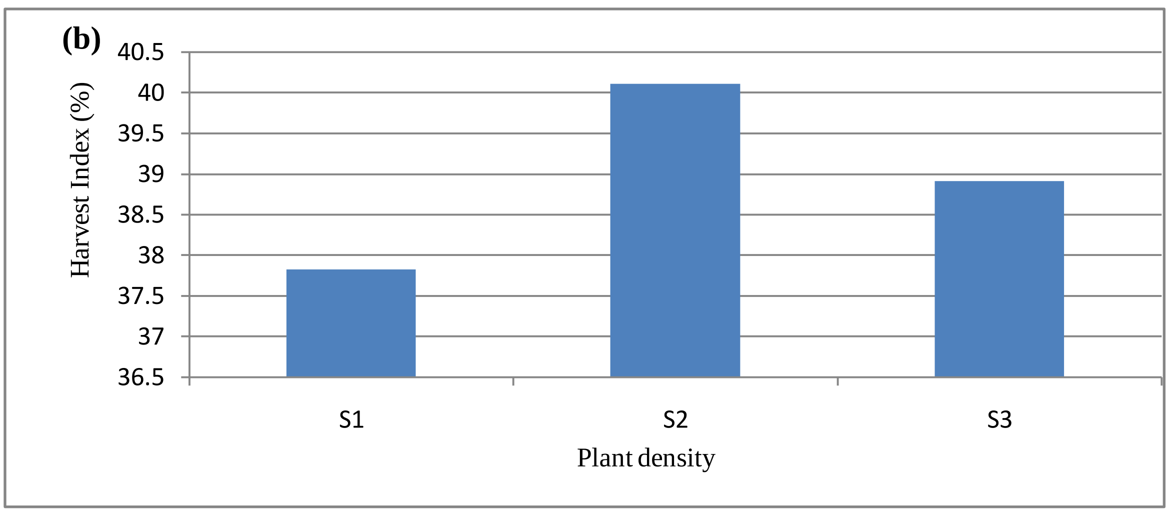
Foysalkabir *et al.* (2016) found that 30cm × 10cm plant spacing gave the highest harvest index of mungbean.

4.3.3.3. Interaction effect of spacing and IAA

In case of interaction effect of spacing and IAA, A_3S_2 (100 ppm IAA application + 30 cm row to row distance) found to have highest harvest index percent that was 41.01%. On the other hand, lowest harvest index percent was recorded in A_2S_3 (50 ppm IAA application + 40 cm row to row distance) which was 38.26 % (Table 9).



Note: A_1 : No IAA
A_2 : 50 ppm IAA
A_3 : 100 ppm IAA
A_4 : 150 ppm IAA



Note: S_1 : 20 cm ×10 cm ,
S_2 : 30 cm ×10 cm
S_3 : 40 cm ×10 cm

Figure 13. Effect of IAA (a) and plant density (b) on harvest index of BARI Mung 6

Table 9. Interaction effect of IAA and plant density on stover yield ha^{-1}, biological yield ha^{-1} and harvest index of BARI Mung 6

Treatments	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
A_1S_1	0.55 d	4.28 g	38.76
A_1S_2	0.79 bcd	4.38 fg	39.28
A_1S_3	0.80 bcd	4.31 g	39.68
A_2S_1	0.65 cd	4.78 cde	38.93
A_2S_2	0.72 bcd	5.09 bc	40.29
A_2S_3	0.78 bcd	4.65 def	38.26
A_3S_1	0.73 bcd	4.38 fg	40.21
A_3S_2	1.12 a	5.38 a	41.01
A_3S_3	0.88 abc	5.11 ab	39.34
A_4S_1	0.92 ab	4.82 bcde	40.61
A_4S_2	0.88 abc	4.84 bcd	39.04
A_4S_3	0.66 cd	4.52 defg	39.78
LSD $_{(0.05)}$	**0.252**	**0.317**	-
CV(%)	**15.78**	**14.34**	-

CHAPTER 5

SUMMARY AND CONCLUSION

The field experiment was conducted at the Agronomy field of central research farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from March 2014 to June 2014 to study the effect of Indole-3-acetic acid (IAA) on flower and pod dropping, growth and yield of mungbean under different plant density.

The experiment was consisted of four levels of IAA application viz. i) A_1= control, ii) A_2 = Foliar spray of Indole-3-acetic acid (IAA) @ 50 ppm at 25 DAS iii) A_3 = Foliar spray of Indole-3-acetic acid (IAA) @ 100 ppm at 25 DAS and iv) A_4 = Foliar spray of Indole-3-acetic acid (IAA) @ 150 ppm at 25 DAS and three spacing viz. i) S_1= 20cm x 10 cm, ii) S_2= 30cm x 10 cm and iii) S_3=40cm x10cm.

The experiment was laid out in randomized complete block design (RCBD) with three replications. The layout of the experiment was prepared for distributing the treatments. The experimental field was divided into 3 blocks. Each block was again divided into 12 plots. The total numbers of unit plots of the experiment were 36 (12 × 3). The size of the unit plot was 3.75 m × 1.78 m (6.675 m^2). There were 0.50 m width and 10 cm depth for drains between the blocks. Each treatment was again separated by drainage channel of 0.4 m width and 10 cm depth.The treatments were randomly distributed to each block following the experimental design. Mungbean variety was sown as test seeds of BARI Mung 6 crop on 11 March, 2014. Before sowing the land was prepared well by two plowing followed by laddering respectively on 8 and 10 March. Urea and TSP and MoP were applied as basal to supply N, P_2O_5 and K_2O @ 30, 48, 30 kg ha^{-1} respectively.

Data was recorded on growth, flower and pod dropping, stover yield and biological yield of experimental materials of whole plot. The analysis was performed using the MSTAT–C (Version 2.10) computer package program. The mean differences among the treatments were compared by least significant difference test (LSD) at 5 % level of significance.

Results showed that plant density had significant effect on plant height, number of leaves plant^{-1}, dry weight of leaves plant^{-1}, dry weight of root plant^{-1}, and dry weight of stem plant^{-1}. Among all the plant densities S_2 produced the highest dry weight of leaves plant^{-1} (13.40 g), root plant^{-1} (2.14 g) and stem plant^{-1} (9.891 g) at 65 days after sowing (DAS). However S_2 produced the tallest plant (43.76 cm), highest number of leaves plant^{-1} (23.98) at 55 DAS. Levels of IAA foliar application also showed significant effect on growth parameters for all the growth stages. A_4 treated plots showed the tallest plant height (45.30 cm), number of leaves plant^{-1}(23.89) at 55 DAS. However, A_3 gave the highest dry weight of leaves plant^{-1} (13.31 g), root plant^{-1} (2.14 g) and stem plant^{-1} (10.78 g) at 65 DAS. Shortest plant was found in no IAA treated plots. In the case of interaction of treatments, A_4S_2 gave the tallest plant (50.04 cm) and the highest leaves number plant^{-1} (26.07) at 55 DAS. On the other hand, A_3S_2 showed the highest dry weight of leaves plant^{-1} (14.96 g), root plant^{-1} (2.87 g) and stem plant^{-1} (11.901 g) at 65 DAS.

Plant density and IAA foliar application significantly influenced inflorescence number plant^{-1}, dry weight of inflorescence plant^{-1}, number of flower and pod dropping plant^{-1} and flower and pod dropping percentage plant^{-1} of BARI Mung 6. Highest inflorescence number plant^{-1}(7.29), dry weight of inflorescence plant^{-1} (17.35g) was recorded in S_2 at 65 and 55DAS respectively. However, S_1 showed lower number of flower and pod dropping plant^{-1} (17.95) but highest flower and pod dropping percentage plant^{-1} (56.98 %). Highest flower and pod dropping plant^{-1} (20.22) was recorded in S_3 where S_2 showed lowest number of flower and pod dropping percentage plant^{-1} (48.98 %). On the other hand, highest inflorescence number plant^{-1}(7.24), dry weight of inflorescence plant^{-1} (18.33 g) was recorded in A_2 at 65 DAS and A_3 at 55 DAS respectively. Lowest number of flower and pod dropping plant^{-1}(16.99), flower and pod dropping percentage plant^{-1} (47.47%) was recorded in A_4 where no IAA treated plots have highest number of flower and pod dropping plant^{-1}(21.42), flower and pod dropping percentage plant^{-1} (60.17%). Interaction effect of A_3S_2 gave lowest flower and pod dropping percentage plant^{-1} (44.76 %). This treatment also gave highest number of inflorescence plant^{-1}(8.16) and dry weight of inflorescence plant^{-1} (26.30g) at 65 and 55 DAS respectively. However, lowers lowest flower and pod dropping plant^{-1} (16.28) was recorded in A_3S_1.

Yield parameters showed to be influenced by plant density and IAA foliar application. The highest stover yield m^{-2} (88.4 g) were recorded in S_2 treatment where S_1 gave lowest stover yield m^{-2} (71.9 g). In case of IAA foliar application, A_3 showed highest stover yield m^{-2} (91.50 g) where control treatment gave lowest stover yield m^{-2} (72.06g). In case of interaction effect, A_3S_2 gave highest stover yield ha^{-1} (1.12 t ha^{-1}).

Yield parameters showed to be influenced by spacing and IAA foliar application. The highest stover yield (0.88 t ha^{-1}), biological yield (5.41 t ha^{-1}) and harvest index (40.11%) were recorded in S_2 treatment where S_1 gave the lowest stover yield (0.71 t ha^{-1}), biological yield (4.81 t ha^{-1}) and harvest index (37.82%). In case of IAA foliar application, A_3 showed the highest stover yield (0.91 t ha^{-1}), biological yield (5.33 t ha^{-1}) and harvest index (40.33%) where control treatment gave the lowest stover yield (0.72 t ha^{-1}) and biological yield (4.91 t ha^{-1}). However, the lowest harvest index percent was recorded in A_4 (38.75%). In case of interaction effect, A_3S_2 gave the highest stover yield ha^{-1} (1.12 t ha^{-1}), biological yield (5.38 t ha^{-1}) and harvest index (40.01%).

From the results of the experiment, it might be concluded that the performance of BARI mung-6 was better in 30 cm plant density with 100 ppm IAA foliar application. For determination of effectiveness of IAA foliar application, further trail should be performed in different locations for more conformation.

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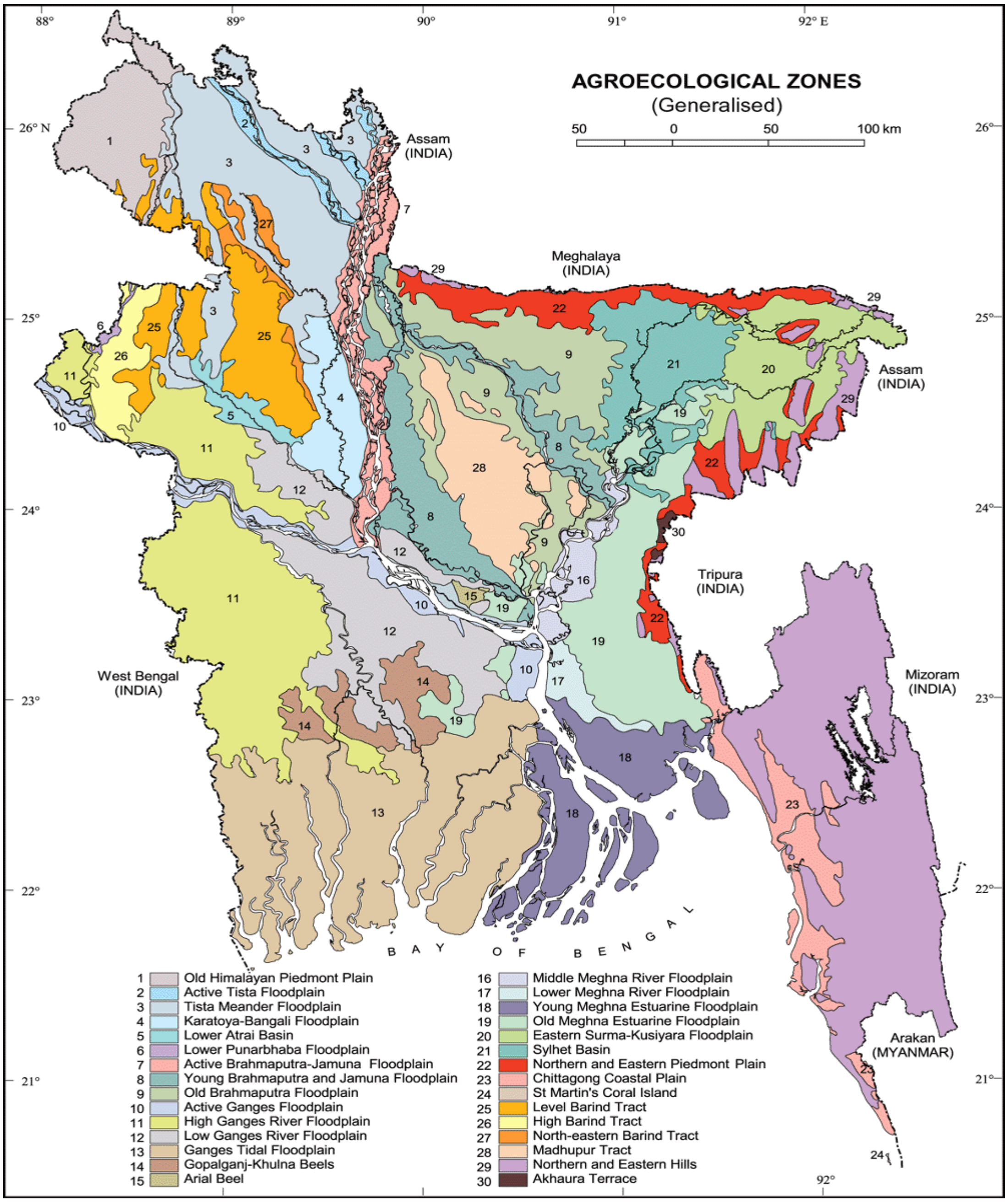
APPENDICES

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



Appendix II. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from March 2014 to July 2014

Month	Air temperature (^{0}C)		R. H. (%)		Total rainfall (mm)
	Maximum	Minimum	Maximum	Minimum	
March	37.4	20.2	80.2	32.4	3.80
April	39.4	19.4	80.2	39.2	65.60
May	38.2	19.3	89.2	40	96.23
June	37.2	17.4	88.4	46.3	282.7
July	35.6	18.2	88.2	55.4	107.8

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka

Appendix III. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

Morphological features	Characteristics
Location	Horticulture Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow redbrown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Mechanical analysis

Constituents	Percentage (%)
Sand	27
Silt	43
Clay	30

C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.45
Total nitrogen (%)	0.03
Available P (ppm)	20
Exchangeable K (%)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix-IV. Analysis of variance of data on plant height at different DAS of BARI Mung 6

Sources of variation	Degrees of freedom (df)	Mean square of plant height at			
		35 DAS	45 DAS	55 DAS	65 DAS
Replication	2	24.059	74.823	43.340	97.812
Factor A (Indole-3-acetic acid)	3	33.673*	24.080*	45.551**	20.187*
Factor B (Spacing)	2	5.435*	22.856*	31.062*	39.014*
Interaction (A X B)	6	20.978*	32.018**	9.493*	4.290*
Error	22	6.775	5.462	6.197	9.630

** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-V. Analysis of variance of data on number of leaves plant^{-1} at different DAS of mungbean

Sources of variation	Degrees of freedom (df)	Mean square of number of leaves plant^{-1} at			
		35 DAS	45 DAS	55 DAS	65 DAS
Replication	2	6.323	4.469	4.8920	5.214
Factor A (Indole-3-acetic acid)	3	8.756**	9.092**	5.513**	7.412**
Factor B (Spacing)	2	6.729**	10.895**	21.310**	19.985**
Interaction (A X B)	6	2.875**	2.709*	4.174**	3.056*
Error	22	0.532	1.124	1.258	1.129

** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-VI. Analysis of variance of data on dry weight of root plant^{-1} of BARI Mung 6

Sources of variation	Degrees of freedom (df)	Mean square of dry weight of root plant^{-1}			
		35 DAS	45 DAS	55 DAS	65 DAS
Replication	2	0.095	0.381	0.789	0.565
Factor A (Indole-3-acetic acid)	3	0.126**	0.151**	0.286**	0.574**
Factor B (Spacing)	2	0.142**	0.092*	0.083*	0.073
Interaction (A X B)	6	0.113	0.126**	0.119*	0.094
Error	22	0.023	0.029	0.064	0.089

** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-VII. Analysis of variance of data on dry weight of stem plant^{-1} of BARI Mung 6

Sources of variation	Degrees of freedom (df)	Mean square of dry weight of stem plant^{-1}			
		35 DAS	45 DAS	55 DAS	65 DAS
Replication	2	0.972	13.326	8.084	8.612
Factor A (Indole-3-acetic acid)	3	1.725**	6.175*	11.962**	17.863**
Factor B (Spacing)	2	0.502**	5.253*	7.251*	10.154**
Interaction (A X B)	6	0.396*	3.272	10.332*	6.769*
Error	22	0.503	3.377	3.91	4.152

** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-VIII. Analysis of variance of data on dry weight of leaves plant^{-1} of BARI Mung 6

Sources of variation	Degrees of freedom (df)	Mean square of dry weight of leaves plant^{-1}			
		35 DAS	45 DAS	55 DAS	65 DAS
Replication	2	3.129	22.497	38.291	25.491
Factor A (Indole-3-acetic acid)	3	8.458**	8.569**	5.765*	3.189
Factor B (Spacing)	2	3.052**	3.974*	6.153*	13.815**
Interaction (A X B)	6	1.169	3.891*	5.239*	3.896*
Error	22	0.832	1.698	2.217	2.689

** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-IX. Analysis of variance of data on number of inflorescence plant^{-1} of BARI Mung 6

Sources of variation	Degrees of freedom (df)	Mean square of number of inflorescence plant^{-1}		
		45 DAS	55 DAS	65 DAS
Replication	2	0.257	0.683	0.085
Factor A (Indole-3-acetic acid)	3	0.255*	0.689**	2.682**
Factor B (Spacing)	2	1.278**	2.717**	5.137**
Interaction (A X B)	6	0.337**	0.606**	0.907*
Error	22	0.103	0.211	0.635

** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-X. Analysis of variance of data on inflorescence dry weight plant^{-1} of BARI Mung 6

Sources of variation	Degrees of freedom (df)	Mean square of inflorescence dry weight plant^{-1}		
		45 DAS	55 DAS	65 DAS
Replication	2	0.091	11.167	66.786
Factor A (Indole-3- acetic acid)	3	0.131*	46.460*	50.718
Factor B (Spacing)	2	0.035*	12.759	80.311**
Interaction (A X B)	6	0.056*	11.898*	52.788
Error	22	0.062	18.894	26.210
** : Significant at 1% level of probability; * : Significant at 5% level of probability				

Appendix-XI. Analysis of variance of data on flower dropping plant^{-1} of BARI Mung 6

Sources of variation	Degrees of freedom (df)	Mean square of	
		Flower and pod dropping plant^{-1}	Flower and pod dropping percentage plant^{-1}
Replication	2	275.028	47.111
Factor A (Indole-3-acetic acid)	3	914.991	762.778**
Factor B (Spacing)	2	463.444*	835.444**
Interaction (A X B)	6	512.074*	389.778*
Error	22	490.240	178.819
** : Significant at 1% level of probability; * : Significant at 5% level of probability			

Appendix-XII. Analysis of variance of data on yield characteristics of BARI Mung 6

Source of variation	Degrees of freedom (df)	Mean square of	
		Stover Yield (t/ha)	Biological Yield
Replication	2	0.030	0.962
Factor A (Indole acetic acid)	3	0.079**	1.715**
Factor B (Spacing)	2	0.083**	0.522**
Interaction (A X B)	6	0.055*	0.386*
Error	22	0.022	0.179
** : Significant at 1% level of probability; * : Significant at 5% level of probability			