EFFECT OF LEAF CLIPPING AND NITROGEN FERTILIZER ON GROWTH AND YIELD OF MUNGBEAN

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CERTIFICATE

*This is to certify that the thesis entitled "**EFFECT OF LEAF CLIPPING AND NITROGEN FERTILIZER ON GROWTH AND YIELD OF MUNGBEAN**" 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,** embodies the result of a piece of bonafide research work carried out by **FATIMATUZZOHORA SHOHANA, Registration No.: 17-08187**, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that any help or sources of information as has been availed of during the course of this work has been duly acknowledged & style of the thesis have been approved and recommended for submission.

Dated:

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ABSTRACT

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during the period of March to June 2018 to study the effect of leaf clipping and nitrogen fertilizer on growth and yield of mungbean. The treatment consisted of two leaf clipping *viz*. C_0 = No leaf clipping (Control), C_1 = Leaf clipping (Removal of leaves having no inflorescence) and five nitrogen fertilizer doses *viz*. N_0= 0 kg urea ha^{-1}, N_1= 25 kg urea ha^{-1}, N_2= 50 kg urea ha^{-1}, N_3= 75 kg urea ha^{-1}, N_4= 100 kg urea ha^{-1}. The experiment was laid out in split-plot design having three replications. Leaf clipping, levels of nitrogen fertilizer and their interaction had significant influence on growth, yield and yield components of mungbean. The tallest plant(28.97, 44.97 and 45.55cm at 30, 45 and 60 DAS, respectively),the highest pod length (9.06 cm), pods plant^{-1} (10.67), seeds pod^{-1} (12.07), maximum weight of 1000-seed (47.64g), highest seed yield (1.34 t ha^{-1}), harvest index (37.14%) were obtained from 50 kg urea ha^{-1} along with leaf clipping (removal of leaves having no inflorescence) while the lowest from control treatment. 50 kg urea ha^{-1} and removal of leaves (leaves having no inflorescence) could be an optimum arrangement of mungbean for its optimum yield.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAS	=	Days after sowing
g	=	gram (s)
ha^{-1}	=	Per hectare
HI	=	Harvest Index
kg	=	Kilogram
LAI	=	Leaf area index
LSD	=	Least Significant Difference
Max	=	Maximum
Min	=	Minimum
mm	=	millimeter
MoP	=	Muriate of Potash
N	=	Nitrogen
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
NS	=	Non significant
ppm	=	Parts per million
RCBD	=	Randomized complete block design
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
T	=	Ton
TSP	=	Triple Super Phosphate
viz.	=	Videlicet (namely)
Wt.	=	Weight

CHAPTER 1

INTRODUCTION

Pulse is an important food crop for Bangladeshi people. It is an important source of protein and is called "Poorman's Meat" (Hossain *et al*., 2003). It is a common food item for Bangladeshi people in everyday meal. The farmers in the country are cultivating pulse from long past with a recent adoption of improved varieties.

The Pulse Research Centre of BARI has developed 36 improved varieties of pulses along with other improved technologies (Hossain, 2017). Pulse is grown mostly in the winter season. It is also grown in the Kharif season. Therefore, pulses have the opportunities to cover more areas round the year. Eight varieties of Mungbean namely BARI Mung-1, BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5, BARI Mung-6, BARI Mung-7 and BARI Mung-8 were developed during 1987 to 2015 (Hossain, 2017). These varieties are broadly cultivated in the farmers' fields since the release of the varieties.

It contains protein about twice as much as cereals. It also contains amino acid, lysine which is generally deficit in food grains (Elias *et al.*, 1986). Pulse bran is also used as quality feed for animals. A large number of pulse crops are grown in Bangladesh, among those, mungbean (*Vigna radiata*) is the third most important pulse crop in terms of area and production (Asaduzzaman *et al*., 2008). Its importance is related to its short growing period ideal for intensive crop production, which makes it an ideal cash crop. It fixes nitrogen in soil and improves soil health, thus becomes an important component in cropping patterns (Ahmed *et al*., 1978).

Mungbean is widely grown in Bangladesh. It contains 19.5% to 28.5% protein (AVRDC, 1988). It supplies a substantial amount of nitrogen to the succeeding non-legume crops (i.e., rice) grown in rotation (Sharma and Prasad, 1999). Major area of mungbean is replaced by cereals (Abedin and Anwarul, 1991).

Now-a-days, it is being cultivated after harvesting of Rabi crops such as wheat, mustard, lentil, etc. It is grown three times in a year covering 23264 ha with an average yield of 0.77 t/ha (BBS, 2010).

In Bangladesh per capita consumption of pulses is only 14.72 g (BBS, 2012) as against 45.0 g recommended by World Health Organization. Mungbean is one of the most emergent pulse crops of Bangladesh. The present nutritional status of developing countries like Bangladesh is a matter of leading concern since the most of the people are enduring from malnutrition (Mahbub *et al.,* 2015).

Mungbean is envisaging as the best of all pulses from the nutritional viewpoint and which comprised of 51% carbohydrate, 26% protein, 4% minerals and 3% vitamins (Kaul, 1982; Uddin *et al*., 2009). The young plants are used as animal pasturage and the residues as compost.

The climatic condition of Bangladesh is favorable for winter farming of mungbean but it can cultivate in both summer and winter (Hossain *et al*., 2016). Production of mungbean can be increased by cultivation of summer mungbean through varietal development and proper management practices (Uddin *et al*., 2009).

Bangladesh has been experiencing shortage of land for pulses, whereas its demand is increasing day by day. Thus, increasing yield remains to be the option for elevating pulse production in the country. In this regard, Mungbean can play an important role (Salam *et al*., 2017).

Mungbean is highly responsive to fertilizers and growth hormone. It has a marked response to nitrogen, phosphorus and potassium. These nutrients play a vital role in plant physiological process. For legume especially mungbean, nitrogen is more useful because it is the main component of amino acids as well as protein. Growth and yield of mungbean is affected by leaf clipping and fertilizer doses. Total dry matter production is positively correlated with the amount of foliage displayed in upper 50% of the canopy (Hamid *et al.,* 1990).

It seems likely that the foliage developed in the lower part of the canopy has little or negative contribution to dry matter production.

In some situations, physical leaf is adequate and even more than required, but the functional efficiency is far lower due to utilizing resources as a respiratory burden of excessive leaves (Venkateswarlu and Visperas, 1987; Mondal, 2007). Removal of apical shoot above node 5 or removal of inflorescence or axillary bud at nodes 1-4 together with the apical shoot greatly increased pod number and seed weight of mungbean (Clifford, 1979).The leaves at flowering nodes are the major contributors to seed filling and development (AVRDC, 1974). Greater light penetration in the canopy through defoliation has reduced the abortion of flowers and immature pods and increased seed yield in mungbean (Mondal, 2007).

Excessive leaf development in mungbean during the later growth stages was found to be detrimental to seed yield (Patel *et al.*, 1992). Production of leaves, particular in the lower part of the plant often causes mutual shading resulting in yield reduction. Thus manipulation of source may provide opportunity for increasing yield in plants having habit of excessive leaf development. Inadequate leaf production in the vegetative phase indicates that during the post-flowering phase, when the sink activity was high, most photosynthates required for the growth and development of pods comes from the current photosynthesis (Kuo *et al.*, 1978).

High population pressure and increased demand for food and other agricultural commodities have already started disruption of the natural resource base and environment in Bangladesh. The production capacity of our land is decreasing progressively due to intensive cropping with high yielding crop varieties and high input technologies. However, legume crops are considered as the contributor to improve the soil health worldwide.

Hence the present study was undertaken with the following objectives:

- ✓ To determine the effect of leaf clipping on growth and yield of mungbean
- ✓ To evaluate the optimum doses of nitrogen to get better result
- ✓ To study the combined effect of leaf clipping and nitrogen on growth and yield of mungbean.

CHAPTER II
REVIEW OF LITERATURE

The application and introduction of leaf clipping in the growth and development of different plants is already a reality with plausible results. A good number of research works on different level of fertilizer application has been done by researchers in and outside of the country. Research work related to the study of mungbean was reviewed and presented in this chapter.

Hossen *et al.* (2015) conducted a research work at the research field of the Horticulture Research Center at Labukhali, Patuakhali during the period from January to March 2014 to find out the most suitable BARI Mungbean variety and optimum rates of N concerning higher seed yield under the regional condition of Patuakhali (AEZ-13). Two BARI Mungbean varieties namely BARI mung-5 (V_1) and BARI mung-6 (V_2) and five levels of N fertilizer including control viz. 0kg Nha^{-1} (N_0), 30kg Nha^{-1} (N_{30}), 45kg Nha^{-1} (N_{45}), 60kg Nha^{-1} (N_{60}) and 75kg Nha^{-1}(N_{75}) were used for the study. In case of variety, BARI mung–6 produced significantly longest pod (7.56 cm), maximum pods (9.14), maximum seeds (9.14), highest weight of 100–seed (4.48 g), highest seed weight (4.33 g) and highest seed yield (1.56 t $ha^{–1}$) than BARI mung–5 at harvest. In case of N fertilizer, longest pod (7.96 cm), maximum pods $plant^{–1}$ (10.45), maximum seeds $pod^{–1}$ (9.70), higher weight of 100–seed (4.52 g), higher weight of seed (5.73 g $plant^{–1}$) and greater seed yield (1.85 t $ha^{–1}$) were also obtained in 45 kg N $ha^{–1}$ compare other N levels. The BARI mung–6 × 45 kg N ha–1 for seed yield was found under the regional condition of Patuakhali (AEZ-13).

Razzaque *et al*. (2017) conducted an experiment at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during kharif II season of 2011 to investigate the growth, dry matter production and yield of mungbean genotypes under nutrient stress soil. Ten mungbean genotypes viz., IPSA-12,

GK-27, IPSA-3, IPSA-5, ACC12890053, GK-63, ACC12890055, BARI Mung-6, BUmug- 4 and Bina moog- 5 and six nitrogen fertilizer levels viz., 0, 20, 40, 60, 80 and 100 kg N ha^{-1} were included as experimental treatments. Results revealed that increasing nitrogen level in nutrient stress soil increased growth and dry matter production up to 60 kg N ha^{-1} irrespective of genotype and thereafter decreased. Among the mungbean genotype IPSA 12 showed maximum leaf area, dry matter production and seed yield (14.22 g $plant^{-1}$) in nutrient stress soil. The lowest seed yield (7.33 g $plant^{-1}$) was recorded in ACC12890053 under control condition.

Ayub *et al.* (1999) studied response of two mungbean cultivars namely NM-54 and NM-92 to nitrogen levels of 0, 20, 40 and 60 kg ha^{-1} was under field conditions. The cultivar NM-92 gave significantly higher seed yield than cultivar NM-54 due to higher number of pod bearing branches $plant^{-1}$, number of pods $plant^{-1}$ and number of seeds pod^{-1}. Yield and yield components were also influenced significantly by nitrogen levels. The application of nitrogen at the rate of 60 kg ha^{-1} significantly depressed the seed yield and yield components except number of pods $plant^{-1}$ which were statistically similar with nitrogen application of 40 kg ha^{-1}. Maximum increase in seed yield, recorded at 40 kg N ha^{-1}, was about 31 percent higher of control. The increase in seed yield with nitrogen application was related to higher number of pods $plant^{-1}$, number of seeds pod^{-1} and 1000-grain weight. Protein contents were also influenced significantly by nitrogen application, being maximum (26.18%) at nitrogen level of 40 kg ha^{-1}. Nitrogen application at the rate of 40 kg ha^{-1} seems to be the optimum level for harvesting higher yield of mungbean.

Hamid (1991) evaluated the influence of rate and frequency of foliar N fertilization on the yield performance and nutrient uptake of mungbean in a series of experiments. Foliar applied N generally increased seed yield over the untreated control excepting the treatment with 20 mg N l^{-1}. A concentration of 10 mg N l^{-1} was most beneficial to pod and seed development than the higher or lower concentrations. Spraying N at around flowering caused significant yield increase but application twice (at around flowering and at late reproductive phase) gave significantly greater seed yield than any single application. Field experiment also confirmed that foliar N at 10 mg l^{-1} applied twice in the reproductive phase gave greater yield advantage.

Malik *et al*. (2003) conducted a study to determine the effect of varying levels of nitrogen(0, 25 and 50 kgha^{-1}) and phosphorus (0, 50, 75 and 100 kgha^{-1}) on the yield and quality of mungbean (*Vigna radiata* L.) cultivar NM-98 during the year 2001. Although plant population was not affected significantly but various growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25-75 kg NP ha^{-1} resulted in maximum seed yield (1112.96 kgha^{-1}). Maximum protein content (25.6%) were obtained from plots fertilized @ 50-75 kg NP ha^{-1} followed by protein content of 25.1% obtained from plots fertilized @ 25-75 kg NP ha^{-1}. Highest net income (Rs. 21374.9) was also obtained by applying N and P @ 25 and 75 kg NP ha^{-1}, respectively.

Jamro *et al*. (2018) carried out an experiment to evaluate the growth and yield response of mungbean under the influence of NP combination levels during the year 2013 at the Experimental Area of Oilseeds Section, Agriculture Research Institute, Tandojam. The results of the experiment showed that various combination of Nitrogen and Phosphorus (NP) levels significantly affected crop parameters. The maximum crop stand m^{-2} (128.7), plant height cm (59.54), number of branches plant^{-1} (12.74), number of pods plant^{-1} (33.32), number of seeds plant^{-1} (376.2) seed weight plant^{-1} (17.61 g) seed index (32.05 g) and seed yield (2290.0 kg ha^{-1}) were found with the application of NP combination level of 50-75 kg ha^{-1}. Whereas, for varieties, V1 i.e. AEM-96 surpass in all parameters as compared to V_2 i.e. NM-94, which gave maximum (120.11) crop stand m^{-2}, maximum (52.55 cm) plant height, 10.67 plant m^{-2}, maximum (24.03) branches plant^{-1}, maximum (15.07) pods plant^{-1}, maximum

(30.01 g) seed weight plant^{-1} and maximum (2439.2 kg ha^{-1}) seed yield. Among the interactions the highest seed yield was recorded in variety AEM-96 with NP combination level of 50-75 kg ha^{-1} followed by the interaction of variety AEM-96 with NP combination of 50-50 kg ha^{-1}, whereas lowest seed yield kg ha^{-1} was recorded variety NM-94 with NP combination 25.00 kg ha^{-1}. The variety AEM-96 under NP combination level 50-75 kg ha^{-1} perform better and gave highest yield 2439.2 kg ha^{-1}.

Azadi *et al*. (2013) conducted an experiment in order to evaluate and determine the appropriate nitrogen fertilization, the morphological characteristics and seed yield of three mungbean cultivars. The experiment was done as split plot based on randomized complete block design with four replications in summer 2011 in the city of Khorramabad. In this study, different levels of nitrogen fertilizer (control, 50, 100, 150 kg/ha urea) as sub-plots and three mungbean cultivars (Partow, Gohar, local) was considered as the main factor. The result of analysis variance on morphological characteristics on seed yield showed that between different cultivar in the eyes of first pod height and seed yield were significant at 5% level probability. In addition, between different amounts of nitrogen fertilizer for stem diameter and number of node and seed yield showed significantly different. Interaction between urea fertilizer and cultivars, number of nodes and seed yield were significant effect at 1% and 5% level probability. The highest seed yield of 8.9 grams per square meter and the number of sub-branches with (1.5) and the height of the first pod from ground level with (25.51 cm) and stem diameter (1.13 cm) and number of nodes (8.28 pcs) and pod length (7.5 cm) was obtained at 150 kg/ha urea. Between different amount of nitrogen fertilizer, 150 kg/ha urea, showed higher values than the other. In this experiment, 150 kg/ha nitrogen fertilizer with partow cultivar is the most appropriate treatment and suitable for this region.

Jalali *et al*. (2017) conducted an experiment at the Experimental Farm of (ANASTU), Kandahar during 2015 to study the effect of varying nitrogen levels on growth and yield of mungbean (*Vigna radiata* L. Wilczek) in semi-arid region of Kandahar, Afghanistan. Experimental treatments comprised of seven N levels (0, 10, 20, 30, 40, 50, 60 kg N ha^{-1}). The experiment was laid-out in a RCBD design with three replications. The results indicated that nitrogen levels with a few expectations significantly influenced the growth parameters and yield characteristics of mungbean. The maximum plant height and net assimilation rate was recorded when nitrogen was applied @ 60 kg N ha^{-1} while the lowest were found in control treatment. The highest leaf area surface, leaf area index, total dry matter $plant^{-1}$, number of primary branches $plant^{-1}$, root dry weight, root length, root nodule count at maximum flowering, crop growth rate and relative growth rate were recorded from the plots supplied with N @ 40 kg ha^{-1}. Total number of pods $plant^{-1}$, pod length, number of grains pod^{-1}, number of grains $plant^{-1}$, grains weight $plant^{-1}$ were significantly highest with treatment 30 kg N ha^{-1}, but 1000-grains weight had non-significant influence due to N levels. Grain, straw and biological yield were found significantly higher (1.96, 5.29, 7.25 t ha^{-1}) in treatment 30 kg N ha^{-1}. Significantly lowest grain, straw and biological yields were recorded in control treatment. Harvest index was non-significant with maximum harvest index (27.7%) in treatment 20 kg N ha^{-1} and the lowest (24.3%) in control.

Achackzai *et al.* (2012) conducted a study to evaluate the growth response of mungbean [*Vigna radiata* (L.) Wilczek] cultivars subjected to different levels of applied N fertilizer. To achieve the aim, an experiment conducted in the experimental field of Agricultural Research Institute (ARI), Quetta. The soil of the study area was basic in reaction, salt free, medium textured having low organic matter and total N contents. Four different cultivars of mungbean viz., NM-92, NM-98, M-1, and NCM-209 grown in kharif season for two consecutive years i.e., 2007 and 2008. Six different levels of N fertilizer applied at the rate zero, 20, 40, 60, 80 and 100 kg ha^{-1}. While, a constant dose of P_2O_5 and K_2O also applied to each N level (except control, zero). Urea fertilizer used as a source of N, while TSP and SOP as sources of P and K, respectively. The plot size kept as 2.40 m^2/ (4X4X0.15), and arranged in a randomized complete block design (RCBD). Results showed that different fertilizer levels did significantly ($p<0.05$) influenced most of the growth attributes of the mungbean. Maximum days to flowering (48.25) and number of branches $plant^{-1}$(3.8 3) recorded for plants subjected to highest dose of applied N fertilizer viz., 100 kg ha^{-1}. Similar responses toward added N fertilizer also noted for various cultivars of mungbean. Maximum days to flowering (47.72) and number of leaves $plant^{-1}$ (5.86) recorded for NCM-209. Whereas, the maximum plant height (38.52 cm) number of branches $plant^{-1}$ (3.72) obtained for mungbean cultivar M-1. The correlation coefficient (r) studies exibited that plant height (0.593), number of leaves $plant^{-1}$ (r=0.325), number of branches plant-^{1} (r=0.187) and leaf area (r=0.342) significantly ($p<0.05$) and positively correlated with their grain yield (kg ha^{-1}). However, days to 50% flowering (r=-0.265) are also significantly but negatively associated with their grain yield (kg ha^{-1}). Thus based on correlation studies it could revealed that cultivars under cultivation displayed a wide range of variation for most of the mentioned growth traits and could be exploited in breeding programme to enrich the mungbean genetic treasure.

Asaduzzaman *et al.* (2008) conducted an experiment at the experiment field of the Department of Agronomy, Sher-e-Bangla Agricultural University; Dhaka, Bangladesh to evaluate the effect of nitrogen and irrigation managements on dry matter accumulation and yield of mungbean (*Vigna radiata* L.) cv. BARI mung-5 during the period from March to May 2006. The trial comprised of ten treatments such as T_1 =No fertilizer and irrigation (control), T_2=20 kg N ha^{-1} as basal, T_3=20 kg N ha^{-1} as basal + one irrigation at flower initiation stage, T_4=30 kg N ha^{-1} as basal, T_5=30 kg N ha^{-1} as basal + one irrigation at flower initiation stage, T_6=40 kg N ha^{--1} as basal, T_7=40 kg N ha^{-1} as basal + one irrigation at flower initiation stage, T_8= 10 kg N ha^{-1} as basal and 10 kg N ha^{-1} as split +one irrigation at first flowering stage, T_9= 15 kg N ha^{-1} as basal and 15 kg N ha^{-1} as split +one irrigation at flower initiation stage and T_{10}= 20 kg N ha as basal and

20 kg N ha^{-1} as split +one irrigation at flower initiation stage. Irrespective of treatment differences the mungbean plant as a pulse crop showed a lag phase for slow dry matter production in early growth stage (up to 40 DAS) that increase up to harvest. Application of 30 kg N ha^{-1} as basal with one irrigation at flower initiation stage (35 DAS) significantly improved dry matter accumulation. This greater dry matter production eventually partitioned to pods per plant, seeds per plant and 1000-seed weight which is greater resulted with maximum seed yield per plant (5.53 g) or per hectare (1.65 t). A functional positive relationship was observed in with pods per plant and seeds per plant.

Liu *et al.* (2017) conducted a two years field experiment on Jinhai5, a semi-compact corn cultivar. Three days after silking the plants were subjected to removal of the uppermost two leaves (S_2), four leaves (S_4) or six leaves (S_6), with no leaf removal as control (S_0). They evaluated the effects of leaf removal on N remobilization, photosynthetic capacity of the remaining leaves for N uptake and N accumulation in kernels. Their results concluded that, under high plant density, excising the uppermost two leaves promoted N remobilization from vegetative organs to kernels and enhanced photosynthetic capacity for N uptake, leading to an increased N accumulation in kernels (19.6% higher than control). However, four or six uppermost leaves removal reduced N remobilization from stem and photosynthesis for poor N uptake, resulting in 37.5 and 50.2% significantly reduced N accumulation in kernels, respectively.

Wei *et al.* (2018) evaluated an experiment to reveal the mechanism of leaf removal in maize, tandem mass tags label-based quantitative analysis coupled with liquid chromatography-tandem mass spectrometry were used to capture the differential protein expression profiles of maize subjected to the removal of the two uppermost leaves (S_2), the four uppermost leaves (S_4), and with no leaf removal as control (S_0). Excising leaves strengthened the light transmission rate of the canopy and increased the content of malondialdehyde, whereas decreased the activities of superoxide dismutase and peroxidase. Two leaves removal increased the photosynthetic capacity of ear leaves and the grain yield significantly, whereas S_4 decreased the yield markedly. Besides, 239 up-accumulated proteins and 99 down-accumulated proteins were identified between S_2 and S_0, which were strongly enriched into 30 and 23 functional groups; 71 increased proteins and 42 decreased proteins were identified between S_4 and S_0, which were strongly enriched into 22 and 23 functional groups, for increased and decreased proteins, respectively.

Rao and Ghildiyal (1985) analyzed source and sink relationship in mungbean var. PS-16 using source and sink alteration technique. Effect of source and sink variation on photosynthesis nodulation, leaf nitrogen and chlorophyll content was examined in relation to growth and yield characters. The data indicated the possible limitation of source in determining the sink yield in Mungbean var PS-16. It appeared however, that sink itself was instrumental in hastening the decrease in photosynthesis and leaf senescence by affecting directly mobilization and utilization of leaf nitrogen and indirectly nodulation.

Howlader *et al.* (2018) made an effort to assess the effect of source-sink manipulation on yield contributing characters and yield of sesame. The experiment was laid out in two factors randomized complete block design consisted of two varieties of sesame *viz.*Binatil-3 and Local-Black and five levels of source-sink manipulation *viz.*control (M_0), removal of lower empty leaves, lower empty branches and top of the inflorescence (M_1), removal of top of the inflorescence (M_2), removal of all branches and removal of lower empty leaves (M_3) and lower empty branches (M_4) with three replications. Source-sink manipulations were imposed during capsule development stage (50 days after emergence). Results revealed that the higher number of capsules plant^{-1} (16.17), seeds capsule^{-1} (53.27), maximum 1000-seed weight (2.72 g), higher seed capsule wall ratio (2.52), seed yield plant^{-1} (2.35 g), yield (938.96 kg ha^{-1}) and harvest index (36.40%) were produced by the modern variety Binatil-3 than the traditional variety Local-black. Source-sink manipulation showed positive response to yield attributes compared with control. Maximum seeds capsule^{-1} (57.13), 1000-seed weight (2.92 g), higher seed capsule wall ratio (2.71), seed yield plant^{-1} (2.78 g) and yield (1110.96 kg ha^{-1}) were found from removal of lower empty leaves, lower empty branches and top of the inflorescence (M_1). Yield was increased by 71.77%, 46.88%, 8.52% and 22.45% due to M_1, M_2, M_3 and M_4 manipulation. Although all the source-sink manipulation treatments gave higher yield in their respective variety, the highest (1258.63 kg ha^{-1} and 125.04%) yield was obtained when lower leaves, lower empty branches and top of the inflorescence of the variety Binatil-3 were removed i.e. from V_1M_1 treatment. Therefore, Binatil-3 with removal of lower empty leaves, lower empty branches and top of the inflorescence manipulation was the best treatment in respect of yield and yield contributing characters of sesame.

Mondal *et al.*(1978) determined photosynthetic rate, ribulose 1,5-bisphosphate carboxylase activity, specific leaf weight, and leaf concentrations of carbohydrates, proteins, chlorophyll, and inorganic phosphate periodically from midbloom until maturity in leaves of soybean plants (*Glycine max* L., var. Hodgson) from which reproductive and vegetative sinks had been removed 32 hours before measurement, or continuously since midbloom. Leaf photosynthesis, measured in the top of the canopy, was partially inhibited by both sink removal treatments. This inhibition was of constant magnitude from midbloom until maturity. Leaf photosynthesis in the top of the canopy declined from midbloom until maturity in the control as well as in the desinked plants. The decline in photosynthesis was gradual at first, but later became more abrupt. The photosynthetic decline was equally evident in the yellowing leaves of control plants and in the dark green leaves of the continuously desinked plants. Neither the inhibition of photosynthesis by sink removal nor the decline in photosynthetic rate with time was clearly related to any of the measured traits.

Slack (1985) in a first experiment, imposed six levels of leaf removal on January-sown tomatoes and de-leafing was continued so that the length of stem with leaves attached was constant for a given treatment. Flower opening on de-leafed plants was delayed but only significantly so in the most severe treatment. There was no effect on stem elongation. Yield decreased with severity of leaf removal but the rate of fruit ripening was enhanced. In a second experiment, three levels of de-leafing were used but treatment was delayed until the fruits began to ripen. The treatments were combined factorically with three planting densities and three contrasting cultivars. There were no effects of de-leafing on flower opening or stem elongation. Total yield was reduced by leaf removal in the most severe treatment but there was no effect on fruit numbers or quality. Large and significant effects of plant density were recorded but there were no interactions between density, leaf removal and cultivar. The effects of de-leafing and density were similar in all three cultivars. Crop yield was thus affected by both the severity of leaf removal and by the stage of plant development at which removal occurred. Losses in yield are attributed to a reduction in photosynthetic area and a decrease in the availability of mobile mineral elements which are present in the leaves. It is strongly recommended that de-leafing in commercial tomato crops should not exceed the level of ripening fruits. Large and significant effects of plant density were recorded but there were no interactions between density, leaf removal and cultivar. The effects of de-leafing and density were similar in all three cultivars. Crop yield was thus affected by both the severity of leaf removal and by the stage of plant development at which removal occurred. Losses in yield are attributed to a reduction in photosynthetic area and a decrease in the availability of mobile mineral elements which are present in the leaves. It is strongly recommended that de-leafing in commercial tomato crops should not exceed the level of ripening fruits.

Adams *et al.* (2015) conducted an experiment to assess whether the severity of leaf removal or modifying night temperature set-points based upon the amount of solar radiation intercepted the previous day could affect tomato yields. A night temperature set-point of 16°C increasing linearly by 3 K for every 1000 klx h (˜ 67 mol m^{-2} d^{-1}) was compared with a 19°C set-point which decreased by 5 K for every 1000 klx h. Similar mean diurnal temperatures were achieved in these two regimens and consequently there was little effect on the pattern of yield or cumulative yields for the whole season. When leaves were removed every week up to two trusses above the ripening truss (high leaf removal: HLR), fruits were warmer during the day and cooler at night, and ripened 1.2 d earlier than those on plants where leaves were removed up to two trusses below the ripening truss (low leaf removal: LLR). The leaf removal treatments had a similar pattern of yield and there was no significant difference in the cumulative yields for the season. This was despite the fact that the HLR plants probably had only 50% of the leaf area of LLR plants. This lack of response was primarily attributed to the poor light penetration in the canopy, which meant that lower leaves contributed little to the net canopy photosynthesis. The effects of leaf removal on fruit quality and water usage were presented and discussed in relation to the best leaf removal strategy to use for commercial tomato production.

Koga and Rukmini (2017) used two new higher yielding varieties at two sites for two planting dates (September and October) in their studies. In these experiments, up to 10 bottom leaves were removed, and topping was done to reduce the number of remaining leaves to 14 against the standard of 18 leaves. In some treatments, additional fertilizers were applied to improve yield and quality of the remaining leaves. The highest value gain was obtained when six bottom leaves were pruned. However, an additional 400 kg/ha of high analysis fertilizer was applied at pruning, resulting in a yield increase of 1104 kg/ha compared to the standard (no priming, no additional fertilizer). The same trend was obtained in the previous season (2014/15), where 421 kg/ha yield increase was observed when six leaves were pruned with similar fertilizer adjustments.

Marowa *et al.* (2015) carried out a field experiment at Kutsaga Research Station to investigate the possibility of improving yield and quality of cured leaf by removing the lower leaves (primings) and applying additional nitrogen to the remaining leaves. The experiment was laid out as a split plot experiment in a randomized complete block design with three replications. A plant spacing of 1.2 m between rows and 0.56 m within rows was used. All recommended agronomic practices in flue-cured tobacco production were observed except that 0, 2, 4 and 6 lowest leaves were removed and discarded at 6 weeks after planting. A supplementary ammonium nitrate side dressing was applied at topping at a rate of 0, 5, 10 and 25 kg N/ha. The removal of 4 leaves plus the addition of 10 kg N/ha at topping resulted in a 22.42 % increase in income above that obtained from the control. However, removal of 4 leaves plus excessive amounts of N (25 kg/ha) resulted in very large leaves but the saleable yield was lower than that from the control or other plots with the same priming removal level plus less additional N. The addition of 25 kg N/ha when only 2 leaves were removed produced the highest saleable yield and recorded 19.67 % yield increase above the control. Addition of 10kg N/ha when 4 leaves were removed resulted in 19.04 % yield increase above the control. The latter however had a better grade index. It was also noted that the removal of 4 leaves plus an extra 10 kg N/ha at topping and the removal of 2 leaves plus an additional 25 kg N/ha at topping resulted in a substantial increase of the saleable yield for all reaping groups. Removal of priming leaves plus the addition of supplementary nitrogen did not increase leaf expansion. It did not lower yields but it improved the quality of the cured leaf and this resulted in better income basing on the gross margin of the expanded project. It is therefore concluded that the removal of the lowest 4 leaves plus an addition of an extra 10 kg N/ha neither lowers yield nor quality but brings with it income benefits to the farmer.

Srinivasan *et al.* (2016) parameterized a mechanistic biophysical and biochemical model of canopy carbon exchange and microclimate (MLCan) for a modern US Midwest soybean cultivar. Model simulations showed that soybean crops grown under current and elevated (550 [ppm]) [CO_2] overinvest in leaves, and this is predicted to decrease productivity and seed yield 8% and 10%, respectively. This prediction was tested in replicated field trials in which a proportion of emerging leaves was removed prior to expansion, so lowering investment in leaves. The experiment was conducted under open-air conditions for current and future elevated [CO_2] within the Soybean Free Air Concentration Enrichment facility (SoyFACE) in central Illinois. This treatment resulted in a statistically significant 8% yield increase. This is the first direct proof that a modern crop cultivar produces more leaf than is optimal for yield under today's and future [CO_2] and that reducing leaf area would give higher yields. Breeding or bioengineering for lower leaf area could, therefore, contribute very significantly to meeting future demand for staple food crops given that an 8% yield increase across the USA alone would amount to 6.5 million metric tons annually.

Heidari (2015) conducted a field and a laboratory experiment in order to determine the effect of defoliation treatments on maize yield, yield components and produced seed germination traits in 2012. The field experiment included six defoliation treatments (D_1= control, no leaf removal, D_2 = defoliating tassel leaf, D_3 = defoliating ear leaf, D_4 = defoliating leaves at the top of the ear, D_5 = defoliating leaves under ear, D_6 = defoliating all leaves). Germination traits of seed produced from maternal plant were tested at the laboratory experiment. Results showed that complete defoliation severely reduced seed yield, row number per ear, seed number per ear, cob length, cob weight and ear weight ($P < 5\%$). Defoliation treatments had minor effect on produced seed germination traits. Defoliation treatments had no significant effect on ear skin weight. Ear weight and ear skin weight had a significant and positive correlation with all traits except 100-seed weight. Defoliating leaves under the ear (D_5) had higher cob weight than defoliating leaves at the top of the ear (D_4). Ear leaf removal had higher seed yield than defoliating leaves under and at the top of ear (D_4,

D_5). Defoliation treatments had no significant effect on seed-ling shoot length and root length.

Khan (2010) conducted an experiment at Agricultural Research Farm of NWFP Agricultural University, Peshawar, Pakistan in the summer of 2003 and repeated in 2004. The seeds of two mungbean cultivars (NM-92 and NM-98) were primed, some for 6 h and others for 12 h in using either distilled water (0MPa osmotic potential) or Polyethylene glycol-8000 (PEG) solution having -0.2, -0.5 and -1.2 MPa osmotic potential. A control treatment (dried seeds) was also included in the experiment. The primed seed were dried back, till the weight become constant and were store for sowing at 25°C. Data was collected on mung bean leaf area, dry matter production and growth parameters at different growth stages. Seed moisture content at maturity stage was also determined. There was no significant difference in leaf area for the different cultivars and seed treatment duration also did not lead to a significant difference in leaf area. However, seed priming techniques significantly affected the measured parameters. Dried seed had developed lower leaf area and dry matter compared to primed seeds. An exponential linear model of leaf area and total dry matter revealed that dry matter production was linearly related to leaf area (r^2 = 77.23). The linear relationship between the leaf area and dry matter hold true our hypothesis and thus we concluded that beside environmental and genetical factors, the dry matter production is a function of leaf area in aerated seed of mungbean crop in semi-arid areas like north western Pakistan.

Tollenaar and Daynard (1978) conducted a study to evaluate the effect of leaf removal on kernel dry matter accumulation, kernel moisture content, and rate of black layer formation in kernels, in relation to changes in soluble-solid content of the stem of maize (*Zea mays* L.). In 1970, defoliation wk was begun at mid-silking and continued at 2-wk intervals until 6 after mid-silking. The treatments consisted of (1) no leaf removal, (2) 50% of leaf blades removed, and (3) all leaf blades removed. In 1971, a wk after mid-silking was treatment with complete leaf removal at 1 added. Kernel number was greatly affected by the treatments during the wk after mid-silking, whereas later defoliation affected mainly first 2 kernel weight. Soluble-solid content in the stem declined rapidly after leaf removal, indicating an accelerated utilization of soluble carbohydrates from the stem for grain growth. Maturity, expressed as both kernel-moisture content and rate of black layer formation, was affected significantly by the defoliation treatments. The data presented indicate that a decrease in the source–sink ratio during grain-filling advances date of maturity.

Clifford (1979) described an experimental design to test the hypothesis that it is the available assimilate supply from source leaves which limits flower and fruit development and hence harvestable sink yield in mungbeans. Seeds of *Phaseolus aureus* Roxb. were inoculated with an effective strain of Rhizobium (*R. phaseoli* strain 3824) obtained from Rothamsted Experimental Station. Plants were raised to the stage at which they had a pair of primary leaves and four expanded trifoliate leaves. Plants were subjected to the following treatments: (i) Control, intact plants; (ii) subtending leaf at node 5 removed; (iii) as 2, and leaves at nodes 3 and 4 removed; (iv) apical shoot removed above node 5; (v) as 4, and inflorescence or auxiliary buds at nodes 1-4 removed. The removal of the subtending leaf had no measurable effect on fruit number or seed weight. This was perhaps unexpected since the subtending leaf is a major source of assimilate for the reproductive sink in legumes. But presumably assimilate diversion from remaining leaves maintained flower and fruit development.

Alam *et al.* (2008) conducted a research work at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, Rajshahi, Bangladesh during the period from 2005 to 2006 with twenty wheat genotypes to study the effect of source-sink manipulation on grain yield. Significant variations among the genotypes were observed for grains spike^{-1}, 100-grain weight and grain yield spike^{-1}. He reported that, removal of flag leaf caused decrease in grains spike^{-1}, 100-grain weight and grain yield main spike^{-1} by 9.94%, 7.65% and 16.88%, respectively compared to the treatment of no leaf removal.

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted at the research plot of Sher-e-Bangla Agricultural University Farm, Dhaka during the period of March to June, 2018 to study the effect of leaf clipping and nitrogen fertilizer on growth and yield of mungbean. Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Description of the experimental site

3.1.1 Site and soil

Geographically the experimental field was located at $23^0 77'$latitude and $90^0 35'$longitudes at an altitude of 9m above the mean sea level. The soil is belonged to the Agro-ecological Zone – Modhupur Tract (AEZ 28). The land topography was medium high and soil texture was silt clay with pH 8.0. The physical and chemical characteristics of the experimental soil have been presented in Appendix-III.

3.1.2 Climate and weather

The climate of the locality is subtropical which is characterized by high temperature and heavy rainfall during *Kharif* season (April-September) and scanty rainfall during *Rabi* season (October- March) associated with moderately low temperature. The experiment was conducted during *Kharif-I* season. The experimental location has been shown in Appendix-II.

3.2 Planting materials

BARI Mung-6

BARI Mung-6 was used as planting material. BARI Mung-6 was released and developed by BARI in 2003. Plant height of the cultivar ranges from 40 to 45 cm. Average yield of this cultivar is about 1600 $kgha^{-1}$. The seeds of BARI Mung-6 for the experiment were collected from BARI, Joydebpur, Gazipur.

3.3 Treatments under investigation

There were two factors in the experiment as mentioned below:

Factor A: Leaf clipping (2)

C_0 = No leaf clipping

C_1 = Leaf clipping (Removing of leaf having no inflorescence)

Factor B: Nitrogen Fertilizer (5)

N_0= 0 kg urea ha^{-1}

N_1= 25 kg urea ha^{-1}

N_2= 50 kg urea ha^{-1}

N_3= 75 kg urea ha^{-1}

N_4= 100 kg urea ha^{-1}

3.3.1 Treatment combinations

There are 10 treatment combinations of different leaf clipping and different amount of Nitrogen fertilizer used in the experiment under as following:

1. C_0N_0	6. C_1N_0
2. C_0N_1	7. C_1N_1
3. C_0N_2	8. C_1N_2
4. C_0N_3	9. C_1N_3
5. C_0N_4	10. C_1N_4

3.4 Experimental design and layout

The experiment was laid out in a split-plot design having three replications. Each replication had 10 unit of plots to which the treatment combinations were assigned randomly. The unit plot size was $3m^2$ (1.5m ×2m). The replication plots and unit plots were separated by 1m and 0.75m spacing respectively.

3.5 Land preparation

The experimental land was opened with a power tiller on 08 March, 2018. Ploughing and cross ploughing were done with country plough followed by laddering. Land preparation was completed on March 20, 2018 and was ready for sowing of seeds.

3.6 Fertilizer application

Nitrogen fertilizer was applied as in treatment variables. TSP and Mop were applied @ 85 kg/ha and 35kg/ha, respectively in all plots. All fertilizers were applied by broadcasting and mixed thoroughly with soil.

3.7 Sowing of seeds

The seeds of Mungbean were sown on March 21, 2018. Before sowing, the seeds were treated with Bavistin to control the seed borne disease. The seeds were sown in rows in the furrows having a depth of 2-3 cm. The furrows were covered with the soil soon after seeding. Row to row distance was maintained at 20 cm.

3.8 Intercultural operations

3.8.1 Weed control

The crop field was weeded and herbicides were applied as per treatment of weed control methods.

3.8.2 Thinning

Thinning was done two times; first thinning was done at 10 DAS and the second was done at 18 DAS to maintain optimum plant population. Plant to plant distance was maintained at 10 cm.

3.8.3 Irrigation and drainage

Pre sowing irrigation was given to ensure the maximum germination percentage. During the whole experimental period there was a heavy rainfall. So it was essential to remove the excess water from the field. Irrigation was provided at 15 DAS for optimizing the vegetative growth of Mungbean for all the experimental plots equally. Proper drainage system was also made available for draining out excess water from irrigation and also rainfall from the experimental plot.

3.8.4 Insect and pest control

At late stage of growth pod borer and yellow mosaic virus attacked the plant. Ripcord 10 EC was sprayed at the rate of 1ml with 1litre water and was sprayed at 15 days interval. The plants that were attacked by yellow mosaic disease were uprooted and buried at a distant place under the soil. To avoid the destruction of pods by birds, the whole working area was covered by net.

3.9 Leaf clipping

Leaf clipping was done after flowering. It was done in the lower 2-3 leaves which had no inflorescence, by removing the whole leaf with the help of a knife.

3.10 Determination of maturity

At the time when 80% of the pods turned brown color, the crop was considered to attain maturity.

3.11 Harvesting and sampling

Harvesting was done when about 80% of the pods became brown to black in color. The matured pods were collected by hand picking from a pre demarcated area at the center of each plot. The pods were collected thrice from each plot.

3.12 Threshing

The pods were sun dried for three days by placing them on the open threshing floor. Seeds were separated from the pods by removing the pod cover by hand.

3.13 Drying, cleaning and winnowing

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

3.14 Parameters studied

I. Plant height

II. Number of leaves plant^{-1}

III. Pod length

IV. Pods plant^{-1}

V. Seeds pod^{-1}

VI. 1000 seed weight

VII. Seed yield

VIII. Stover yield

IX. Biological yield

X. Harvest index

3.15 Procedures of Data Collection

I. Plant height (cm)

The height of the selected plants was measured from the ground level to the tip of the plants at 30, 45 and 60 days after sowing to determine the average value for each treatment.

II. Leaves plant^{-1} (no.)

Number of leaves per plant was counted from each selected plant sample and then averaged at 30, 45 and 60 days after sowing.

III. Pod length (cm)

Pod length was measured in centimeter scale from randomly selected ten pods. Mean value of them was recorded treatment wise.

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

Number of pods per plant was counted from each selected plant sample.

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

Average number of seed pod^{-1} was calculated by counting the number of seed from 10 randomly selected pod for each treatment.

VI. 1000 seed weight (g)

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

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

Seed yield was recorded on the basis of total harvested seeds per 3m^2 and was expressed in the terms of yield (t ha^{-1}). Seed yield was adjusted at about 12% moisture content.

VIII. Stover yield

Stover yield was determined from the central $3m^2$ area of each plot. After threshing, the plant parts were sun-dried and weight was taken and finally converted to ton per hectare.

IX. Biological yield

The biological yield was calculated with the following formula-

Biological yield = Grain yield + Stover yield

X. Harvest index (%)

Harvest index was calculated on dry basis with the help of following formula-

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

3.16 Data analysis

The collected data on different parameters were compiled and statistically analyzed to find out the significant difference of different nitrogen fertilizer doze and leaf clipping on growth and yield contributing characters of Mungbean with the help of computer package program Statistix 10.0 and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of significance.

CHAPTER IV
RESULTS AND DISCUSSION

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

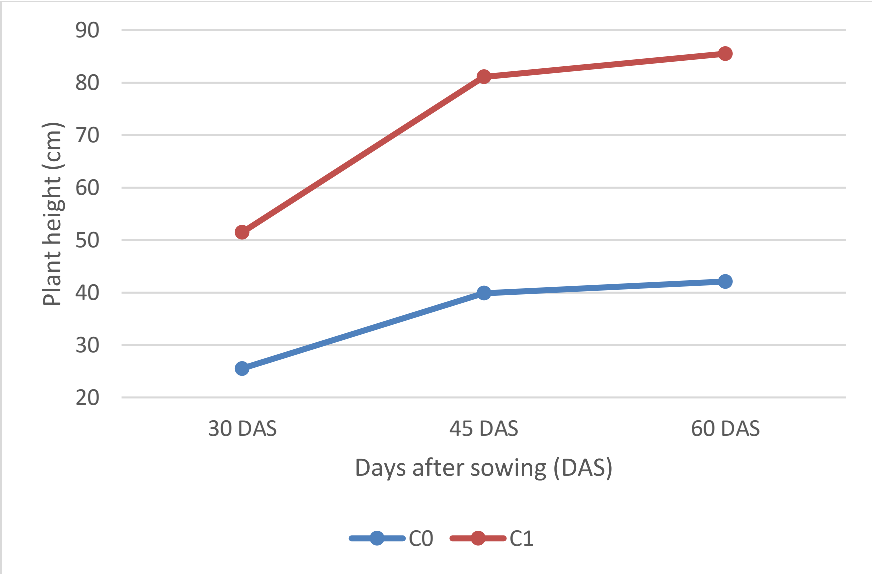
4.1 Plant height

There was a significant variation in plant height at 45 and 60 days after sowing (DAS) due to leaf clipping. The tallest plant (25.94, 41.24 and 43.41cm at 30, 45 and 60 DAS, respectively) was obtained from C_1 (Removal of empty leaf) and the shortest plant (25.53, 39.87 and 42.09 cm at 30, 45 and 60 DAS, respectively) from C_0 (Control) (Fig. 1). The increasing trend of plant with leaf clipping was also observed by Sultana (2008).

The plant height was significantly varied with the different doses of nitrogen fertilizer. The tallest plant (28.19, 44.78 and 45.04cm at 30, 45 and 60 DAS, respectively) was obtained from N_2 (50 kg urea ha^{-1}) and the shortest plant (22.07, 36.58 and 40.90cm at 30, 45 and 60 DAS respectively) obtained from N_0 (control) (Fig. 2).

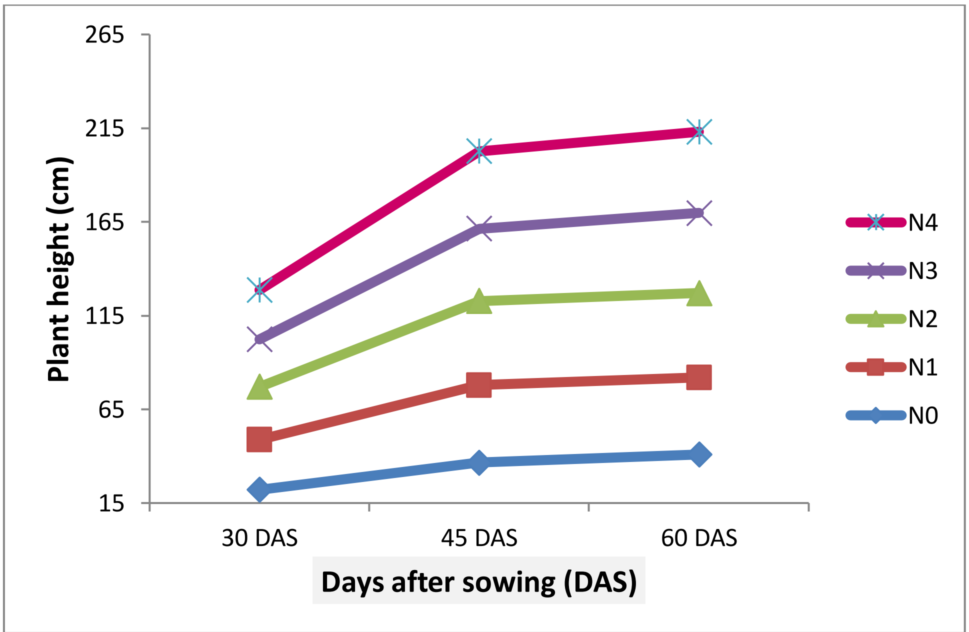
Razzaque *et al*. (2017) reported that increasing nitrogen level in nutrient stress soil increased growth and dry matter production up to 60 kg urea ha^{-1} irrespective of genotype and thereafter decreased.

Interaction of leaf clipping and nitrogen fertilizer was significant in case of plant height of mungbean (Table 1). The tallest plant (28.97, 44.97 and 45.55cm at 30, 45 and 60 DAS, respectively) was obtained from C_1N_2 (leaf clipping with 50kg urea ha^{-1}) treatment combination which was statistically similar with C_0N_2(no leaf clipping with 50kg urea ha^{-1}) treatment combination. While the shortest (22.07, 36.21, and 40.76cm at 30, 45 and 60 DAS, respectively) with C_0N_0 (with control) which was statistically similar with C_0N_1 (25 kg urea ha^{-1} with no leaf clipping).



C_0 = No leaf clipping, C_1 = Leaf clipping (Removal of leaves having no inflorescence)

Figure 1. Effect of leaf clipping on the plant height of mungbean at different days after sowing (LSD = NS, 1.21 and 1.20 at 30, 45 and 60 DAS, respectively)



N_0= Control, N_1=25 kg urea ha^{-1}, N_2 =50 kg urea ha^{-1}, N_3=75 kg urea ha^{-1}, N_4=100 kg urea ha^{-1}

Figure 2. Effect of different doses of nitrogen fertilizer on plant height of mungbean at different days after sowing (LSD= 1.54, 1.92 and 1.89 at 30, 45 and 60 DAS, respectively)

Table 1. Interaction of leaf clipping and nitrogen fertilizer on the plant height of mungbean at different days after sowing

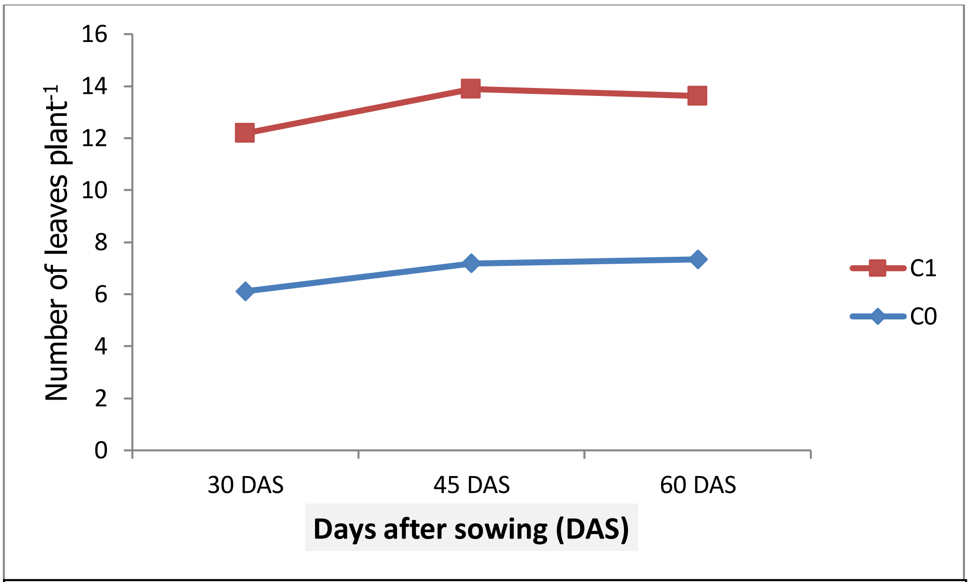
Treatment combination	Plant height (cm) at		
	30 DAS	45 DAS	60 DAS
C_0N_0	22.07 d	36.21 f	40.76 e
C_0N_1	26.61 bc	40.17 c	40.93 e
C_0N_2	27.41 ab	44.59 a	44.52 ab
C_0N_3	24.89 c	38.21 de	41.36 de
C_0N_4	26.67 bc	40.19 c	42.90 c
C_1N_0	22.08 d	36.96 ef	41.05 e
C_1N_1	26.79 bc	42.53 b	42.73 cd
C_1N_2	28.97 a	44.97 a	45.55 a
C_1N_3	25.84 bc	39.19 cd	44.14 a-c
C_1N_4	26.02 bc	42.54 ab	43.59 bc
$LSD_{(0.05)}$	1.965	1.487	1.466
CV (%)	5.05	4.58	5.90

4.2 Leaves plant^{-1}

The number of leaves plant^{-1} was significantly influenced by leaf clipping at 45 and 60 DAS. The maximum number of leaves plant^{-1} (6.11, 7.18 and 7.34 at 30, 45 and 60 DAS, respectively) was obtained from C_0 (control) treatment and the minimum (6.08, 6.71 and 6.27 at 30, 45 and 60 DAS, respectively) from C_1 (leaf clipping) treatment (Fig. 3).

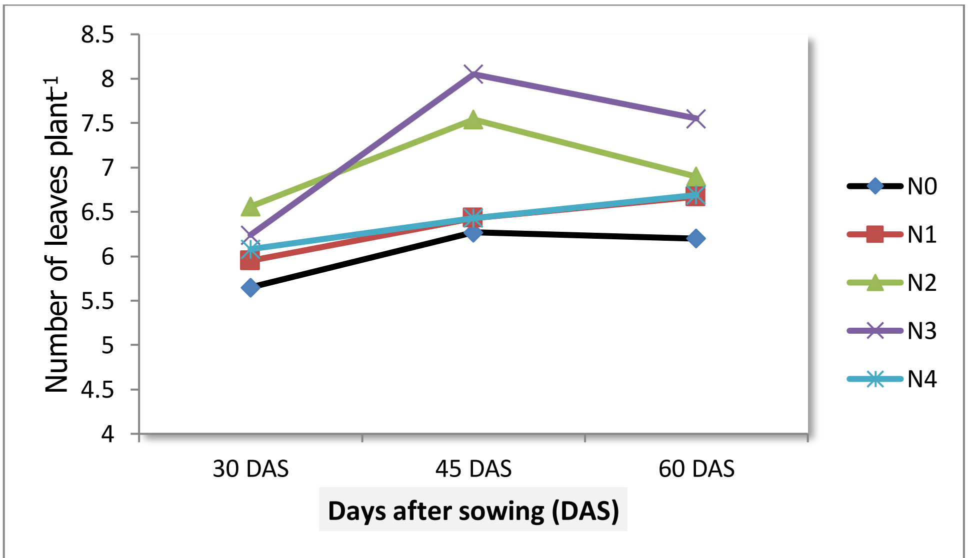
The number of leaves plant^{-1} was significantly influenced by doses of nitrogen. The N_3 (75 kg urea ha^{-1}) produced maximum number of leaves (6.24, 8.05 and 7.55 at 30, 45 and 60 DAS, respectively)which was statistically similar with N_2(50kg urea ha^{-1}) and the minimum (5.65, 6.27 and 6.20 at 30, 45 and 60 DAS, respectively) number of leaves plant^{-1} was recorded in N_0 (control) (Fig. 4). Mauyo *et. al.*, (2008) observed that the number of leaves increases with the increase of dose of nitrogen up to a certain level.

Interaction of leaf clipping and nitrogen doses had significant variation on number of leaves plant^{-1} of mungbean. The highest number of leaves plant^{-1} (6.26, 8.50 and 8.50 at 30, 45 and 60 DAS, respectively) was obtained from C_0N_3 (75 kg urea ha^{-1} with control) treatment while the lowest number of leaves plant^{-1} (5.62, 6.13 and 5.53 at 30, 45 and 60 DAS, respectively) from C_1N_0 (leaf clipping with control).



C_0=No leaf clipping, C_1=Leaf clipping (Removal of leaves having no inflorescence)

Figure 3. Effect of leaf clipping on the number of leaves plant^{-1} of mungbean at different days after sowing (LSD = NS, 0.46 and 0.44 at 30, 45 and 60 DAS, respectively)



N_0= Control, N_1=25 kg urea ha^{-1}, N_2 =50 kg urea ha^{-1}, N_3=75 kg urea ha^{-1}, N_4=100 kg urea ha^{-1}

Figure 4. Effect of different doses of nitrogen fertilizer on the number of leaves plant^{-1} of mungbean at different days after sowing (LSD = 0.039, 0.73 and 0.689 at 30, 45 and DAS, respectively)

Table 2. Interaction of leaf clipping and nitrogen fertilizer on the number of leaves plant^{-1} of mungbean at different DAS

Treatment combination	Number of leaves plant^{-1} at		
	30 DAS	**45 DAS**	**60 DAS**
C_0N_0	5.67 g	6.40 e	6.87 b-e
C_0N_1	5.97 e	6.67 de	7.07 bc
C_0N_2	6.57 a	7.87 b	7.27 b
C_0N_3	6.27 b	8.50 a	8.50 a
C_0N_4	6.09 d	6.47 e	6.97 b-d
C_1N_0	5.62 h	6.13 e	5.53 g
C_1N_1	5.93 f	6.20 e	6.27 f
C_1N_2	6.55 a	7.20 cd	6.53 d-f
C_1N_3	6.21 c	7.60 bc	6.60 c-f
C_1N_4	6.07 d	6.40 e	6.40 ef
$LSD_{(0.05)}$	0.029	0.5641	0.53
CV (%)	0.56	5.56	5.28

Yield contributing characters:

4.3 Pod length

There was a significant variation with the pod length of mungbean due to the leaf clipping (Table 4). The longest pod length (8.54 cm) was obtained from C_1 (leaf clipping) treatment compared to C_0 (control) treatment.

Pod length is one of the most important yield contributing characters of mungbean. Different doses of nitrogen showed significant variation in pod length (Table 5). The longest pod length (8.63 cm) was recorded in N_2 (50 kg urea ha^{-1}) which was statistically similar to the result obtained from N_3 (75 kg urea ha^{-1}) and N_1 (25 kg urea ha^{-1}). The shortest pod length (7.09 cm) was observed in N_0 (control). This result is in full agreement with Hossen *et al.* (2015). He reported that pod length increased significantly due to increasing dose of nitrogen up to 45 kg urea ha^{-1} followed by both 30 and 60 kg urea ha^{-1} where both doses were statistically similar in respect of pod length. Moniruzzaman *et al*. (2009) reported that pod length was significantly influenced by higher dose of nitrogen.

Interaction of leaf clipping and different doses of nitrogen fertilizer was significant on pod length of mungbean (Table 6). The highest pod length (9.06 cm) was obtained from C_1N_2 (leaf clipping with 50 kg urea ha^{-1}) treatment which was statistically similar with C_1N_3 (leaf clipping with 75 kg urea ha^{-1}) and C_1N_1 (leaf clipping with 25 kg urea ha^{-1}) while the lowest pod length (6.17 cm) was obtained from C_0N_0 (control).

4.4 Pods plant^{-1}

There was a significant variation in the number of pods plant^{-1} due to leaf clipping. The maximum number of pods plant^{-1} (9.02) was obtained from C_1 (leaf clipping) treatment and the minimum number of pods plant^{-1} (7.59) was obtained from C_0 (control) (Table 4).

The number of pods plant^{-1} was significantly influenced by different doses of nitrogen. The highest number of pod plant^{-1} (9.73) was recorded in N_2(50kg urea ha^{-1}) which was statistically similar with result obtained from N_3 (75kg urea ha^{-1}). The lowest number of pod plant^{-1}(5.84) was recorded in N_0 (control). This result is in full agreement with Parvez (2011). He found that high N dose (50 kg ha^{-1}) gave significantly higher number of pods and seeds pod^{-1}. Hossen *et al.* (2015) reported that the maximum number of pods plant^{-1} was obtained in 45 kg urea ha^{-1}, whereas control treatment produced the minimum number of pods plant^{-1}. Moniruzzaman *et al*. (2009) reported that there was a significant effect of N fertilizers on pod production plant^{-1}.

Interaction effect of leaf clipping and different doses of nitrogen was significant on number of pods plant^{-1}. The highest number of pods plant^{-1} (10.67) was obtained from C_1N_2 (50 kg urea ha^{-1} with leaf clipping) which was statistically similar with C_1N_3 (75 kg urea ha^{-1} with leaf clipping) and C_1N_1 (25 kg urea ha^{-1} with leaf clipping) while the lowest number of pods plant^{-1} (4.80) from C_0N_0 (control treatment) (Table 6).

4.5 Seeds pod^{-1}

There was a significant variation in the number of seeds pod^{-1} due to the leaf clipping. The maximum number of seeds pod^{-1} (11.28) was obtained from C_1 treatment and the minimum (10.31) was from C_0. (Table 4)

The number of seeds pod^{-1} of mungbean was significantly varied with different doses of nitrogen. The highest number of seeds pod^{-1}(11.47) was recorded inN_2 (50 kg urea ha^{-1}) which was statistically similar with N_1 (25 kg urea ha^{-1}) and N_3 (75 kg urea ha^{-1}). The lowest number of seeds pod^{-1} (9.80) was obtained from N_0 (control). This result is in full agreement with Razzaque *et al.* (2017). They recorded that there was general trend of increase in seed yield with the increase of N fertilizer but it was at par with 60 kg urea ha^{-1} and thereafter decreased the seed yield of mungbean. Hossen *et al.* (2015) found that among the nitrogen doses, nitrogen fertilizer at the rate of 45 kg ha^{-1} produced significantly the more seeds pod^{-1} followed by 30 kg urea ha^{-1}. While the minimum number of seeds pod^{-1} was taken from the control or without nitrogen in the study. Similar result was also obtained by Parvez (2011), who found that high nitrogen dose gave significantly higher number of seeds pod^{-1}.

Interaction effect of different doses of nitrogen and leaf clipping had a significant effect on number of seeds pod^{-1} (Table 6). The highest number of seeds pod^{-1} (12.07) was obtained from C_1N_2 (50 kg urea ha^{-1} with leaf clipping) treatment which was statistically similar with C_1N_1 (25 kg urea ha^{-1} with leaf clipping) and C_1N_3 (75 kg urea ha^{-1} with leaf clipping). While the lowest number of seeds pod^{-1} (9.60) was obtained from C_0N_0 (control treatment).

4.6 Thousand seed weight (TSW)

There was significant variation in the thousand seed weight due to the leaf clipping. The maximum thousand seed weight (44.38g) was obtained from C_1 (leaf clipping) and the minimum (39.33g) from C_0 (control) (Table 4).

The 1000 seed weight of mungbean was significantly varied with different doses of nitrogen. The highest 1000 seed weight (43.89g) was recorded in N_2 (50 kg urea ha^{-1}) which was statistically similar with the result found from N_1 (25 kg urea ha^{-1}). In contrast, the lowest 1000 seed weight (39.15g) was recorded in N_0 (control). Similar result was found by Hossen *et al.* (2015). They stated that urea at the rate of 45 kg ha^{-1} recorded the highest weight of 100 seed followed by 30 kg urea ha^{-1}, while it was lowest in control treatment. Similarly, Mian and Hossain (2014) also found significant variation on 1000-seed weight where 1000-seed weight had higher in $urea_{40}$ kg ha^{-1}. Similarly, Ayub *et al.* (1999) also found that the urea at the rate of 40 kg ha^{-1} produced highest 1000-grain weight.

Interaction effect of different doses of nitrogen and leaf clipping had a significant variation on thousand seed weight. The highest thousand seed weight (47.64g) was obtained from C_1N_2 (leaf clipping with 50 kg urea ha^{-1}) treatment which was statistically similar with C_1N_1 (leaf clipping with 25 kg urea ha^{-1}) while the lowest thousand seed weight (38.14g) was obtained from C_0N_0 (control treatment) (Table 6).

Table 3. Effect of leaf clipping on the yield contributing characters of mungbean

Treatments	Pod length (cm)	Pods plant^{-1} (No.)	Seeds pod^{-1} (No.)	1000-seed weight (g)
C_0	7.59b	7.59 b	10.31 b	39.33 b
C_1	8.54 a	9.02 a	11.28 a	44.38 a
$LSD_{(0.05)}$	0.3992	1.394	0.760	3.678
CV(%)	8.95	13.28	9.95	7.69

Table 4. Effect of different doses of nitrogen fertilizer on the yield contributing characters of mungbean

Treatments	Pod length (cm)	Pods plant^{-1} (No.)	Seeds pod^{-1} (No.)	1000-seed weight (g)
N_0	7.09 c	5.84 e	9.80 c	39.15 d
N_1	8.20 ab	8.50 bc	11.28 ab	43.65 ab
N_2	8.63 a	9.73 a	11.47 a	43.89 a
N_3	8.41 ab	9.30 ab	11.09 a-c	41.78 c
N_4	7.98 b	8.19 cd	10.26 c	40.82 cd
$LSD_{(0.05)}$	0.6312	1.204	0.701	1.815
CV (%)	6.39	21.67	12.87	12.75

Table 5. Interaction of leaf clipping and different doses of nitrogen fertilizer on the yield contributing characters of mungbean

Treatment combination	Pod length (cm)	Pods plant^{-1} (No.)	Seeds pod^{-1} (No.)	1000-seed weight (g)
C_0N_0	6.17 d	4.80 e	9.60 f	38.14 e
C_0N_1	7.80 c	7.87 cd	10.63 df	39.83 de
C_0N_2	8.20 bc	8.80 bc	10.87 b-d	40.13 de
C_0N_3	8.00 c	8.60 bc	10.41 d	39.40 e
C_0N_4	7.76 c	7.90 cd	10.02 d	39.14 e
C_1N_0	8.00 c	6.87 d	10.12 d	40.15 de
C_1N_1	8.60 ab	9.13 a-c	11.94 ab	47.46 ab
C_1N_2	9.06 a	10.67 a	12.07 a	47.64 a
C_1N_3	8.82 a	10.00 ab	11.77 a-c	44.15 c
C_1N_4	8.20bc	8.47 b-d	10.50 df	42.50 d
$LSD_{(0.05)}$	0.49	1.71	1.12	3.05
CV (%)	6.39	21.67	12.87	12.75

4.7 Seed yield (t ha^{-1})

There was a significant variation in the seed yield ha^{-1} due to the leaf clipping. The maximum seed yield ha^{-1} (0.96 tha^{-1}) was obtained from C_1 (leaf clipping) and the minimum (0.73 tha^{-1}) was obtained in C_0 (control) (Table 7).

The yield of mungbean was significantly varied with different doses of nitrogen. Yield is a function of various yield components such as number of pod plant^{-1}, seed pod^{-1} and 1000 grain weight. The highest seed yield (1.16 tha^{-1}) was recorded in N_2 (50 kg urea ha^{-1}) which was statistically similar with N_3 (75 kgurea ha^{-1}). In contrast, the lowest seed yield was recorded in N_0 (control).

Hossen *et al.* (2015) reported that the seed yield was higher in 45 kg urea ha^{-1} followed by 30 kg urea ha^{-1} and the minimum seed yield was obtained from the control treatment. Eric *et al*. (2012), Ayub *et al*. (1999), Siddiqui (2010) and Sen *et al*. (2010) found significant variation in grain yield.

Interaction of different nitrogen doses and leaf clipping had a significant variation seed yield ha^{-1}. The highest seed yield (1.34 tha^{-1}) was obtained from C_1N_2 (leaf clipping with 50 kg urea ha^{-1}) treatment combination which was statistically similar with C_1N_3 (leaf clipping with 75 kg urea ha^{-1}) while the lowest (0.38 tha^{-1}) from C_0N_0 (control) (Table 9).

4.8 Stover yield (t ha^{-1})

The experimental result varied with growth and yield of Mungbean by leaf clipping on stover yield of mungbean. Results showed that the maximum stover yield (2.39 tha^{-1}) was recorded from C_0 (control) whereas the lowest stover yield (2.34tha^{-1}) was achieved from C_1 (leaf clipping) (Table 7).

Stover yield of mungbean had a significant variation from different doses of nitrogen. Results revealed that the highest stover yield (2.54 tha^{-1}) was recorded from N_2 (50 kg urea ha^{-1}) which was statistically similar with N_3 (75 kg urea ha^{-1}) and N_1 (25 kg urea ha^{-1}) whereas the lowest stover yield (1.69 ton) was achieved from N_0 (control).

Significant variation was observed in the interaction effect of different doses of nitrogen and leaf clipping on stover yield (Table 9). Results revealed that the highest stover yield (2.81 tha^{-1}) was recorded from C_0N_2 (no leaf clipping with 50 kg urea ha^{-1}) which was statistically similar with C_0N_3 (no leaf clipping with 75 kg urea ha^{-1} The lowest stover yield (1.59 tha^{-1}) was recorded from C_1N_0 (leaf clipping with controlled nitrogen application).

4.9 Biological yield (t ha^{-1})

There was no significant influence on the biological yield of Mungbean due to leaf clipping (Table 7). The maximum biological yield (2.95 tha^{-1}) was found from C_1 (leaf clipping), and the minimum biological yield (2.93 tha^{-1}) from C_0 (control) condition.

Biological yield of Mungbean was significantly influenced by different doses of nitrogen (Table 8). The maximum biological yield (3.70 tha^{-1}) was found from N_2 (50 kg urea ha^{-1}). The lowest biological yield (2.20 tha^{-1}) was observed from N_0 (control).

Interaction effect of different nitrogen doses and leaf clipping had a significant influence on biological yield of Mungbean. The highest biological yield (3.79 tha^{-1}) was obtained from C_0N_2 (no leaf clipping with 50 kg urea ha^{-1}) treatment combination which was statistically similar with C_1N_2 (leaf clipping with 50 kg urea ha^{-1}) while the lowest biological yield (2.18 tha^{-1}) was recorded from C_0N_0 (control)which was statistically similar with C_1N_0 (leaf clipping with control N) (Table 9).

4.10 Harvest index (%)

There was a significant influence in the harvest index of mungbean due to the leaf clipping. The maximum harvest index (32.50%) was obtained from C_1 (leaf clipping) and the minimum (20.96%) was obtained in C_0 (control) (Table 7).

Harvest index of Mungbean was significantly varied with different doses of nitrogen. The maximum harvest index (31.31%) was recorded in N_2 (50 kg urea ha^{-1})which was statistically similar with N_3 (75 kg urea ha^{-1}). In contrast, the lowest harvest index was recorded in N_0 (control).

Interaction effect of different nitrogen doses and leaf clipping had a significant influence on harvest index of mungbean. The highest harvest index (37.14%) was obtained from C_1N_2 (leaf clipping with 50 kg urea ha^{-1}) treatment combination which was statistically similar with C_1N_3 (leaf clipping with 75 kg urea ha^{-1}) while the lowest (18.46%) from C_0N_0 (control treatment) (Table 9).

Table 6. Effect of leaf clipping on the seed, stover, biological yield and harvest index of mungbean

Treatments	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
C_0	0.73 b	2.34	2.95	20.96 b
C_1	0.96 a	2.39	2.93	32.50 a
$LSD_{(0.05)}$	0.2309	NS	NS	5.228
CV(%)	8.33	13.29	9.34	7.98

Table 7. Effect of different doses of nitrogen fertilizer on the seed, stover, biological yield and harvest index of mungbean

Treatments	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N_0	0.51 c	1.69 c	2.20 d	23.63 c
N_1	0.78 bc	2.12 a-c	2.90 c	26.74 bc
N_2	1.16 a	2.54 a	3.70 a	31.31 a
N_3	0.97 ab	2.35 ab	3.32 c	27.84 ab
N_4	0.64 bc	1.96 bc	2.59 c	24.12 bc
$LSD_{(0.05)}$	0.3651	0.4413	0.3238	3.82
CV (%)	7.54	6.67	9.17	8.27

Table 8. Interaction of leaf clipping and different doses of nitrogen on the seed, stover, biological yield and harvest index of mungbean

Treatment combination	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
C_0N_0	0.38 f	1.80 de	2.18 f	18.46 g
C_0N_1	0.57 d-f	2.25 bc	2.82 cd	20.25 fg
C_0N_2	0.98 bc	2.81 a	3.79 a	25.49 e
C_0N_3	0.75 c-e	2.55 ab	3.30 b	21.44 f
C_0N_4	0.49 ef	2.07 cd	2.56 e	19.16 fg
C_1N_0	0.65 d-f	1.59 e	2.24 f	28.79 cd
C_1N_1	0.98 bc	1.99 cd	2.97 c	33.23 b
C_1N_2	1.34 a	2.27 bc	3.61 a	37.14 a
C_1N_3	1.19 ab	2.14 cd	3.33 b	34.25 ab
C_1N_4	0.78 cd	1.84 de	2.62 de	29.08 c
$LSD_{(0.05)}$	0.28	0.34	0.25	2.93
CV (%)	7.54	6.67	9.17	8.27

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at the research plot of Sher-e-Bangla Agricultural University Farm, Dhaka during the period of March 2018 to June 2018 to study the effect of leaf clipping and Nitrogen fertilizer on growth and yield of Mungbean. In this experiment, the treatment consisted of two leaf clipping *viz*. C_0 = No leaf clipping (Control), C_1 = Leaf clipping (Removal of leaves having no inflorescence) and five nitrogen doses *viz*.N_0= 0 kg urea ha^{-1}, N_1= 25 kg urea ha^{-1}, N_2= 50 kg urea ha^{-1}, N_3= 75 kg urea ha^{-1}, N_4= 100 kgurea ha^{-1}. The experiment was laid out in a split-plot design having three replications. Data on different growth parameters, physiological parameters and yield contributing parameters of Mungbean were recorded. The collected data were statistically analyzed for evaluation of the treatment effect. A significant variation among the treatment was found while different level of leaf clipping and with different doses of nitrogen fertilizer.

Plant height was significantly influenced by leaf clipping. The tallest plant (25.94, 41.24 and 43.41cm at 30, 45 and 60 DAS, respectively), minimum number of leaves plant^{-1} (6.08, 6.71 and 6.27 at 30, 45 and 60 DAS, respectively), the longest pod length (8.54 cm), the maximum number of pods plant^{-1} (9.02), maximum number of seeds pod^{-1} (11.28), an highest weight of thousand seed (44.38g) , the maximum seed yield hectare^{-1} (0.96 ton) , the maximum biological yield (2.95 tha^{-1}) , the maximum harvest index (32.50%) was obtained from C_1(Leaf clipping) compared to C_0 (Control) treatment.

All parameters significantly varied due to the different doses of nitrogen fertilizer. The tallest plant (28.19, 44.78 and 45.04cm at 30, 45 and 60 DAS respectively), the longest pod length (8.63 cm), the highest number of pod plant^{-1} (9.73), highest number of seeds pod^{-1} (11.47), maximum weight of 1000-seed (43.89g), the highest seed yield (1.16 ton ha^{-1}), highest stover yield (2.54 t ha^{-1}), maximum biological yield (3.70 t ha^{-1}), maximum harvest index (31.31%) were recorded in N_2 (50 kg urea ha^{-1}). But maximum number of leaves plant^{-1} (6.24, 8.05 and 7.55 at 30, 45 and 60 DAS respectively) were obtained from N_3 (75 kg urea ha^{-1}). The shortest plant (25.53, 39.87 and 42.09 cm at 30, 45 and 60 DAS respectively), minimum (5.65, 6.27 and 6.20 at 30, 45 and 60 DAS respectively) number of leaves plant^{-1}, shortest pod length (7.09 cm), lowest number of pods plant^{-1} (5.84), lowest number of seeds pod^{-1} (9.80), minimum weight of 1000-seed (39.15 g), lowest seed yield (0.51 t ha^{-1}), minimum biological yield (2.20 t ha^{-1}), minimum harvest index (23.63%) were recorded from N_0 (control).

Interaction of leaf clipping and nitrogen fertilizer doses was significant on all parameter. The tallest plant (28.97, 44.97 and 45.55cm at 30, 45 and 60 DAS respectively), the longest pod length (9.06 cm), the highest number of pod plant^{-1} (10.67), highest number of seeds pod^{-1} (12.07), maximum weight of 1000-seed (47.64g), the highest seed yield (1.34 ton ha^{-1}), maximum harvest index (37.14%) were recorded in C_1N_2 (50 kg urea ha^{-1} with leaf clipping). But the maximum number of leaves plant^{-1}(6.26, 8.50 and 8.50 at 30, 45 and 60 DAS respectively) were obtained from C_0N_3 (75 kg urea ha^{-1} with control).The highest stover yield (2.81 ton ha^{-1}) and the highest biological yield (3.79 ton)were obtained from C_0N_2 (50kg urea ha^{-1} with control). The shortest plant (22.07, 36.21, and 40.76cm at 30, 45 and 60 DAS respectively), shortest pod length (6.17 cm), lowest number of pods plant^{-1} (4.80), lowest number of seeds pod^{-1} (9.60), minimum weight of 1000-seed (38.14g), lowest seed yield (0.38 t ha^{-1}), minimum biological yield (2.18 t ha^{-1}), minimum harvest index (18.46%) from C_0N_0 (Control N with no leaf removal).The lowest number of leaves plant^{-1} (5.62, 6.13 and 5.53 at 30, 45 and 60 DAS respectively)and lowest stover yield (1.59 ton) were recorded from C_1N_0 (leaf clipping with no nitrogen application).

Conclusion

Based on the findings of the research it could be concluded that-

- ✓ N_2 (50 kg urea ha^{-1}) provided the best result in terms of yield and yield contributing parameters.
- ✓ Leaf clipping (Removal of leaves having no inflorescence) showed the best performance regarding most of the yield contributing parameters.
- ✓ 50 kg urea $ha^{-1}$with leaf clipping (removal of leaves having no inflorescence) gave the best result considering yield and yield contributing parameters.

Recommendation

Further experiments may be conducted with different levels leaf clipping treatments and different doses of nitrogen fertilizer in different agro-ecological zones(AEZ) of Bangladesh.

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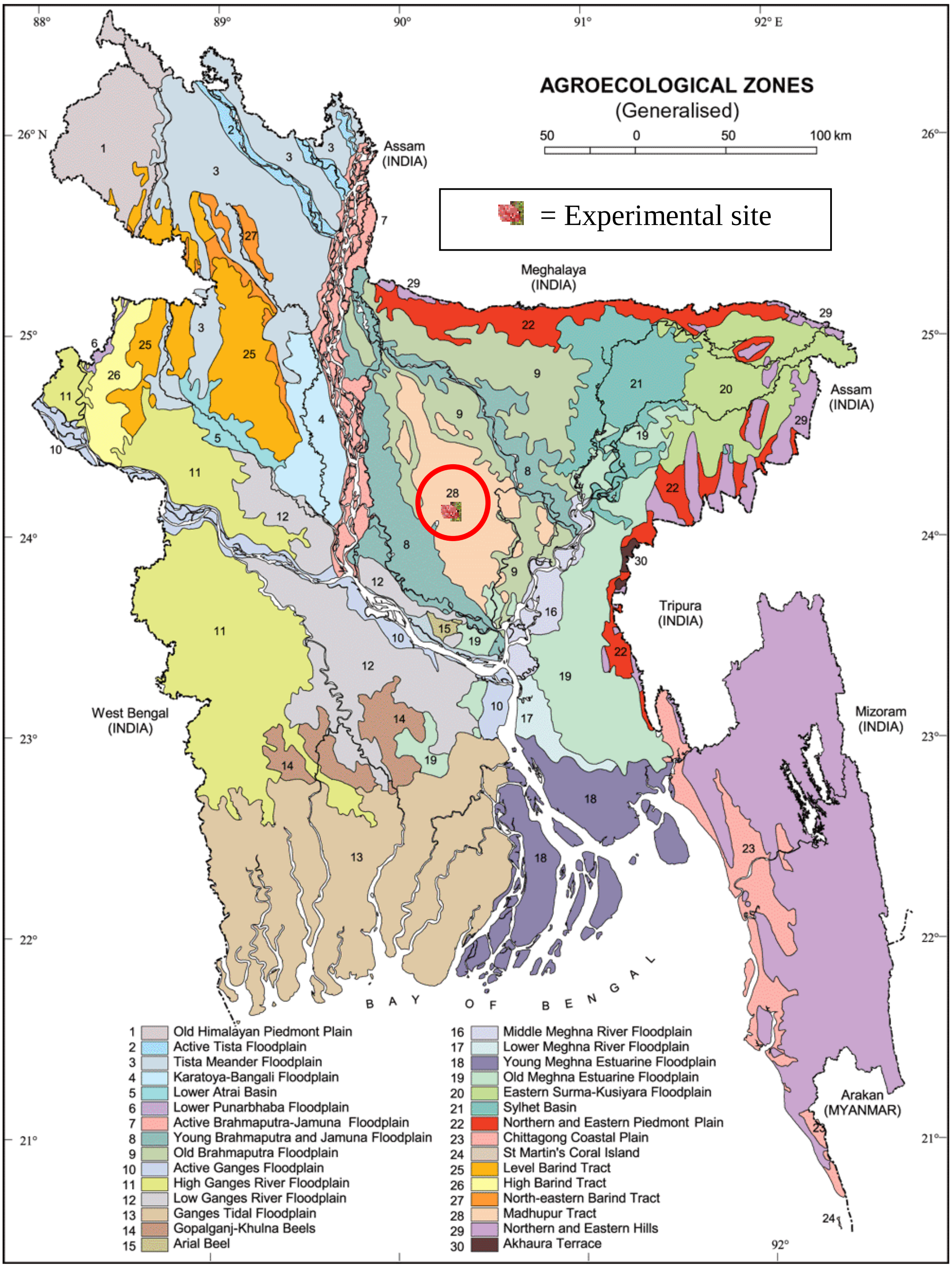
APPENDICES

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



Appendix II. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from March to June, 2018

Month	Air temperature(^{0}C)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
March	34	16	57	17.62
April	35	20	66	99.35
May	35	21	75	147.24
June	36	20	80	88.60

- Monthly Average
- Source: World Weather Online (https://www.worldweatheronline.com/dhaka-weather-averages/bd.aspx)

Appendix III. Characteristics of the soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. The physical and chemical characteristics of soil (0-15cm depth)

Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Soil Characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.75
Total nitrogen (%)	0.07
Phosphorus	22.08 µg/g soil
Sulphur	25.98 µg/g soil
Magnesium	1.00 meq/100g soil
Boron	0.48 µg/g soil
Copper	3.54 µg/g soil
Zinc	3.32 µg/g soil
Potassium	0.30 µg/g soil

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

Appendix IV. Analysis of variance of the data on plant height

A. Plant height at 30 DAS

Source of variation	DF	SS	MS	F	P
Replication (A)	2	1.027	0.513		
Leaf clipping (B)	1	1.257	1.257	0.2829	0.9852
Error I	2	8.883	4.442		
Nitrogen fertilizer (C)	4	125.368	31.342	7.2983	0.0015
B*C	4	4.443	1.111	0.2586	0.4430
Error II	16	68.711	4.294		
Total	29	209.711			

Grand Mean	25.735
CV (replication*leaf clipping)	9.85
CV (replication*leaf clipping*nitrogen fertilizer)	5.05

B. Plant height at 45 DAS

Source of variation	DF	SS	MS	F	P
Replication (A)	2	5.556	2.778		
Leaf clipping (B)	1	13.981	13.981	1.4672	0.3495
Error I	2	19.058	9.529		
Nitrogen fertilizer(C)	4	229.975	57.494	6.0774	0.0036
B*C	4	5.198	1.299	0.1374	0.0439
Error II	16	151.364	2.460		
Total	29	425.133			

Grand Mean	40.556
CV (replication*leaf clipping)	9.22
CV (replication*leaf clipping*nitrogen fertilizer)	4.68

C. Plant height at 60 DAS

Sources of variation	DF	SS	MS	F	P
Replication (A)	2	37.413	18.706		
Leaf clipping (B)	1	13.028	13.028	10.9439	0.0598
Error I	2	2.381	1.190		
Nitrogen fertilizer (C)	4	58.374	14.593	1.0896	0.0805
B*C	4	5.868	1.467	0.1095	0.3948
Error II	16	214.304	2.390		
Total	29	331.367			

Grand Mean	42.754
CV (replication*leaf clipping)	11.29
CV (replication*leaf clipping*nitrogen fertilizer)	5.90

Appendix V. Analysis of variance of the data on number of leaves plant^{-1}

A. Number of leaves plant^{-1}at 30 DAS

Sources of variation	DF	SS	MS	F	P
Replication (A)	2	0.027	0.014		
Leaf clipping (B)	1	0.011	0.011	2.0473	0.2787
Error I	2	0.011	0.005		
Nitrogen fertilizer (C)	4	2.766	0.692	593.5635	0.2888
B*C	4	0.002	0.000	0.4120	0.0008
Error II	16	0.019	0.001		
Total	29	2.835			

Grand Mean	6.095
CV (replication*leaf clipping)	3.89
CV (replication*leaf clipping*nitrogen fertilizer)	0.56

B. Number of leaves plant^{-1}at 45 DAS

Sources of variation	DF	SS	MS	F	P
Replication (A)	2	0.222	0.111		
Leaf clipping (B)	1	1.685	1.685	5.3482	0.1469
Error I	2	0.630	0.315		
Nitrogen fertilizer(C)	4	15.317	3.829	10.8309	0.0002
B*C	4	0.643	0.161	0.354	0.0029
Error II	16	5.657	0.345		
Total	29	24.155			

Grand Mean	6.944
CV (replication*leaf clipping)	6.29
CV (replication*leaf clipping*nitrogen fertilizer)	5.56

C. Number of leaves plant^{-1}at 60 DAS

Sources of variation	DF	SS	MS	F	P
Replication (A)	2	1.167	0.583		
Leaf clipping (B)	1	8.587	8.587	11.4082	0.0776
Error I	2	1.505	0.753		
Nitrogen fertilizer (C)	4	5.776	1.444	4.5554	0.0120
B*C	4	1.791	0.448	1.4124	0.2748
Error II	16	5.072	0.317		
Total	29	28.898			

Grand Mean	6.800
CV (replication*leaf clipping)	7.87
CV (replication*leaf clipping*nitrogen fertilizer)	5.28

Appendix VI. Analysis of variance of the data on yield contributing characters

A. Pod length

Sources of variation	DF	SS	MS	F	P
Replication (A)	2	0.517	0.258		
Leaf clipping (B)	1	6.769	6.769	132.3833	0.0075
Error I	2	0.102	0.051		
Nitrogen fertilizer(C)	4	8.544	2.136	8.0385	0.0009
B*C	4	1.623	0.406	1.5270	0.2416
Error II	16	4.252	0.266		
Total	29	21.806			

Grand Mean 8.061
CV (replication*leaf clipping) 8.95
CV (replication*leaf clipping*nitrogen fertilizer) 6.39

B. Pod plant^{-1}

Sources of variation	DF	SS	MS	F	P
Replication (A)	2	14.352	7.176		
Leaf clipping (B)	1	15.423	15.423	2.3460	0.0478
Error I	2	13.148	6.574		
Nitrogen fertilizer (C)	4	55.128	13.782	4.2484	0.0026
B*C	4	2.059	0.515	0.1587	0.0157
Error II	16	51.905	3.244		
Total	29	152.015			

Grand Mean 8.311
CV (replication*leaf clipping) 13.28
CV (replication*leaf clipping*nitrogen fertilizer) 21.67

C. Seed pod^{-1}

Sources of variation	DF	SS	MS	F	P
Replication (A)	2	0.372	0.186		
Leaf clipping (B)	1	7.115	7.115	10.7305	0.0819
Error I	2	1.326	0.663		
Nitrogen fertilizer (C)	4	11.659	2.915	1.5098	0.0246
B*C	4	1.145	0.286	0.1489	0.0189
Error II	16	30.889	1.931		
Total	29	52.505			

Grand Mean 10.793
CV (replication*leaf clipping) 9.95
CV (replication*leaf clipping*nitrogen fertilizer) 12.87

D. 1000-seed weight

Sources of variation	DF	SS	MS	F	P
Replication (A)	2	24.461	12.231		
Leaf clipping (B)	1	191.370	191.370	4.2409	0.0175
Error I	2	90.249	45.124		
Nitrogen fertilizer(C)	4	94.479	23.620	0.8299	0.0456
B*C	4	37.347	9.337	0.3281	0.0227
Error II	16	455.378	22.570		
Total	29	893.278			

Grand Mean 41.854
CV (replication*leaf clipping) 7.69
CV (replication*leaf clipping*nitrogen fertilizer) 12.75

Appendix VII. Analysis of variance of the data on seed, stover, biological yield and harvest index

A. Seed yield

Sources of variation	DF	SS	MS	F	P
Replication (A)	2	0.197	0.098		
Leaf clipping (B)	1	0.943	0.943	2.2780	0.0273
Error I	2	0.828	0.414		
Nitrogen fertilizer (C)	4	1.608	0.402	4.1184	0.0176
B*C	4	0.032	0.008	0.0813	0.0416
Error II	16	1.562	0.089		
Total	29	5.169			

Grand Mean 0.811
CV (replication*leaf clipping) 8.33
CV (replication*leaf clipping*nitrogen fertilizer) 7.54

B. Stover yield

Sources of variation	DF	SS	MS	F	P
Replication (A)	2	1.070	0.535		
Leaf clipping (B)	1	0.817	0.817	0.7015	0.0075
Error I	2	2.329	1.164		
Nitrogen fertilizer (C)	4	2.606	0.651	1.0287	0.0142
B*C	4	0.120	0.030	0.0473	0.0324
Error II	16	10.132	0.130		
Total	29	17.072			

Grand Mean 2.131
CV (replication*leaf clipping) 13.29
CV (replication*leaf clipping*nitrogen fertilizer) 6.67

C. Biological yield

Sources of variation	DF	SS	MS	F	P
Replication (A)	2	0.750	0.375		
Leaf clipping (B)	1	0.005	6.005	0.0015	0.0126
Error I	2	5.932	2.966		
Nitrogen fertilizer (C)	4	8.268	2.067	1.9313	0.0154
B*C	4	0.091	0.023	0.0212	0.1016
Error Ii	16	17.125	1.070		
Total	29	32.170			

Grand Mean 2.942
CV (replication*leaf clipping) 9.34
CV (replication*leaf clipping*nitrogen fertilizer) 9.17

D. Harvest index

Sources of varation	DF	SS	MS	F	P
Replication (A)	2	257.778	128.889		
Leaf clipping (B)	1	998.672	998.672	8.6634	0.0986
Error I	2	230.549	115.275		
Nitrogen fertilizer (C)	4	232.220	58.055	1.2726	0.0321
B*C	4	11.701	2.925	0.0641	0.0472
Error II	16	729.891	45.618		
Total	29	2460.811			

Grand Mean 26.728
CV (replication*leaf clipping) 7.98
CV (replication*leaf clipping*nitrogen fertilizer) 8.27