GROWTH AND YIELD RESPONSE OF MUNGBEAN TO ADDED UREA FOLIAR SPRAY AND LEAF CLIPPING

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GROWTH AND YIELD RESPONSE OF MUNGBEAN TO ADDED UREA FOLIAR SPRAY AND LEAF CLIPPING

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CERTIFICATE

This is to certify that the thesis entitled ***"GROWTH AND YIELD RESPONSE OF MUNGBEAN TO ADDED UREA FOLIAR SPRAY AND LEAF CLIPPING"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***AGRONOMY****, embodies the results of a piece of bona fide research work carried out by* ***MD. DALOUR HOSSAIN****, Registration. No.* ***12-04808*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated: December, 2018

Dhaka, Bangladesh

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DEDICATED TO

MY

BELOVED PARENTS

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ABSTRACT

An experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka, during March to May 2018 to study the impact of added urea foliar spray and leaf clipping on growth and yield of mungbean. The experiment composed of four levels of urea foliar spray *viz*. F_0 = Recommended Fertilizer (RF) + No Foliar Spray (FS), F_1 = RF + 1% Urea FS at Flower Initiation (FI), F_2 = RF + 2% Urea FS at FI, F_3 = RF + 3% Urea FS at FI and four levels of Leaf clipping *viz*. C_0 = No leaf clipping, C_1 = Clipping 1 basal leaf, C_2 = Clipping 2 basal leaves, C_3 = Clipping total apical leaves having no inflorescence. BARI Mung-5 was used as study material. The experiment was laid out in Split-plot Design with three replications. Results indicated that foliar spray and leaf clipping had significant effect on most of the growth and yield contributing parameters. In case of foliar spray of urea, the maximum plant height (51.96 cm), nodules plant^{-1} (5.19), highest above ground dry matter plant^{-1} (11.89 g), pods plant^{-1} (7.95), pod length (7.70 cm), seeds pod^{-1} (10.92), 1000 seed weight (46.33 g), seed yield (0.90 t ha^{-1}), stover yield (2.35 t ha^{-1}) and biological yield (3.32 t ha^{-1}) were recorded from F_0 (Recommended Fertilizer, RF + No Foliar Spray, FS). In case of leaf clipping the maximum plant height (51.46 cm), above ground dry matter plant^{-1} (11.85 g), nodules plant^{-1} (5.1), pods plant^{-1} (7.50), pod length (7.57 cm), seeds pod^{-1} (10.54), 1000 seed weight (46.49 g), seed yield (0.98 t ha^{-1}), stover yield (2.43 t ha^{-1}) and biological yield (3.41 t ha^{-1}) were recorded from C_1 (Clipping 1 basal leaf). Regarding combined effect, the maximum plant height (61.20 cm), nodules plant^{-1} (5.23), highest above ground dry matter plant^{-1} (14.76 g), pods plant^{-1} (9.81), pod length (7.82 cm), seeds pod^{-1} (12.08), 1000 seed weight (48.07 g), seed yield (1.26 t ha^{-1}), stover yield (2.62 t ha^{-1}), biological yield (3.88 t ha^{-1}) and harvest index (32.55%) were recorded from the treatment combination of F_0C_1. So, F_0 (Recommended Fertilizer + No Foliar Spray) along with C_1 (Clipping 1 basal leaf) is suggested for yield improvement in mungbean cultivation.

LIST OF CONTENTS

LIST OF CONTENTS (contd.)

LIST OF CONTENTS (contd.)

LIST OF CONTENTS (contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Contd.)

LIST OF APPENDICES

LIST OF PLATES

LIST OF ACRONYMS

%	=	Percent
µg	=	Micro gram
^{0}C	=	Degree Celsius
AEZ	=	Agro-Ecological Zone
BARC	=	Bangladesh Agricultural Research Council
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAS	=	Days after sowing
df	=	Degrees of freedom
et al.	=	And others
etc.	=	Etcetera
FI	=	Flower Initiation
FS	=	Foliar Spray
g	=	Gram
ha^{-1}	=	Per hectare
HI	=	Harvest Index
hr	=	Hour
kg	=	Kilogram
LSD	=	Least significant difference
m	=	Meter
max.	=	Maximum
min.	=	Minimum
mm	=	Millimeter
N	=	Nitrogen
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
NS	=	Non-significant
ppm	=	Parts per million
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

Pulses are the cheapest source of high quality proteins, minerals and energy in human diet. Essential amino acids like leucine, isoleucine, lysine, valine etc are the constituents of quality proteins which are generally deficient in food grains. Though pulses are excellent sources of proteins, but they are treated as minor crops and received little attention from farmers. With the development of irrigation facilities, the area of cultivation of HYV cereal crops has been increased significantly, while pulses have been pushed to marginal lands of low yield potential. The area under pulse production has been decreasing continuously in Bangladesh alarmingly (Shahjahan, 2001).

In Bangladesh, a large number of people are suffering from malnutrition. For alleviating human malnutrition for the poorest segment of the country's population, pulses have been identified as crops with exceptional potential. The excellent value of pulses is highly complementary to a cereals-based diet in developing countries. It is called the poor men's meat as it is the cheapest source of protein. Pulses are cheaper sources of protein than animal proteins (Singh and Jambunathan, 1989). A minimum per capita intake of pulse should be 80 g day^{-1}, whereas it is 8.72 g day^{-1} in Bangladesh (BBS, 2018). The most prominent reason behind this is that national production of the pulses is not adequate against our national demand and lack of sufficient research in this regard. Therefore, the present study aims to increase the yield of pulse and mungbean in Bangladesh.

Bangladesh has favorable agro-ecological conditions for production of a number of pulses. Among them grasspea, lentil, mungbean, blackgram, chickpea, fieldpea and cowpea are important. Mungbean (*Vigna radiata* L.) is one of the most important pulse crops in Bangladesh. It belongs to the family Fabaceae. It is a warm season crop. It is grown mainly in semi-arid to sub humid low lands with (600 to 1000 mm annual rainfall, 20° to 30°C mean temperature during the period of crop production and at elevation not exceeding 1,800m to 2,000m (Poehlman, 1991). It can also tolerate high temperatures up to 40^0C but does well at $(30 – 35)^0$C, on a wide range of soil types but are best in deep, well drained loam or sandy loam soil (Gowda and Kaul, 1982). It has had more than 150 cultivated species and originated mainly from Africa; however, Asia and the Asian tropical regions have the greatest magnitude of genetic diversity of mungbean (http:// www.ars-usda.gov /npgs).

Its edible seed is characterized by higher digestibility, flavor, high protein content and absence of any flatulence effects (Ahmad *et al*., 2008). Each 100 grams of mungbean seed contains about (25-26)% protein, (1-3)% fat, (5-4)% carbohydrates, (3.5-4.5)% fibers, (4.5- 5.5)% ash, calcium 132 mg and phosphorus 367 mg (Frauque, *et al*. 2000). In Bangladesh it is used as whole or split seeds in preparing soup but in other countries, sprouted seeds are widely used as vegetables. The green plants are used as animal feed and residues are used as green manure. The crop is potentially useful in improving cropping systems as catch crop due to its rapid growth and early maturation (60-70 days). It can also fix atmospheric nitrogen through its symbiotic relationship with soil bacteria and thus improves soil fertility.

The total production of mungbean in Bangladesh during 2016-17 was 34,783 tons from an area of 1,02,311 ha (BBS, 2018). There are several reasons for the low production of mungbean. It is cultivated with minimum tillage or even zero tillage, use of local varieties, sowing very early or very late the season with minimum or even no fertilizers especially nitrogen, no pesticides, no insecticides etc. coupled with no irrigation and drainage facilities. All these factors are primarily responsible for low yield of mungbean which is incomparable with the yields of developed countries of the world (FAO, 1999). Secondly the marginal land for mungbean is notable for back drop of its lower production.

Researchers opined that mungbean and other pulses stop their symbiosis during flower initiation due to feed their reproductive units. So nitrogen is found shortage at that time which is resulted in abortion of flowers and pods (Patel *et al*., 1984). Nitrogen is the most useful for pulse crops because it is the component of protein (BARC, 1997). Foliar applied N to mungbean at flowering stage was found to increase seed yields (Abdo, 2001). The foliar application of nitrogen alone was more effective than NPK combinedly in producing higher number of seeds per pod (Hamayun *et al*., 2011). In this situation foliar spray of urea at flowering could be an option to check the abortion rate in pulses.

Generally, the mobilization of nutrient elements (i.e., translocation and re translocation) takes place within the plant during its life cycle. The extent of remobilization of the elements (e.g., N, P and K), however, depends on the availability of these elements in the plant and demand for photosynthesis. Fertilizers (N and P) may increase significantly mungbean yield (Patel and Parmer, 1986) by increasing root growth, nodulation, leaf area, and total dry matter. But optimum fertilizer requirement depends on soil fertility levels and methods of application. In this context the foliar application of nitrogen at flowering stage may fulfill the nitrogen requirement of plant at its flowering stage received very minimum N (20 kg ha^{-1}) as basal dose.

A number of studies have been reported on the effect of source-sink manipulations on the productivity of different crops. Selective defoliation improved light interception in fababean resulting in a greater photosynthetic efficiency. On the contrary, Pommer *et al.* (1984) and Hamid and Hashem (1991) observed that defoliation reduced dry matter accumulation in maize. A complete defoliation at reproductive stage reduced yield in mungbean (Rao and Ghuldyal, 1985; Hintz and Fehz, 1990), pigeonpea (Pandey and Singh, 1981), maize (Singh and Nair, 1975; Hicks *et al*., 1977), cowpea (Pandey, 1983) and sesame (Roshid, 1998). Flower removal increased dry matter accumulation in remaining reproductive sink in groundnut (Talwar *et al*., 1992) and seed yield in soybean (Olpenshaw *et al*., 1978).

Inadequate leaf production in the vegetative phase indicates that during the post-flowering phase, when the sink activity was high, most photosynthetic required for the growth and development of pods come from the current photosynthesis (Kuo *et al.,* 1978). It is therefore imperative, that for high yield formation in mungbean, it should have to attain adequate foliage development prior to pod development stage. So the old leaves are taken into considered for clipping of mungbean genotypic differences in leaf area development in mungbean have been reported (Hamid *et al.,* 1990).

However, the optimum leaf area index for maximizing yield or biomass production has not been elaborately reported. Excessive leaf development during the later growth stages was found to be detrimental to seed yield (Patel *et al.,* 1992).

Production of leaves, particularly in the lower part of the plant often causes mutual shading resulting in yield reduction. Total dry matter production is positively correlated with the amount of foliage displayed in upper 50% of the canopy of mungbean (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. Thus manipulation of source may provide opportunity for increasing yield in plants with excessive leaf development habit.

Sink in mungbean is determined by the number of pods per plant (Mackenzie *et al.,* 1975), number of seeds per pod and weight of' an individual seed (AVRDC, 1976). 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 rnungbean (Clifford, 1979). The leaves at flowering nodes are the major contributors to seed filling and development (AVRDC, 1974). Hence, the present study has been undertaken to maximize the seed yield of mungbean by manipulating its source-sink through removal of selective leaves and additional foliar spray of urea during onset of flowers with following objectives.

1. To determine the effect of added foliar spray of urea on the productivity of mungbean.
2. To evaluate the effect of leaf clipping (source-sink manipulation) on mungbean yield.
3. To study the combined effect of leaf clipping and urea foliar spray on the growth and yield of mungbean.

CHAPTER 2

REVIEW OF LITERATURE

Mungbean is a popular pulse crop in Bangladesh as well as many countries of the world. Very few studies related to increase growth, development and yield of mungbean have been carried out in Bangladesh along with all over the world. In this chapter, an effort has been made to review the available information in home and abroad regarding the effect of leaf clipping and foliar spray of urea on the growth and yield of mungbean and other legumes.

2.1 Effect of nitrogen

The management of fertilizer is the important one that greatly affects the growth, development and yield of this crop. Pulses although fix nitrogen from the atmosphere, there is evidence that application of nitrogenous fertilizers become helpful in increasing the yield. (Patel *et al.*, 1984; Ardeshana *et al.*, 1993). Nitrogen is an essential element and important determinant in growth and development of crop plants (Tanaka *et al.,* 1984). Its deficiency constrains leaf area expansion, enhances leaf senescence, alters canopy structure and subsequently reduces crop yields (Wolf *et al.,* 1988).

Azadi *et al*., (2013) conducted an experiment to evaluate and determine the appropriate nitrogen fertilization on the morphological characteristics and seed yield of mungbean using three cultivars. In that study, three mungbean cultivars (Partow, Gohar, locall) were considered as the main factor while different levels of nitrogen fertilizer (control, 50, 100, 150) kg/ha urea were used as sub-plot factor. The result showed that pod length and seed yield were varied among different cultivars. In addition, stem diameter, number of node and seed yield showed significant difference among various amounts of nitrogen fertilizer. The highest seed yield of 8.9 grams per square meter and the number of sub-branches 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) were obtained at 150 kg/ha urea. Hence, 150 kg/ha nitrogen fertilizer with partow cultivar (V_1) was suggested as the most appropriate treatment and suitable for that region. Rajender *et al.* (2002) found that pods per plant increased with increasing N rates up to 30 kg N ha^{-1}.

Achakzai *et al*. (2012) conducted an experiment to evaluate the growth response of mungbean cultivars subjected to different levels of applied N fertilizer. They took four different cultivars of mungbean viz., NM-92, NM-98, M-1, and NCM-209 and six different levels of N fertilizer applied @ (zero, 20, 40, 60, 80 and 100) kg ha^{-1}. A constant dose of P_2O_5 and K_2O were also applied to each N level (except control, zero). Urea fertilizer was used as a source of N, while TSP and MOP as sources of P & K, respectively. Maximum days to flowering (48.25) and number of branches $plant^{-1}$ (3.83) recorded for plants subjected to highest dose of applied N fertilizer was 100 kg ha^{-1}. Similar responses towards added N fertilizer was also noted for various cultivars of mungbean. Maximum days to flowering (47.72) and number of leaves $plant^{-1}$ (5.86) was recorded from NCM-209. Whereas, the maximum plant height (38.52 cm), branches $plant^{-1}$ (3.72) obtained for mungbean cultivar was M-1. The correlation coefficient (r) studies exibited that plant height (r = 0.325), branches $plant^{-1}$ (r = 0.187) and leaf area (r = 0.342) significantly ($p<0.05$) and positively correlated with their grain yield. However, days to 50% flowering (r = -0.265) was also significantly but negatively associated with their grain yield. 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 asset.

During the Kharif season, 2000, Tickoo *et al.* (2006) carried out an experiment on mungbean cultivars Pusa 105 and Pusa Vishal of which seeds were sown at 22.5 and 30 m spacing and supplied with 36-46 kg NP ha^{-1} and 58-46 kg NP ha^{-1} in a field experiment conducted in Delhi, India. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cultivar Pusa 105. NP rates had no significant effects on both the biological and grain yield of the crop. Row spacing at 22.5 cm resulted in higher grain yields in both crops.

A field experiment was conducted by Oad and Buriro (2005) to determine the effect of different NPK levels (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40) kg ha^{-1} on the growth and yield of mungbean cultivar AEM 96 in Tandojam, Pakistan, during the spring season, 2004. The different NPK levels significantly affected the crop parameters. 10-30-30 kg NPK ha^{-1} was the best treatment, recording plant height of 56.25 cm, germination of 90.50%, satisfactory plant population of 162.0 prolonged days taken to maturity of 55.50, pod length of 5.02 cm, seed weight of 10.53g per plant, seed index of 3.52 g and the highest seed yield of 1205.20 kg ha^{-1}. There was no significant change in the crop parameters beyond this level.

The response of mungbean cultivar NM - 98 was studied to seed inoculation and different levels of fertilizer (0-0, 15-30, 30-60 and 45-90 kg N- P_2O_5 ha^{-1}) under field conditions by Nadeem *et al.* (2004). Application of fertilizer significantly increased the yield and the maximum seed yield was obtained when 30 kg N ha^{-1} was applied along with 60 kg P_2O_5 ha^{-1}.

An experiment was performed by Malik *et al.* (2003) to determine the effect of varying levels of nitrogen (0, 25 and 50) kg ha^{-1} and phosphorus (0, 50, 75 and 100) kg ha^{-1} on the yield and quality of mungbean cultivar NM-98 in 2001. They observed that number of flowers per plant was found to be significantly higher with 25 kg N ha^{-1}. Number of seeds per pod was significantly affected by varying levels of nitrogen and phosphorus. Growth and yield components were significantly affected by nitrogen and phosphorus. Growth and yield components also were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg P ha^{-1} resulted in maximum seed yield (1112.96 kg ha^{-1}).

The influence of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) on mungbean cultivars MH 85-111 and T44 were determined in a field experiment conducted by Rajender *et al.* (2002) in Hisar, Haryana, India during the summer of 1999-2000. The number of branches, pods per plant, seeds per pod, 1000-seed weight and straw yield were increased with increasing N rates, whereas grain yield increased with increasing rates up to 30 kg N ha^{-1} only.

An experiment was conducted by Razzaque *et al*. (2015) to find out the nitrogen acquisition and yield of mungbean genotypes affected by different levels of nitrogen fertilizer in low fertile soil. Ten mungbean genotypes viz. IPSA-12, GK-27, IPSA-3, IPSA-5, ACC12890053, GK-63, ACC12890055, BARI Mung-6, BU mug- 4 and Binamoog- 5 and six nitrogen fertilizer levels such as (0, 20, 40, 60, 80 and 100) kg N ha^{-1} were included as experimental treatments. Results showed that increasing applied nitrogenous fertilizer in low fertile soil increased nitrogen acquisition of mungbean which increased number of pods plant^{-1} and seeds pod^{-1} and finally increased yield of mungbean upto 60 kg N ha^{-1} irrespective of genotype and thereafter decreased. Genotype IPSA - 12 produced the highest seed yield (14.22 g plant^{-1}) at 60 kg N ha^{-1}. The lowest yield (7.33 g plant $^{-1}$) was recorded in ACC12890053 in control. From regression analysis, 54 kg nitrogen ha^{-1} was suggested as the optimum dose for mungbean cultivation in the low fertile soil.

The effect of seed inoculation at different nitrogen levels on mungbean was studied by Mahboob and Asghar (2002) at the agronomic research station, Farooqabad in Pakistan. They revealed that various yield components like 1000 grain weight were affected significantly with 50-50-0 NPK kg ha^{-1}. Again they revealed that seed inoculation with 50-50-0 NPK kg ha^{-1} exibited superior performance in respect of seed yield (955 kg ha^{-1}).

The performance of mungbean was studied by Srinivas *et al.* (2002) 0, 25 and 40 kg N ha^{-1} and 0, 25, 50 kg P ha^{-1} were taken as treatment variables. They observed that the number of pods per plant was increased with the increasing rate of N up to 40 kg ha^{-1} followed by a decrease with further increase in N dose. They also observed that 1000-seed weight was increased with increasing rate of N up to 40 kg ha^{-1} along with increasing rates of P.

The effect of varying levels of N and P fertilizers was tested by Karle and Pawar (1998) on summer mungbean. They reported higher seed yield in mungbean with the application of 15 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}.

Patel *et al.* (1992) conducted a field experiment evaluate the response of mungbean to sulphur fertilization under different levels of nitrogen and phosphorus. Mungbean cultivar Gujrarat-2 and K-851 were given 10 kg N + 20 kg P ha^{-1}, 20 kg N + 40 kg P ha^{-1} and (0, 10, 20 or 30) kg S ha^{-1} as gypsum. Seed yield were (1.2 and 1.24) t ha^{-1} in Gujrarat -2 and K -851 respectively with 20 kg N + 40 kg P ha^{-1}.

A field experiment was carried out by Sharma and Sharma (1999) during summer seasons at Golaghat, Assam, India. Mungbean was grown using farmers practices (no fertilizer) or using a combinations of fertilizer application (30 kg N + 35 kg P_2O_5 ha^{-1}). Seed yield was 0.40 ton ha^{-1} with farmer's practices, while the highest yield obtained by the fertilizer application was 0.77 ton ha^{-1}. Ali *et al*. (1990), Mondal and Gaffer (1983), Gaffer and Razzaque (1983), reported that different levels of nitrogen significantly increased plant height.

According to these findings this is seemed that different fertilizers specially nitrogen has a great role in mungbean crop improvement in case of quality and quantity both. During flowering, Rhizobium bacteria become disappeared. At that time supplimental N helps the legume to stop flower and pod dropping.

2.2 Effect of foliar spray of nitrogen

Foliar application of urea improved the plant height, leaf area, shoot and root dry weights, root and shoot length, volume and number of roots in mungbean thus improved yield (Ezzat *et al*., 2012). They found that mungbean seed yield per hectare showed more response to foliar applied N than K_2O. The best seed yield per hectare was reported from the combined effect of 76 kg ha^{-1} P_2O_5 and foliar spray with N.

Foliar feeding is often the most effective and economical way to accomplish plant nutrient deficiency (Pradeep and Elamathi, 2007). Pulses although fix nitrogen from the atmosphere, there is evident that application of nitrogenous fertilizers during flowering becomes helpful in increasing the yield (Patel *et al.* 1984). Root nodule weight per plant was highest with 30 kg N ha^{-1}.

Rao *et al.* (2016) a field experiment was carried out during Rabi season of 2012-13 at Regional Agricultural Research Station, Lam, Guntur, to find out effect of foliar nutrition on physiological and biochemical parameters of mungbean under irrigated conditions. Among foliar nutrients Urea @ 2% resulted higher yield and superior over other foliar sprays. Application of 2% urea resulted more plant height, leaf area, shoot dry weight and by increasing total chlorophyll content, photosynthetic rate and total protein content.

Mahajan *et al.* (2016) carried out a field experiments in sesame on deep black soil of Mamurabad farm, Oilseed Research Station, Jalgaon (Maharashtra), india during 2009 and 2010 to find out suitable combination of soil and foliar application of urea and diammonium phosphate for seed yield maximization and remunerative treatments. They found that soil application of RDF + foliar spray of 2 percent urea twice at flowering and pod formation stages significantly increased the yield contributing characters *viz*., number of pod plant $^{-1}$ and number of seeds pod^{-1}. These characters significantly contributed in producing higher seed and oil yields and also more remunerative over soil application of RDF alone. Rahman *et al.* (2014) was carried out a trial and observed that foliar spray of N, P and K significantly increased pods/plant, seeds / pod, biomass and grain yield. It may be resulted that foliar spray of N, P and K is the suitable application for the maximum yield of mungbean.

Doss *et al.* (2013) carried out an experiment used pot culture to evaluate the effect of Diammonium phosphate (DAP), Potash (K), Nitrogen (N) and Naphthalene Acetic Acid (NAA) foliar spray treatment on the growth, yield and biochemical constituents of blackgram. The experiment was conducted at Agriculture Farm of St. Joseph's College, Trichy, Tamilnadu state during winter 2006 to 2007. Foliar spray treatment with the aqueous solution of nutrients (2% DAP, 1% K, 2% N and 200 ppm NAA, w/v) was done to the 22nd and 30th day old black gram seedlings and also observed that growth, yield and grain yield was significantly increased with foliar application of nutrients. Maximum grain yield was recorded when spread with 1% K + 200 ppm NAA concentration.

Juli *et al.* (2013) observed the effect of foliar application of urea at different stages on growth and yield of chickpea. The highest seed yield and yield contributing characters were recorded with double spray of 2 % urea at 50 % flowering and at 10 days after 50 % flowering. The results also showed double spray of 2 % urea through foliar application significantly increased the pod plant^{-1}, seed size, seeds pod^{-1} and 1000 seed weight.

Lateef *et al.* (2012) conducted two sets of field experiments in two successive summer seasons to study the effect of soil and foliar fertilization of mungbean. The first set consider the effect of late foliar application of N or K under different levels of phosphatic fertilization on mungbean yield and chemical constituents. Kawmy-l was fertilized with 0, 19, 38, 57 and 76 Kg P_20_5 ha^{-1} at sowing and foliar application of N as 1 % urea solution with K as potassium sulphate 36% K_20 solution; both N and K were applied at early pod formation stage. The second set of experiments objectives was to evaluate the effect of micronutrient application when combined with urea. From this experiment it could be resulted that mungbean productivity responds to combined soil application of P at 57 Kg P_20_5 ha^{-1} and late foliar applied N at early pod formation stage. Foliar spray of urea combined with Fe or Zn may increase seed yield and improve the quality of seeds.

Khalilzadeh *et al*. (2012) carried out an experiment on growth characteristics of mungbean affected by foliar application of urea and bio- organic fertilizers. They found that foliar application of urea substantially improved leaves plant^{-1} and improved number and dry weight of nodule.

Venkatesh and Basu (2011) observed that the effect of foliar application of urea on growth, yield and quality of chick pea. Seed yield and yield contributing characters were the highest recorded with 2 % foliar spray of urea at 75 DAS. Seed size, leaf and seed nitrogen content as well as protein content were also higher recorded in same treatment.

Mondal *et al.* (2010) concluded that seed protein content, leaf area, chlorophyll content, yield and yield attributes of greengram was increased by foliar application of 1.5 % urea at an interval of 4 days of vegetative growth stages at Mymensingh (Bangladesh).

Jeyakumar *et al.* (2008) found that foliar spray of 3 percent (%) urea at flowering and then increased significantly the number of pods plant^{-1}, 1000 grain weight and ultimately grain yield in blackgram.

A study was conducted by Nigamananda (2007) to evaluate the effect of N application time as basal and as DAP (Diammonium phosphate) or urea spray and plant growth regulator (NAA at 40 ppm) on the yield and yield components of mung bean K-851. The recommended rate of N: P: K (20:50:20 kg ha^{-1}) as basal was used as a control. Treatments included: V basal N + foliar N as urea or DAP at 25 or 35 days after sowing (DAS); V basal N + V at 25 DAP + V at 35 DAS as urea or DAP; and V basal N + V foliar spraying as urea or DAP + 40 ppm NAA. Results showed that 2% foliar spray as DAP and NAA, applied at 35 DAS, resulted in the highest values for number of pods/plant (38.3), seeds/pod, test weight flower number, fertility, fertility coefficient and grain yield (9.66 q ha^{-1}).

Sritharan *et al.* (2007) opined that 2 percent urea had the profound effect in improving the total chlorophyll content, soluble protein content and nitrate reductase activity. Foliar sprays of 2 percent urea showed the highest grain yield of 955.20 kg/ha. The yield may be enhancement due to the improved morphological, physiological, biochemical and yield parameters, viz., plant height, number of pods per plant, grain yield, harvest index, chlorophyll content, soluble protein content and nitrate reductase activity.

A field experiment was conducted by Raman and Venkataramana (2006) to investigate the effect of foliar nutrition on crop nutrient uptake and yield of mungbean. There were 10 foliar spray treatments, consisting of water spray, 2% diamonium phosphate (DAP) at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA, DAP + NAA, DAP + Penshibao, DAP + NAA + Penshibao was significantly superior to other treatments in increasing the values of N, P and K uptakes, yield attributes and yield. The highest grain yield of 1529 kg ha^{-1} was recorded with this treatment. Sritharan *et al.* (2005) observed that significant increase in the growth characters like plant height and leaf area due to foliar application of 2 % urea sprayed at three stages of crop growth like vegetative, flowering and pod filling stage for blackgram.

Patel and Patel (1994) carried out a field experiment during the summer seasons of 1990-91 at Navasari, Gujarat, India. Mungbean cv. K 851 was given 20 kg N ± 40 kg P_2O_5 ha^{-1} (recommended rate) the fertilizer application gave the highest seed yield (1.74 t/ha) which however, was not significantly different (1.67 t/ha) from the foliar application of urea (1.5%) + diammonium phosphate (0.5%) at 30 and 40 DAS. Applying only 25 or 50% of the recommended N plus P_2O_5 at recommended rates, with or without foliar N and P significantly decreased the seed yield.

Sritharan *et al.* (2005) reported that foliar spray of nutrients and plant growth regulators have tremendous effects on the yield and productivity of blackgram.

The treatments included foliar spray of 2% urea, 2% DAP, 0.2% Boric acid, 0.5% FeSO4, 0.5% ZnSO4, 0.5% sodium molybdate, 0.1% humic acid, 1% KC1, Salicylic acid 100 ppm, Brassinolide 0.1 ppm and humic acid 20 kg basal application. Among these treatments, foliar spray of 2% urea recorded the highest yield of 955.2 kg/ha followed by foliar spray of KC1 1% along with soil application of humic acid @ 20 kg/ha (926.2 kg/ha). The yield enhancement may be due to improved morphological, physiological and biochemical parameters. Hence among the tested chemicals particularly 2% urea was found effective towards yield maximization in black gram.

Foliar application is regarded as a preferred solution when quick supply of nutrients is hindered or the soil conditions are not conducive for the absorption of nutrients (Salisbury and Ross, 1985). Foliar spray technique helps the nutrients to reach the site of food synthesis directly, leading no wastage and quick supply of food and thereby reduce the requirement of fertilizers. Foliar nutrition can hasten the growth of a crop at a sudden. It is also known that active nodulation of pulse crop stops after 45 to 50 days after sowing and at that time the positive effect of supplying legume plants with supplementary nitrogen was found to have beneficial effects on enhancing growth and increasing seed yield by quick supply of nitrogen. (Ashour and Thalooth, 1983; Attia and El-Dsouky, 2001; El- Kramany and Gobarah, 2005; El-Kramany *et al*., 2003).

Palta *et al.* (2005) and Zeidan (2003) opined that foliar application of urea at 50% flowering increased the yield and seed protein. In legumes, leaf senescence starts earlier before completion of maturity which break the source sink relation, thereby reduces the yield. Nitrogen spray have been found to delay leaf senescence and improve yield.

Das and Jana (2015) conducted a field experiment for three years at Pulses and Oilseeds Research Station, Berhampore, Murshidabad, West Bengal, India, to study the effects of urea spray and seed hydro-priming in lentil. Experimental results revealed that growth, yield attributing characters, yield and seed protein content of lentil were significantly influenced by 2% urea spray and seed hydro-priming, interaction effects of these two factors. Among the foliar spray treatments, two sprays at branching and pod initiation stages recorded the highest seed yield (1271 kg ha^{-1}) of lentil cultivar WBL-58 followed by one spray at flower initiation stage (1236 kg ha^{-1}) irrespective of seed priming. Among the interaction effects, two sprays at branching and pod initiation along with water soaking recorded the highest seed yield (1295 kg ha^{-1}) followed by one spray at flower initiation along with water soaking (1265 kg ha^{-1}). Urea spray and Seed hydro-priming were found to increase the seed yield of lentil to the tune of 17.9 % and seed protein content by 19% over control.

The urea sprayed plant maintained comparatively larger LA at different stages, thus aiding in the supply of photosynthates for the development of pods and grains and also intensification of metabolic activity and efficient utilization of N (Beninger, 1978). This observation is in confirmation with the report of Brevedan *et al.* (1978). Tahir *et al*. (2013) reported that recommended fertilizer with 1% urea foliar spray significantly increased plant height in mungbean. Thus nitrogen containing source (urea) has increased the height substantially compared to the rest of the nutrients (Kalarani, 1991).

As per above reviewing studies it is said that foliar application of nitrogen has significant effect on growth and yield of field crops.

2.3 Source - sink relations: manipulations through leaf clipping

Distribution of photosynthates within a plant represents a coordinated response between photosynthetic production by source leaves and assimilated demand of sinks. Mungbean is a herbaceous plant with semi-indeterminate growth habit. Grain yield of mungbean is determined largely by the availability of assimilates after flowering to grain formation and by the grain capacity to accept assimilates. The yield of final grain number and potential grain size can be termed as sink capacity. Several workers studied the growth characteristics of mungbean. Mungbean grows slowly in early stage, picks up gradually and reaches maximum at flowering. Dry matter accumulation in the vegetative phase can barely support the growth characteristics. Senescence in mungbean is rather slow and hence leaves remain active till the later phase of reproductive development (Biswas and Hamid, 1992).

Studies of Chawdhury *et al.* (1982) indicated seasonal variations in leaf photosynthetic rates in mungbean. Net photosynthetic rate during the post flowering phase was higher which might be related with the sink demand. Although the total dry matter yield is the product of leaf photosynthetic activity and grain yield, the biomass production is not correlated with photosynthetic rate (Lambers, 1987). And as a result selection for increased leaf photosynthetic rate has not apparently resulted in any substantial or consistent increase in yield.

Rao and Ghildyal (1993) showed that the leaf photosynthetic rate in mungbean was the maximum after 28 days of sowing and decreased subsequently. Genotypic differences in leaf area development in mungbean have been reported (Hamid *et al.*, 1990). However, the optimum leaf area index for maximizing yield or biomass production has not been reported.

Patel *et al.* (1984) reported that excessive leaf area development during the later growth stages was found to be detrimental to seed yield. Production of leaves, particularly in the lower part of the plant often caused mutual shading resulting in parasitism and eventually yield reduction.

Clifford (1979) suggested that removal of apical shoot above node 5 or removal of inflorescence or axillary buds at nodes 1-4 together with the apical shoot greatly increased pod number and seed weight of mungbean. Hamid (1989) showed that defoliation at the reproductive stage reduced pod set and grain yield, and the reduction was proportional to the degree of defoliation.

Defoliation affected leaf photosynthetic rates in a number of crop species. Mariko and Hogetsu (1987) reported that defoliated sunflower plants showed higher rates of photosynthesis than those of undefoliated plants. Defoliation tends to influence the ageing of the remaining or new leaves. Physiological approaches in breeding for higher yield in mungbean are often directed to increase the total dry matter production and better redistribution of photosynthesis.

Plant with high dry matter production capacity does not mean high seed yield potential. Increase in yields over the past decade has been possible mainly through favorable partitioning into grains. It may be shown for mungbean also the partioning of dry matter seemed to be more favorable for increasing harvest index. Genotypes of a number of crop species with profuse branching often show poor harvest index in spite of high dry matter yield. In such genotypes, retention of dry matter in vegetative organs is high and is reflected by its poor harvest index. Hamid (1994) demonstrated that the development of tertiary branches and much of the secondary branches in mungbean is counter productive. Therefore, mungbean plant types with a maximum of two to three erect branches having shorter and thicker internodes and basal podding might be desirable for high yield potential. The hypothesis is subject to be tested by regulating source sink capacity.

Partioning of assimilate is generally dependent on the sinks closest to the source. For example, upper leaves export photosynthesis to the shoot apex, lower leaves to roots and middle leaves to both (Wardlaw, 1968). However since phloem sieve connections are on one side of the stem, the leaves on one side may be more efficient at exporting assimilate to sinks on the same side. According to the mass flow hypothesis, anything increasing photosynthesis, increase hydrostatic pressure and translocation rate. However, this is true only if sinks have the ability to utilize the increased production. Otherwise, there would be a steady build up of sugars in the system, causing a feedback inhibition resulting in reduced photosynthesis (Mondal *et al*., 1978).

Photosynthesis rate would be reduced to the rate at which sinks could accept assimilate. For leaf photosynthesis to be at maximum potential rates, sinks must be able to utilize all assimilate produced. Under these conditions partitioning would be controlled by sink strength that is, sink availability and the rate at which available sinks can utilize assimilate (Gifford and Evans, 1981).

The early growth of branches and tillers requires importing assimilate from the main stein or other branches until they become autotrophic. In oats, this usually occurs between the two and four leaf stage (Labanauskas and Dungan, 1956). Partitioning has been extensively studied in small grain crops. Work in wheat and barley has shown that photosynthesis of the flag leaf, stem and head which are the closest sources to the grain is the primary contributor to the grain. (Lupton, 1966; Wardlaw, 1968).

The strength of the grain as a sink and the relative availability and strength of sources affect the assimilate partitioning. If the top leaves are removed, the lower leaves will supply assimilate to the grain: if the lower leaves are removed the flag leaf will transport assimilate to roots (Marshall and Wardlaw, 1973). In soybean, in which almost every node provides seed growth and development. The pattern of translocation from each leaf is similar. The greatest amount of assimilate remains with the pods at the node of the applied leaf; with the rest transported to upper nodes and lower nodes. Lower light levels reducing the amount of assimilate produced (Shibles *et al*., 1975).

Newaz (1980) while working with field bean *(Vicia julia)* reported that defoliation intensified and improved the efficiency of photosynthesis. He noted decreased seed yield through defoliation at 90 days after sowing. He also reported a drastic reduction in yield due to defoliation at 70 days after sowing which *was* mainly attributed to loss of photosynthetic area before the pod filling stage.

In two separate experiments, Williams *et al.* (1976) and Mercer (1976) observed reduced pod growth rate, pod yield, pod and seed number following the defoliation in groundnut *(Arachis hypogea L.).* Hamid *et al.* (1991) stated that removal of leaves after anthesis resulted in yield reduction in rapeseed *(Brassica campestris L.).* They found that there were significant reduction in siliqua number per plant due to defoliation and as branches where usually formed during the pre-anthesis stage, therefore it was expected that the number of branches per plant would be unaltered due to defoliation.

In Thailand, Kupkanchanakul and Roontun (1989) found that leaf removal in deepwater rice at vegetative stage did not significantly affect grain yield, yield components and agronomic characteristics. On the average, yield, panicle number and harvest index were improved by cutting. They noted that it is possible to harvest rice herbage from deepwater rice varieties for animal feed without decreasing the grain yield.

Rastogi and Singh (1969) reported that in wheat the effect of removing the leaves from (a) the main shoot, (b) the side tillers and (c) the main shoot + side tillers at the ear-emergence stage significantly decreased the grain yield/plant and 1000-grain weight and grain weight.

Dann (1968) reported that clipping at vegetative stage decreased the straw and grain yields in wheat. 1000-grain weight was the major yield component which was reduced by clipping. However, highly significant correlations were obtained between dry matter removed by clipping, 1000-grain weight and grain yield. Stoy (1966) stated that in wheat, defoliation of the flag leaf and two top leaves at ear emergence significantly reduced both straw and grain yield.

In cowpea, partial source removal induces increase in pod and seed yield (Hossain *et al.*, 2006a) through the production of higher flowers plant^{-1} with reduced rate of floral abscission (Hossain *et.al*, 2006b). Yield was increased in branching type sesame with clipping at 35 DAS (Kokilavani *et al*., 2007) and in mustard with defoliation at 40 - 85 DAS (Chhabra *et al*., 1996). In some situations, physical leaf area 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). Negative effect of defoliation was reported in non-branching type of sesame (Tewolde *et al*., 1994; Islam, 2010; Banks and Bernardi, 1987). The effect of manipulation of source (leaf) was reported to be both advantageous and disadvantageous in sunflower and maize (Abdi *et al*., 2007; Barimavandi *et al*., 2010). One-third leaf removal from basal portion of the canopy in cowpea increased grain yield over control and severe defoliation decreased seed yield (Hossain *et al*., 2006c; Gustafson *et al*., 2006). Likewise, mild defoliations (16.6 - 20%) during reproductive phase did not adversely affect seed yield in soybean (Board and Harvelle, 1998) and in mungbean (Pandey and Singh, 1984; Begum *et al*., 1997). Reverse results of defoliation was also reported in soybean (Verma *et al*., 1992; Proulx and Naeve, 2009; Borras *et al*., 2004), in cowpea (Pandey, 1983) and in mungbean (Rao and Ghildiyal, 1985).

Islam (2014) showed that all defoliation treatments significantly increased photosynthesis and transpiration rate of the soybean genotypes. Leaf conductance was also increased due to defoliation treatments except defoliation of top one leaf.

Verma *et al*. (1992) and Board and Harville (1998) observed that partial defoliation during flowering and seed filling had no adverse effects on seed yield because of ≤ 20- 33% defoliation at flower initiation phase attains capacity to compensate leaf loss and reached leaf area ≥ 4 immediately after imposed treatment through re-growth of leaves in soybean. In the current investigation, defoliation of top 1 or 2 leaves showed superiority in seed yield compared to other treatments because of higher total dry matter, greater number of pods and seeds. The highest photosynthesis, leaf conductance and transpiration rate were observed in the regenerated leaves after defoliation of top 1 or 2 leaves.

BARI Soybean-5 showed higher photosynthetic rate compared to others. Similarly, the high source - sink ratio caused by defoliation increased the photosynthetic rates in the remaining leaves in okra, mungbean, soybean and groundnut (Bhatt and Rao, 2003; Pandey and Singh, 1984; Chen and Lia, 1991; Ghosh and Sengupta, 1986). Total dry matter production was affected by the defoliation treatments Dry matter production was severely affected by 100% defoliation followed by 50% defoliation of top leaves. BAU Soybean-147 showed the highest and AVRDC Soybean-78 the least total dry matter.

The higher leaf loss compensation capacity could be due to initial leaf area and hence, the remaining leaf after defoliation along with initials and newly emerged leaves together was capable to produce greater total dry matter by increasing photosynthesis (Islam, 2014; Rao and Ghildiyal, 1985).

As per above reviewing studies it is said that source - sink manipulation has distinguishable effect on growth and yield of field crops. Grain yield of mungbean is determined largely by the availability of assimilates after flowering to grain formation and by the grain capacity to accept assimilates also.

CHAPTER 3

MATERIALS AND METHODS

The present research work was conducted at Sher-e- Bangla Agricultural University Farm, Dhaka-1207 during the period from March to May, 2018. Brief description of soil, climate, materials and methods that are used in the experiment have been presented in this chapter.

3.1 Experimental site

The experiment was carried out at Sher-e-Bangla Agricultural University (SAU) Farm, Dhaka-1207, Bangladesh. It is situated between 23°77′ North latitude and 90°35′ East longitude at an altitude of 8.6 meters above the sea level. The land belongs to Agro-ecological zone of Modhupur Tract (AEZ-28). Location of the experiment site is presented in Appendix I.

3.2 Climate condition

The experimental area was under the sub-tropical climate that is characterized by moderately low temperature associated with less rainfall during Rabi season, (October-March) and high temperature, high humidity and heavy rainfall with occasional roaring winds during kharif season (April-September). Details of weather data regarding temperature (^{0}C), total rainfall (mm) and relative humidity (%) during the study period were collected from Bangladesh Meteorological Department, Agargoan, Dhaka-1207 (Appendix II). During the study period (March to May, 2018) the average maximum and minimum temperature were varied as (34, 35 and 34)^{0}C and 16, 20 and 23)^{0}C, respectively. The total rainfall were (65, 155 and 165) mm and the relative humidity were (57, 66 and 68) %, respectively.

3.3 Soil condition

The soil of the research field belongs to "The Modhupur Tract", AEZ - 28 is slightly acidic in reaction with low organic matter content. The experimental area was above flood level and sufficient sunshine with having available irrigation and drainage system during the experimental period. Soil sample from 0-15 cm depth were collected from experimental field and the soil analysis were done from Soil Resources Development Institute (SRDI), Dhaka. The experimental plot was high land having pH 5.6. The physical properties and nutritional status of soil of the experimental plot are given in Appendix III.

3.4 Planting material

Mungbean variety, BARI Mung-5 was used for the experiment. The seed was collected from BARI (Bangladesh Agricultural Research Institute), Joydebpur, Gazipur. Properties of BARI Mung-5 are shown below:

3.4.1 BARI Mung-5

During 1997, Bangladesh Agricultural Research Institute released BARI Mung-5 as a potential mungbean variety having strong resistance to *Cercospora* leaf spot and tolerance to yellow mosaic virus. Plant height of the cultivar ranges from 40cm to 45 cm. Its life cycle is about 55 to 60 days after emergence. One of the main characteristics of this cultivar is synchronization of pod ripening. Average yield of this cultivar is about 1700 kg ha^{-1}. The seeds are large shaped, deep green in color.

3.5 Treatments of the Experiment

The experiment consists of two factors *viz*. foliar spray of urea and leaf clipping. The treatments are as follows:

Factor A: Foliar spray of urea (4 levels)

1) F_0: Recommended Fertilizer (RF) + No Foliar Spray (FS)
2) F_1: RF + 1% Urea FS at Flower Initiation (FI)
3) F_2: RF + 2% Urea FS at FI
4) F_3: RF + 3% Urea FS at FI

Factor B: Leaf clipping (4 levels)

1) C_0: No leaf clipping
2) C_1: Clipping 1 basal leaf
3) C_2: Clipping 2 basal leaves
4) C_3: Clipping total apical leaves having no inflorescence

Therefore, the treatment combinations were given below:

F_0C_0, F_0C_1, F_0C_2, F_0C_3, F_1C_0, F_1C_1, F_1C_2, F_1C_3, F_2C_0, F_2C_1, F_2C_2, F_2C_3, F_3C_0, F_3C_1, F_3C_2, F_3C_3

3.6 Design of the experiment

The experiment was carried out in Split-plot Design with three replications. Foliar spray treatments were assigned in the main plots and leaf clipping treatments were in the sub-plots.

3.7 Layout of the field experiment

At first, the experimental area was divided into three blocks. Each block was further divided into 16 plots for the treatment combinations. Therefore, the total number of plots was 48. Afterwards, the sixteen treatment combinations were allotted to each block with proper randomization as per design of the experiment. The size of the unit plot was 2.2m x 1.5m. A distance of 30 cm between the rows and 10 cm between the plants were maintained. The distance maintained between two plots was 70cm and between blocks was 1.5m. The layout of experiment field presented in Fig. 1.

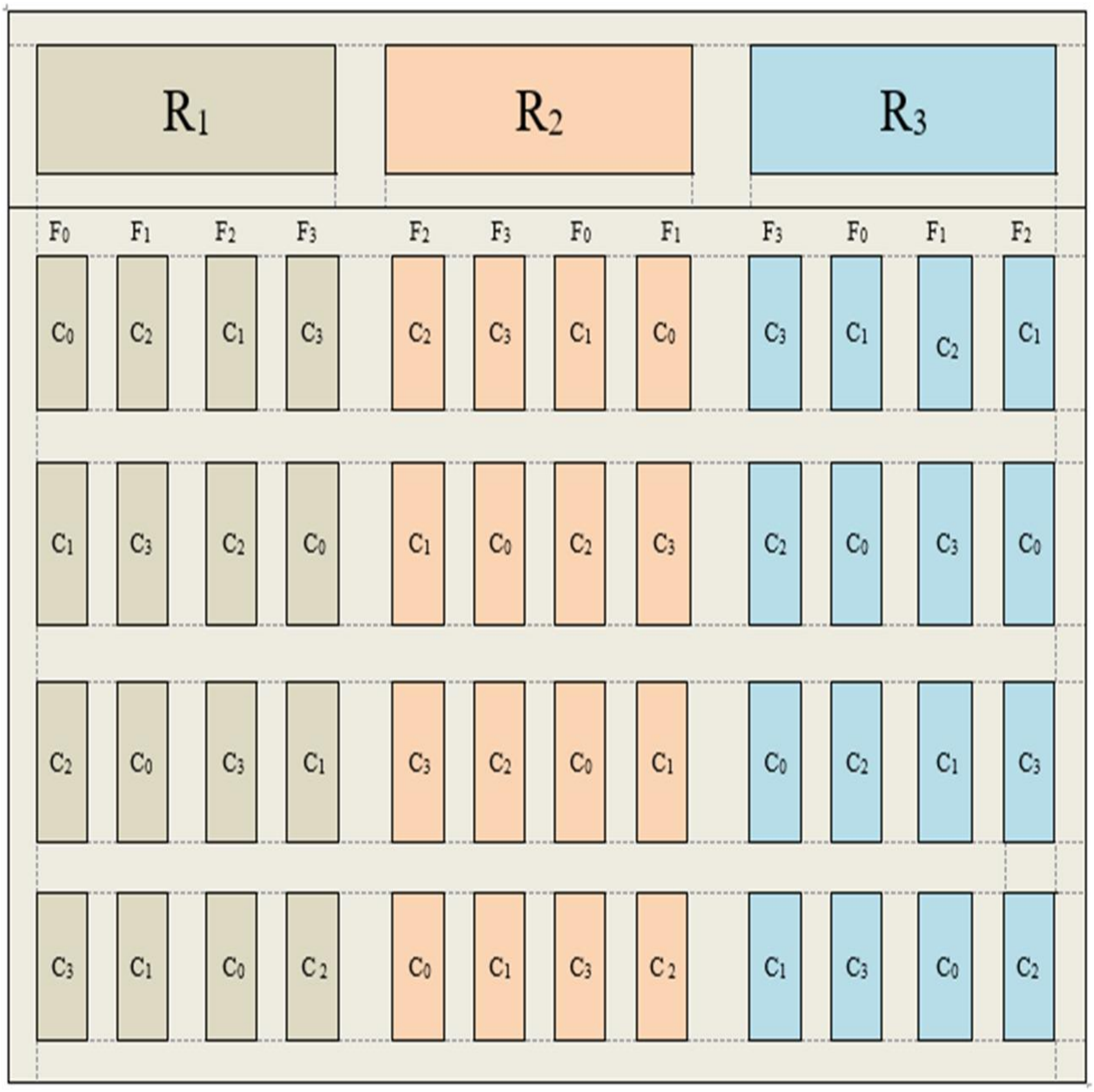


Fig.1. Layout of the experiment field

3.8 Description of the field operations

The details of the cultural operations carried out during the experiment have been presented below:

3.8.1 Growing of crops

3.8.1.1 Seed collection

The seed of the test crop i.e., BARI Mung-5 was collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur on 18 February, 2018.

3.8.1.2 Preparation of the main field and seed sowing

After the plot allotment, the activity were launched during the first week of March, 2018 with a power tiller, and was exposed to the sun for a week; after that, the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Reformation of the borders was also done using a spade. Weeds and stubbles were cleared, and finally obtained a favorable condition of soil for seed sowing. On March 8, 2018 seeds were sown mixing with Bavistin (seed treating chemical).

3.8.1.3 Fertilizers

Fertilizers were applied as basal dose during final land preparation following the rate given below:

Manure and Fertilizer	Recommended doses of fertilizer (kg ha^{-1})
N	20
P_2O_5	40
K_2O	20
S	20
H_3BO_3	1

Source: BARC, 2015

3.8.1.4 Preparation of spray mixture

The required amount of fertilizer was applied according to above mentioned recommended dose during final land preparation in all the four treatments. In addition that 0, 1, 2 and 3 % urea solution were prepared with water. Those solutions were applied in the field using a knapsack sprayer on the mungbean leaves thoroughly during flower initiation.

3.8.1.5 Intercultural operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the mungbean.

3.8.1.5.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening. Further irrigation was done when needed. Stagnant water was effectively drained out at the time of heavy rains.

3.8.1.5.2 Weeding

Several weeding were done to keep the plots free from weeds, which ultimately ensured better growth and development. First weeding was done at 20 days after sowing (DAS), second weeding was done at 45 days after sowing (DAS).

3.8.1.5.3 Plant protection

The plots were infested by Cutworms. It was successfully controlled by applying Matador 120EC at the rate of 83 mL ha^{-1} in 100L water ha^{-1}. There was no disease infestation as observed on the crop.

3.8.2 Harvesting, threshing and cleaning

The crop was finally harvested at full maturity on 26th to 30th May, 2018 and harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of mungbean seed. Fresh weight of grain and stover were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 12%. The stover was sun dried and the yields of grain and stover plot^{-1} were recorded and converted to t ha^{-1}.

3.9 Collection of data

Data were collected on the following parameters

A. Growth parameters

1) Plant height (cm)
2) Above ground dry matter plant^{-1} (g)
3) Partitioning of dry matter plant^{-1} (%)
4) Nodules plant^{-1} (no.)

B. Yield contributing parameters

1) Pods plant^{-1} (no.)
2) Pod length (cm)
3) Seeds pod^{-1} (no.)
4) Weight of 1000-seeds (g)

C. Yield parameters

1) Seed yield (kg ha^{-1})
2) Stover yield (kg ha^{-1})
3) Biological yield (kg ha^{-1})
4) Harvest index (%)

3.10 Procedure of recording data

3.10.1 Plant height

The height of plant was recorded in centimeter (cm) at 15, 30, 45, 60 DAS and harvest. Data were recorded from 5 plants from each plot and average plant height plant^{-1} was recorded. The height was measured from the ground level to the tip of the plant by a meter scale.

3.10.2 Above ground dry matter plant^{-1} (g)

Five plants were collected randomly from each plot at 30, 45, 60 DAS and harvest. Fresh plant samples from each plot were put into envelops and placed in oven maintained at 70^{0}C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final dry weight of the sample was taken and recorded in gram.

3.10.3 Partitioning of dry matter plant^{-1} (%)

The formerly computed above ground dry matter plant^{-1}(g) was broken into its allottee (stem dry weight, leaf dry weight, reproductive unit dry weight etc.) and was calculated in percentage.

3.10.4 Nodules plant^{-1} (no.)

Five plants from each plot was uprooted carefully with soil at 45 and 60 DAS then washed out with water and make clean. The number of nodules plant^{-1} was observed and counted from each plot and average number of nodules plant^{-1} was recorded as per treatment.

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

Numbers of total pods of 5 plants from each plot were counted and the mean numbers were expressed as per plant.

3.10.6 Pod length (cm)

Pod length was taken from randomly selected 20 pods and the mean length was expressed as per pod.

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

The number of seeds pods^{-1} was recorded randomly from selected 20 pods of each treatment combination at the time of harvest. Data were recorded as the average of 20 pods from each plot.

3.10.8 Weight of 1000-seeds (g)

One thousand cleaned, dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and expressed in gram.

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

The seeds collected from 1 square meter of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}.

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

The stover collected from 1 square meter of each plot was sun dried properly. The weight of stover was taken and converted the yield in t ha^{-1}.

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

Biological yield was calculated by the following formula:

$$\text{Biological yield} = \text{Seed yield} + \text{Stover yield}$$

3.10.12 Harvest index (%)

Harvest index was calculated from the ratio of grain yield to biological yield and expressed in percentage. It was calculated by using the following formula.

$$\text{HI (\%)} = \frac{\text{Economic yield (Grain yield)}}{\text{Biological yield (Grain yield + Stover yield)}} \times 100$$

3.11 Statistical analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4
RESULTS AND DISCUSSION

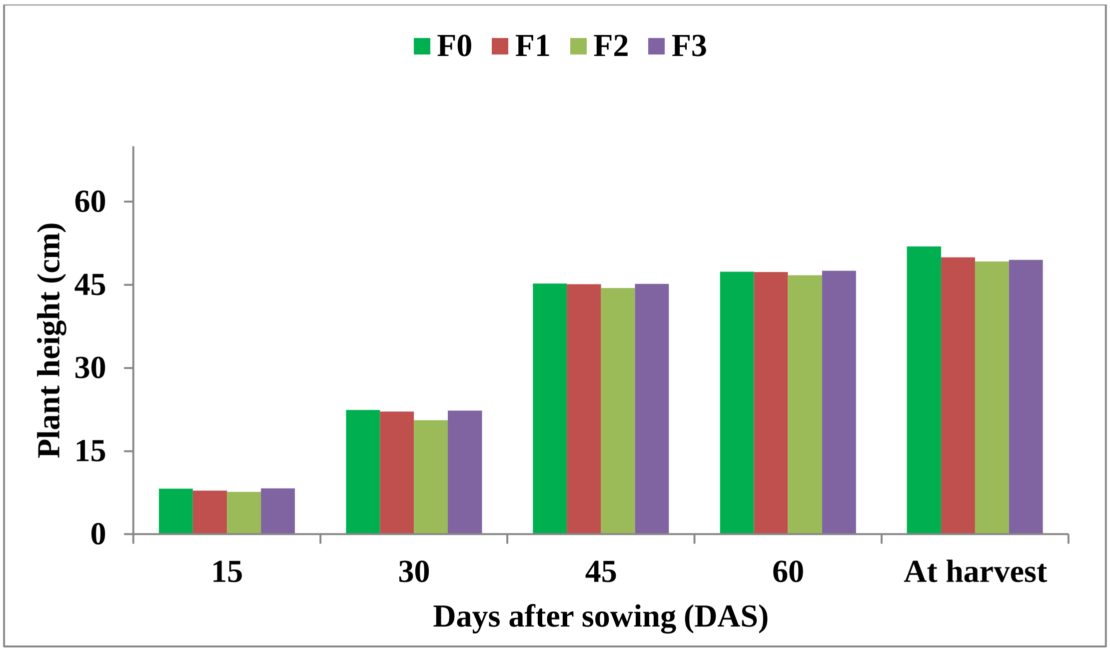
This chapter comprised presentation and discussion on the results obtained from the study on growth and yield response of mungbean to added urea foliar spray and leaf clipping. The analyses of variance (ANOVA) of the data on different growth parameters and yield of mungbean are presented in Appendix IV-VIII The results have been presented and discussed in the different tables and graphs and possible interpretations are given under the following headings:

4.1 Growth parameters

4.1.1 Plant height

4.1.1.1 Effect of foliar spray

Plant height of mungbean at 15, 30, 45, 60 DAS and harvest showed statistically non-significant variation due to fertilizer management in respect of foliar spray of urea (Appendix IV and Fig.2). Results revealed that the maximum plant height at the five stages 15, 30, 45, 60 DAS and harvest were 8.22, 22.41, 45.23, 47.40 and 51.96 cm respectively, which were recorded from F_0 (Recommended Fertilizer + No Foliar Spray) which was statistically similar with F_1 (RF+ 1% Urea FS at Flower Initiation; FI) and F_2 (RF + 2% Urea FS at FI). The minimum plant height 7.65, 20.56, 44.42, 46.73 and 49.23 cm, at 15, 30, 45, 60 DAS and harvest, respectively, were observed from F_2 (RF + 2% Urea FS at FI). These are an agreement with those of Palta *et al*. (2005) and Zeidan (2003) opined that foliar application of urea at 50% flowering increased the yield and seed protein but irresponsive in plant height. It may be due to the effect of symbiotic association of pulses with rhizobium and most of the growth of plants is achieved before reproductive stage of plant when nodules remain active in atmospheric N fixation. So during flowering stage, the effect of added foliar spray results non-significant variation.

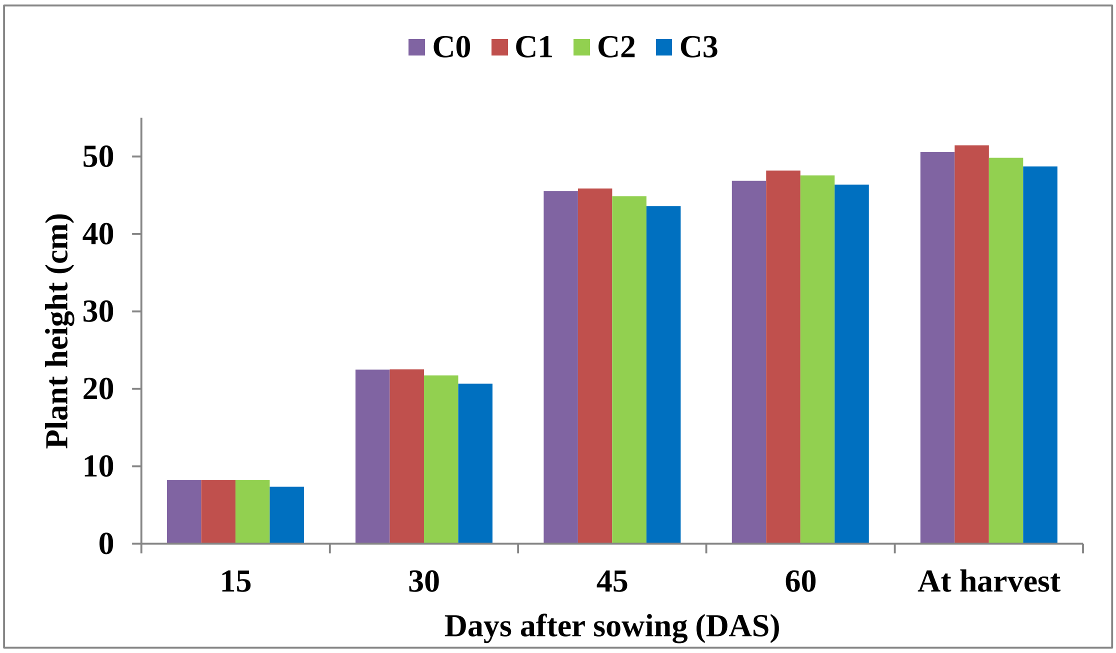


F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

Figure 2. Effect of foliar spray on plant height of mungbean at different days after sowing (LSD $_{0.05}$ = 1.08, 4.47, 4.44, 5.06 and 3.49 at 15, 30, 45, 60 DAS and harvest, respectively).

4.1.1.2 Effect of leaf clipping

Leaf clipping had a significant effect on plant height at 15, 30, 45 DAS but non-significant at 60 DAS and at harvest (Appendix IV and Fig.3). At 15 DAS, the maximum plant height (8.25 cm) was recorded in C_1 (clipping 1 basal leaf) which was statistically similar with C_0 (no leaf clipping) (8.22 cm) and C_2 (clipping 2 basal leaves) (8.23 cm), while the minimum plant height (7.37 cm) was observed in C_3 (clipping total apical leaves having no inflorescence). The maximum plant height (22.53 cm) was found in C_1 which was statistically similar with C_0 (22.49 cm) and followed by C_2 (21.74 cm), while the minimum plant height was obtained in C_3 (20.69 cm) at 30 DAS. At 45 DAS, the maximum plant height was found in C_1 (45.90 cm) which was statistically similar with C_0 (45.57 cm) and followed by C_2 (44.89 cm), whereas the minimum plant height was recorded in C_3 (43.62 cm). At 60 DAS, the maximum plant height was found in C_1 (48.21 cm) which was statistically similar with C_2 (47.56 cm), whereas the minimum plant height was recorded in C_3 (46.37 cm) which was statistically similar with C_0 (46.86 cm). At harvest, the maximum plant height was recorded in C_1 (51.46 cm) which was closely followed by C_0 (50.61 cm) and C_2 (49.86 cm). On the other hand, the minimum plant height was obtained in C_3 (48.74 cm). The finding is close conformity of findings with Tripathi *et al*. (2012), Kumar *et al*. (2009) and Raj and Tripathi (2005). They found that leaf clipping played an important role in producing longest plant of mungbean. It may be due to reduced mobilization of photosynthates to unproductive sink, rather to young meristem, resulting significant variance during early stage but when it goes to reproductive stage, height increment becomes an optional job or even stops, hence non-significant variation at later stage.



C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

Figure 3. Effect of leaf clipping on plant height of mungbean at different days after sowing ($LSD_{0.05}$ = 0.83, 1.29, 2.13, 2.77 and 2.80 at 15, 30, 45, 60 DAS and harvest, respectively).

4.1.1.3 Combined effect of foliar spray and leaf clipping

Combined effect of foliar spray of urea and leaf clipping showed significant differences for plant height at 15, 30, 45, 60 DAS and at harvest (Appendix IV and Table 1). At 15 DAS, the maximum plant height (9.13 cm) was found in the treatment combination of F_3C_0 (Recommended fertilizer + 3% urea foliar spray at flower initiation × No leaf clipping) which was statistically similar with F_0C_0, F_0C_1, F_0C_2, F_0C_3, F_1C_0, F_1C_1, F_2C_0, F_2C_1, F_2C_2, F_3C_0, F_3C_1, F_3C_2 and F_3C_3 while the minimum plant height (6.60 cm) was observed in the treatment combination of F_2C_3 (Recommended fertilizer + 2% urea foliar spray at flower initiation × Clipping total apical leaves having no inflorescence) which was statistically similar with F_0C_0, F_0C_1, F_1C_2, F_1C_3, F_2C_0, F_2C_2, F_3C_1 and F_3C_3.

At 30 DAS, The maximum plant height (24.90 cm) was recorded in the treatment combination of F_0C_2 (F_0 = Recommended fertilizer + No foliar spray× Clipping 2 basal leaves) which was statistically similar with F_0C_2, F_1C_0, F_2C_2, F_3C_0, and F_3C_3 while the minimum plant height (17.92 cm) was found in the treatment combination of F_2C_3 (F_0 = Recommended fertilizer + 2% urea foliar spray at flower initiation × Clipping total apical leaves having no inflorescence) which was statistically similar with F_2C_0.

At 45 DAS, the maximum plant height (50.55 cm) was obtained in the treatment combination of F_3C_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation × Clipping total apical leaves having no inflorescence) which was statistically similar with F_0C_1, F_1C_0, F_2C_1 and F_2C_2 while the minimum plant height (40.69 cm) was recorded in the treatment combination of F_0C_3 (F_0 = Recommended fertilizer + No foliar spray× Clipping total apical leaves having no inflorescence) which was statistically similar with F_1C_1, F_1C_3, F_2C_0, F_2C_3, F_3C_0, F_3C_1 and F_3C_2.

At 60 DAS, the maximum plant height (53.02 cm) was obtained in the treatment combination of F_3C_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation × Clipping total apical leaves having no inflorescence) which was statistically similar with F_0C_1, F_0C_2, F_1C_0, F_1C_2, F_2C_1, F_2C_2 and F_3C_0 while the minimum plant height (40.69 cm) was recorded in the treatment combination of F_2C_0 (Recommended fertilizer + 2% urea foliar spray at flower initiation × Clipping no leaf) which was statistically similar with F_0C_0, F_0C_3, F_1C_1, F_1C_3, F_2C_3, F_3C_0, F_3C_1 and F_3C_2.

At harvest, the maximum plant height (61.20 cm) was obtained in the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf) which was statistically similar with F_1C_0 while the minimum plant height (45.10 cm) was recorded in the treatment combination of F_1C_1 (Recommended fertilizer + 1% urea foliar spray at flower initiation × Clipping 1 basal leaf) which was statistically similar with F_0C_0, F_0C_3, F_1C_3, F_2C_0, F_2C_1, F_2C_3, F_3C_0, F_3C_1 and F_3C_2. It may be due to effect of foliar spray is being non-significant on plant height during flowering and leaf clipping reduced mobilization of photosynthates towards old unexpected leaves; rather, large proportion was migrated to comparatively juvenile shoots and leaf, resulting in increased plant height. On the other hand, the old leaves on which photosynthates translocated, are naturally dropped out during senescence. Hence, traditional practices results in lessening the photosynthetic efficacy.

Table 1. Combined effect of foliar spray and leaf clipping on plant height (cm) of mungbean at different days after sowing (DAS)

Treatment combinations	Plant height (cm)				
	15	30	45	60	At harvest
F_0C_0	7.87 a-d	21.35 c-e	45.90 c-e	46.89 c-d	48.71 c-f
F_0C_1	7.87 a-d	22.28 b-e	48.71 a-e	50.70 ab	61.20 a
F_0C_2	8.93 ab	24.90 a	45.63 c-f	48.45 a-c	51.03 b-e
F_0C_3	8.20 ab	21.09 de	40.69 g	43.57 cd	46.89 d-f
F_1C_0	8.33 a-c	24.78 ab	50.24 ab	50.42 ab	55.82 ab
F_1C_1	8.93 ab	21.99 c-e	42.42 d-g	43.99 cd	45.10 f
F_1C_2	7.47 b-d	21.21 c-e	46.03 b-e	49.85 ab	50.77 b-e
F_1C_3	6.87 cd	20.61 de	41.90 e-g	42.66 d	46.27 d-f
F_2C_0	7.53 a-d	20.03 ef	41.42 fg	42.50 d	50.63 b-f
F_2C_1	8.33 a-c	21.51 c-e	46.51 a-d	50.10 ab	50.33 b-f
F_2C_2	8.13 a-d	22.76 a-d	48.39 a-c	50.37 ab	51.47 b-d
F_2C_3	6.60 d	17.92 f	41.33 g	46.23 b-d	47.53 d-f
F_3C_0	9.13 a	23.78 a-c	44.71 c-g	47.61 a-d	50.69 b-f
F_3C_1	7.87 a-d	21.18 de	41.90 e-g	45.43 b-d	45.81 ef
F_3C_2	8.40 a-c	21.24 c-e	43.54 d-g	44.19 cd	46.16 d-f
F_3C_3	7.80 a-d	23.15 a-d	50.55 a	53.02 a	54.27 bc
$LSD_{0.05}$	**1.65**	**2.577**	**4.255**	**5.534**	**5.602**
CV (%)	**12.21**	**7.00**	**5.61**	**6.95**	**6.63**

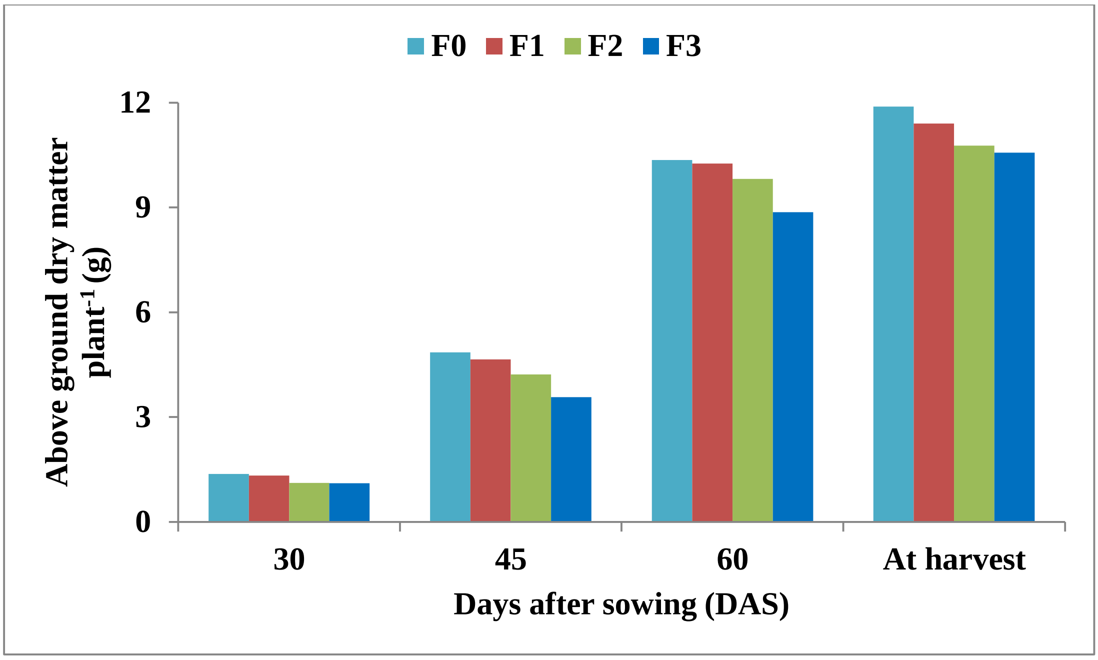
In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of significance
F_0 = Recommended fertilizer + No foliar spray
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

4.1.2 Above ground dry matter plant^{-1} (g)

4.1.2.1 Effect of foliar spray

Statistically significant variation was found due to different foliar spray of urea in terms of above ground dry matter plant^{-1} at 30, 45, 60 DAS and at harvest (Appendix V and Fig.4). At 30 DAS, the highest above ground dry matter plant^{-1} (1.37 g) was found from F_0 (Recommended fertilizer + No foliar spray) which was statistically similar (1.32 g) with F_1 (Recommended fertilizer + 1% urea foliar spray at flower initiation), whereas the lowest dry matter plant^{-1} (1.10 g) was recorded in F_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation) which was statistically similar (1.12 g) with F_2 (Recommended fertilizer + 2% urea foliar spray at flower initiation). The highest above ground dry matter plant^{-1} (4.85 g) was found from F_0 which was statistically similar (4.65 g) with F_1, whereas the lowest dry matter plant^{-1} (3.57 g) was recorded in F_3 which was statistically similar (4.22 g) with F_2 at 45 DAS. At 60 DAS, The highest above ground dry matter plant^{-1} (10.36 g) was found from F_0 which was statistically similar (10.26 g) with F_1 and followed by (9.82 g) with F_2, whereas the lowest dry matter plant^{-1} (8.87 g) was recorded in F_3. At harvest, the highest above ground dry matter plant^{-1} (11.89 g) was found from F_0 which was statistically similar (11.40 g) with F_1, whereas the lowest dry matter plant^{-1} (10.57 g) was recorded in F_3 which was statistically similar (10.77 g) with F_2. Similar result was found by Salisbury and Ross (1985). According to them, Foliar spray technique helps the nutrients to reach the site of food synthesis directly, leading no wastage and quick supply of food and thereby reduce the requirement of fertilizers. Foliar nutrition can hasten the growth of a crop at a sudden. It is also known that active nodulation of pulse crop stops after 45 to 50 days after sowing and at that time the positive effect of supplying legume plants with supplementary nitrogen was found to have beneficial effects on enhancing growth resulting increase in dry matter.

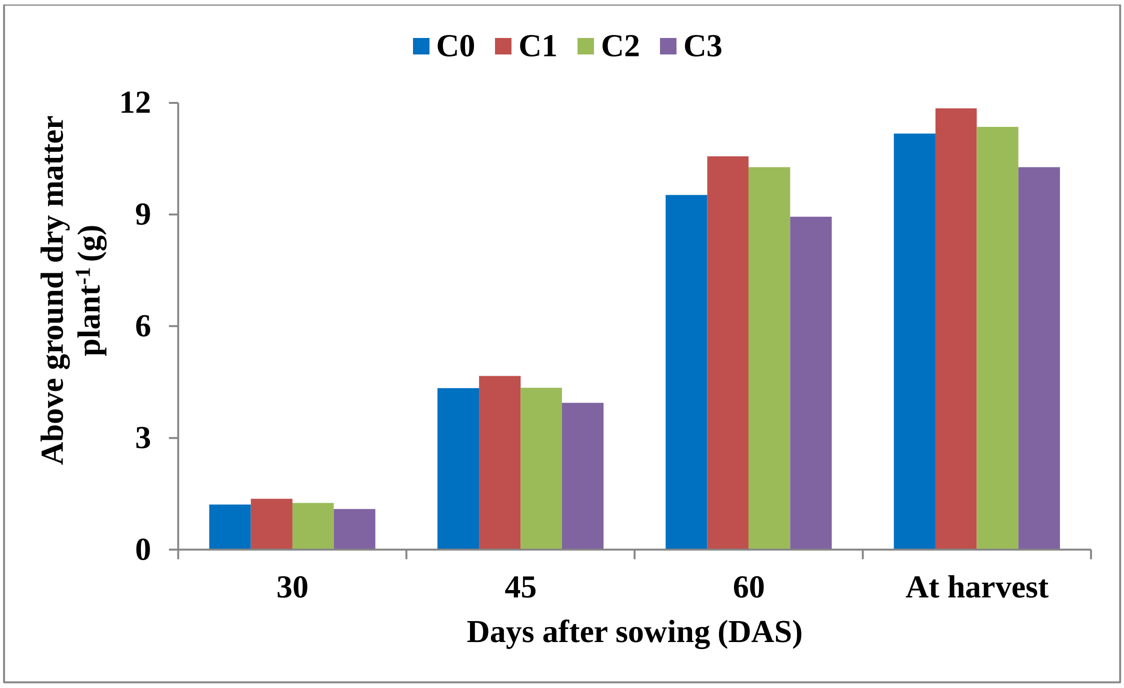


F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

Figure 4. Effect of foliar spray on above ground dry matter plant^{-1}(g) of mungbean at different days after sowing (LSD $_{0.05}$ = 0.12, 0.70, 0.90 and 1.14 at 30, 45, 60 DAS and harvest, respectively).

4.1.2.2 Effect of leaf clipping

Leaf clipping had a significant effect on above ground dry matter plant^{-1} at 30, 45, 60 DAS and at harvest (Appendix V and Fig. 5). At 30 DAS, the highest above ground dry matter content plant^{-1} (1.36 g) was recorded in C_1 (clipping of 1 basal leaf) which was statistically similar (1.25 g) with C_2 (clipping 2 basal leaves) and followed (1.21 g) by C_0 (No leaf clipping), while the lowest dry matter plant^{-1} (1.09 g) was observed in C_3 (clipping total apical leaves having no inflorescence). The highest above ground dry matter plant^{-1} (4.66 g) was found in C_1 which was statistically similar (4.34 g) with C_2 and followed (4.33 g) by C_0, while the lowest dry matter plant^{-1} was obtained in C_3 (3.95 g) at 45 DAS. At 60 DAS, the highest above ground dry matter plant^{-1} was found in C_1 (10.56 g) which was statistically similar with C_2 (10.27 g), whereas the lowest dry matter plant^{-1} was recorded in C_3 (8.94 g) which was statistically similar (9.52 g) with C_0. At harvest, the highest above ground dry matter plant^{-1} was recorded in C_1 (11.85 g) which was closely followed by C_2 (11.35 g) and C_0 (11.17 g). On the other hand, the lowest dry matter plant^{-1} was obtained in C_3 (10.27 g). The high source - sink ratio caused by defoliation increased the photosynthetic rates in the remaining leaves in okra, mungbean, soybean and groundnut (Bhatt and Rao, 2003; Pandey and Singh, 1984; Chen and Lia, 1991; Ghosh and Sengupta, 1986). It may be supposed that above ground dry matter plant^{-1} varied significantly as leaf clipping changes the photosynthetic efficacy of plant



C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

Figure 5. Effect of leaf clipping on above ground dry matter plant^{-1}(g) of mungbean at different days after sowing (LSD $_{0.05}$ = 0.09, 0.41, 0.75 and 0.99 at 30, 45, 60 DAS and harvest, respectively).

4.1.2.3 Combined effect of foliar spray and leaf clipping

Combined effect of foliar spray of urea and leaf clipping showed significant differences for above ground dry matter plant^{-1} at 30, 45, 60 DAS and at harvest (Appendix V and Table 2). At 30 DAS, the highest above ground dry matter plant^{-1} (1.69 g) was found in the treatment combination of F_3C_0

(Recommended fertilizer + 3% urea foliar spray at flower initiation × No leaf clipping) which was statistically similar with F_0C_0 while the lowest dry matter plant^{-1} (0.85 g) was observed in the treatment combination of F_2C_3 (Recommended fertilizer + 2% urea foliar spray at flower initiation × Clipping total apical leaves having no inflorescence) which was statistically similar with F_1C_1 and F_1C_3.

At 45 DAS, the highest above ground dry matter plant^{-1} (5.29 g) was recorded in the treatment combination of F_1C_0 (Recommended fertilizer + 1% urea foliar spray at flower initiation × No leaf clipping) which was statistically similar with F_0C_0, F_0C_1, F_0C_2, F_1C_0, F_1C_2, F_2C_1 and F_2C_2 while the lowest dry matter plant^{-1} (3.03 g) was found in the treatment combination of F_3C_1 (Recommended fertilizer + 3% urea foliar spray at flower initiation × Clipping 1 basal leaf) which was statistically similar with F_2C_0, F_2C_3, F_3C_2 and F_3C_3.

At 60 DAS, the highest above ground dry matter plant^{-1} (13.93 g) was obtained in the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf) while the lowest dry matter plant^{-1} (6.79 g) was recorded in the treatment combination of F_2C_0 (Recommended fertilizer + 2% urea foliar spray at flower initiation × No leaf Clipping) which was statistically similar with F_0C_0 and F_0C_3.

At harvest, the highest above ground dry matter plant^{-1} (14.76 g) was obtained in the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf) which was statistically similar with F_3C_3 while the lowest dry matter plant^{-1} (8.41 g) was recorded in the treatment combination of F_0C_0 (Recommended fertilizer + No foliar spray × No leaf Clipping) which was statistically similar with F_0C_2, F_0C_3, F_2C_0, F_2C_3 and F_3C_1. It may be due to reduced mobilization of photosynthates towards old unexpected leaves; rather, large proportion was migrated to pod and seed development. On the other hand, the old leaves on which photosynthates was translocated, are naturally dropped out during senescence. Hence, traditional practices results in lessening the photosynthetic efficacy which results in low yield.

Table 2. Combined effect of foliar spray and leaf clipping on above ground dry matter plant^{-1}(g) of mungbean at different days after sowing (DAS)

Treatment combinations	Above ground dry matter plant^{-1} (g)			
	30	**45**	**60**	**At harvest**
F_0C_0	1.51 ab	4.80 a-c	8.27 fg	8.41 i
F_0C_1	1.47 bc	5.06 ab	13.93 a	14.76 a
F_0C_2	1.36 b-d	5.12 ab	8.98 d-f	9.71 f-i
F_0C_3	1.16 e-g	4.42 bc	8.08 fg	10.19 e-i
F_1C_0	1.16 e-g	5.29 a	10.34 b-d	10.91 c-g
F_1C_1	0.94 hi	4.14 cd	9.86 c-e	10.50 d-h
F_1C_2	1.33 c-e	4.73 a-c	11.18 bc	12.41 b-d
F_1C_3	1.00 g-i	4.44 bc	10.07 c-e	11.78 c-e
F_2C_0	1.10 f-h	3.04 e	6.79 g	10.04 e-i
F_2C_1	1.29 c-e	5.15 ab	9.79 c-e	11.09 c-f
F_2C_2	1.22 d-f	5.23 ab	10.60 bc	12.62 bc
F_2C_3	0.85 i	3.46 de	8.29 f	8.53 hi
F_3C_0	1.69 a	4.21 cd	10.37 b-d	11.71 c-e
F_3C_1	1.15 e-g	3.03 e	8.67 ef	9.03 g-i
F_3C_2	1.11 f-h	3.57 de	10.33 b-d	12.65 bc
F_3C_3	1.36 b-d	3.46 de	11.65 b	14.18 ab
$LSD_{0.05}$	**0.18**	**0.81**	**1.49**	**1.98**
CV (%)	**8.34**	**11.15**	**9.02**	**10.52**

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of significance

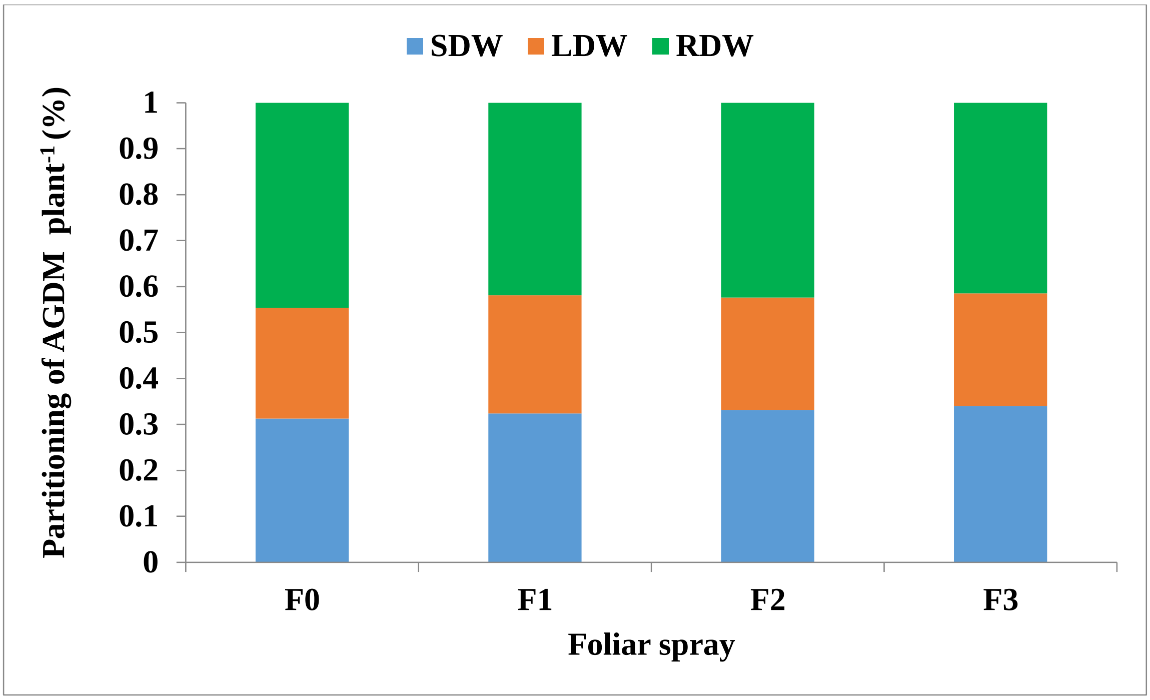
F_0 = Recommended fertilizer + No foliar spray
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

4.1.3 Partitioning of above ground dry matter plant^{-1} (%)

4.1.3.1 Effect of foliar spray

Effect of foliar spray in terms of partitioning of above ground dry matter plant^{-1} (g) at harvest was computed and expressed percentage (Fig. 6). At harvest, stem dry weight plant^{-1} 31.28, 32.42, 33.17 and 33.97 %, leaf dry weight plant^{-1} 24.12, 25.68, 24.44 and 24.52 % and reproductive unit dry weight plant^{-1} 44.60, 41.90, 42.39 and 41.51 % were found from F_0, F_1, F_2 and F_3 respectively. Among the four treatments, the highest Reproductive unit dry weight plant^{-1} (44.60%) was found from F_0 (Recommended fertilizer + No foliar spray) in comparison to others. At early age, as nodules remain active in N fixation, maximum growth is occurred at that time. Recommended fertilizer as basal dose may play vital role in assisting *Rhizobial* activity and hence vigorous growth resulting higher pod retention and ultimately higher grain yield. In addition that foliar N application may have little or even negative effect on plant. Even highly concentrated spray solution may cause severe leaf burn.

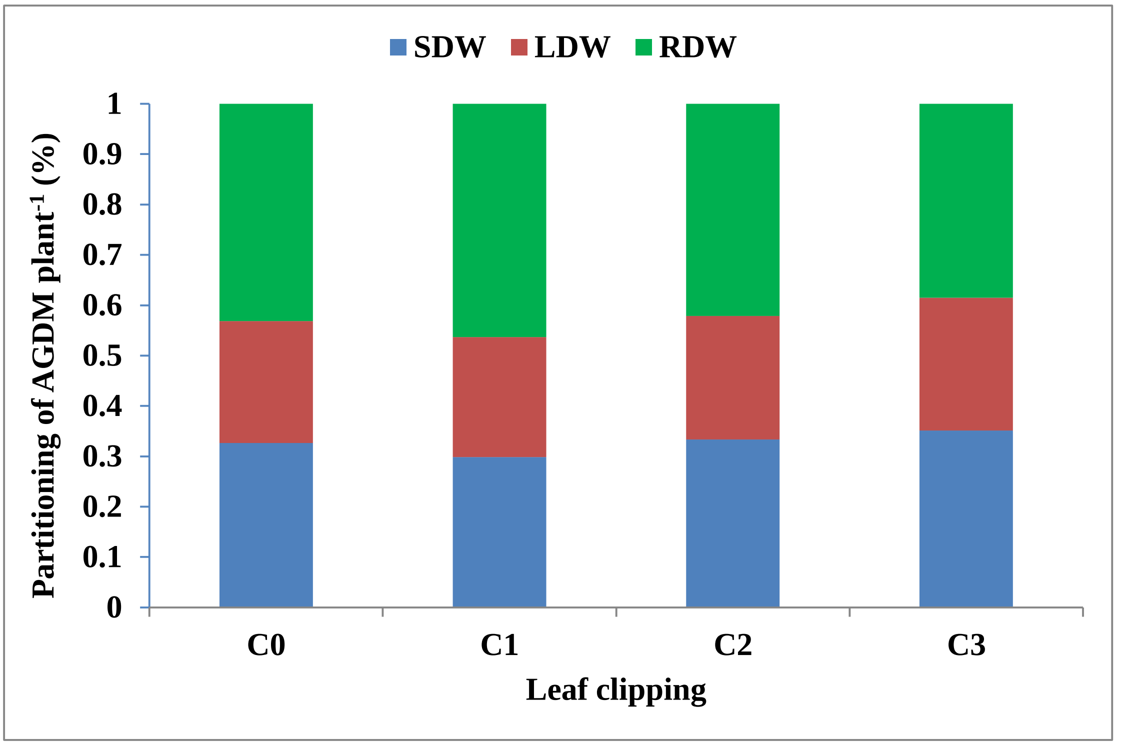


F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation
SDW = Stem dry weight
LDW = Leaf dry weight
RDW = Reproductive unit dry weight

Figure 6. Effect of foliar spray on partitioning of above ground dry matter (AGDM) (i.e. stem dry weight, leaf dry weight and reproductive unit dry weight) plant^{-1} (%) of mungbean at harvest.

4.1.3.2 Effect of leaf clipping

Effect of leaf clipping in terms of partitioning of above ground dry matter plant^{-1} (g) at harvest was computed and expressed in percentage (Fig. 7). At harvest, stem dry weight plant^{-1} 29.84, 32.63, 33.33 and 35.14 %, leaf dry weight plant^{-1} 23.83, 24.24, 24.52 and 26.35 % and reproductive unit dry weight plant^{-1} 42.15, 46.33, 43.13 and 38.51 % were found from C_0, C_1, C_2 and C_3 respectively. Among the four treatments, the highest reproductive unit dry weight plant^{-1} (46.33%) was found from C_1 (Clipping 1 basal leaf) in comparison to others. Leaf clipping may enhance the plant physiological activity like photosynthesis by rapid growth of tender meristem which in turn accumulate more dry matter than control. Stronger, healthy plant also reduce flower and pod drop, resulting higher pods per plant, higher seeds per pod and hence more grain yield. But removal of top leaves may cause contradictory result.



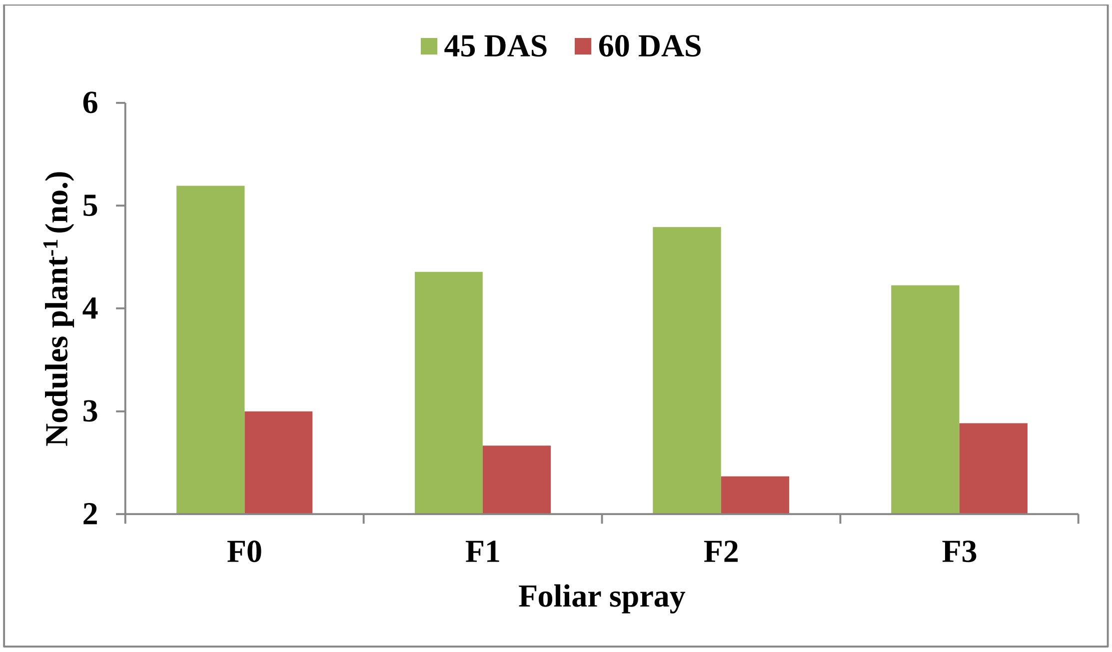
C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence
SDW = Stem dry weight
LDW = Leaf dry weight
RDW = Reproductive unit dry weight

Figure 7. Effect of leaf clipping on partitioning of above ground dry matter (i.e. stem dry weight, leaf dry weight and reproductive unit dry weight) plant^{-1} (%) of mungbean at harvest.

4.1.4 Nodules plant^{-1} (no.)

4.1.4.1 Effect of foliar spray

Statistically significant variation was found due to different foliar spray of urea in terms of nodules plant^{-1} at 45 and 60 DAS (Appendix VI and Fig.8). At 45 DAS, the highest nodules plant^{-1} (5.19) was found from F_0 (Recommended fertilizer + No foliar spray) which was statistically similar (4.79) with F_2 (Recommended fertilizer + 2% urea foliar spray at flower initiation), whereas the lowest nodules plant^{-1} (4.23) was recorded in F_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation) which was statistically similar (4.37) with F_1 (Recommended fertilizer + 1% urea foliar spray at flower initiation). At 60 DAS, the highest nodules plant^{-1} (3.00) was found from F_0 which was statistically similar (2.88) with F_3 and followed by (2.67) with F_1, whereas the lowest nodules plant^{-1} (2.38) was recorded in F_2. Foliar application of urea improved the plant height, leaf area, shoot and root dry weights, root and shoot length, volume and number of roots in mungbean thus improved yield (Ezzat *et al*., 2012). Tripathi *et al*. (2012) and Muhammad *et al*. (2006) found that production of nodules plant^{-1} differed significantly due to different fertilizer application in many legumes. It may be due to added N that supports *Rhizobium* for its physiology.

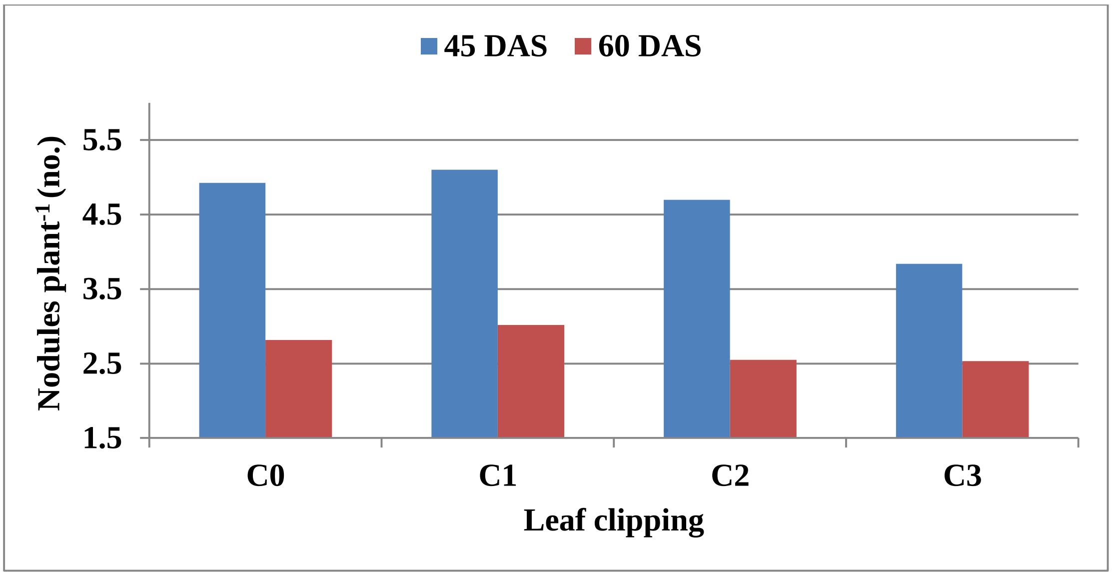


F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

Figure 8. Effect of foliar spray on nodules plant^{-1}(no.) of mungbean at different days after sowing (LSD $_{0.05}$ = 0.77 and 0.26 at 45 and 60 DAS, respectively).

4.1.4.2 Effect of leaf clipping

Leaf clipping had a significant effect on nodules plant^{-1} at 45 and 60 DAS (Appendix VI and Fig.9). At 45 DAS, the highest nodules plant^{-1} (5.10) was recorded in C_1 (clipping 1 basal leaf) which was statistically similar (4.93) with C_0 (no leaf clipping) and followed (4.70) by C_2 (clipping 2 basal leaves), while the lowest nodules plant^{-1} (3.84) was observed in C_3 (clipping total apical leaves having no inflorescence). At 60 DAS, the highest nodules plant^{-1} (3.01) was found in C_1 which was statistically similar (2.82) with C_0, while the lowest nodules plant^{-1} was recorded in C_3 (2.53) which was statistically similar (2.55) with C_2. Leaf clipping may increase below ground dry matter also when it enhances stronger growth, there may be an increased demand for nutrients, hence increased nodule formation.



C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

Figure 9. Effect of leaf clipping on nodules plant^{-1} (no.) of mungbean at different days after sowing (LSD $_{0.05}$ = 0.42 and 0.30 at 45 and 60 DAS, respectively).

4.1.4.3 Combined effect of foliar spray and leaf clipping

Combined effect of foliar spray of urea and leaf clipping showed significant differences for nodules plant^{-1} at 45 DAS and 60 DAS (Appendix VI and Table 3). At 45 DAS, the highest nodules plant^{-1} (5.23) was found in the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf) which was statistically similar to F_1C_1, F_1C_2, F_1C_3, F_2C_1, F_2C_2, F_2C_3, F_3C_0, F_3C_1, F_3C_2 and F_3C_3.

The lowest nodules plant^{-1} (3.17) was observed in the treatment combination of F_1C_0 (Recommended fertilizer + 1% urea foliar spray at flower initiation × No leaf clipping) which was statistically similar to F_0C_0 and F_2C_0.

At 60 DAS, the highest nodules plant^{-1} (3.40) was found in the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf) which was statistically similar to F_0C_0, F_0C_3, F_1C_2, F_1C_3, F_3C_0, F_3C_1 and F_3C_3. The lowest nodules plant^{-1} (1.87) was observed in the treatment combination of F_2C_0 (Recommended fertilizer + 2% urea foliar spray at flower initiation × No leaf clipping) which was statistically similar to F_0C_2, F_1C_0, F_2C_0, F_2C_1 and F_3C_2. It may be assumed that the combined effect of foliar spray and leaf clipping may support Rhizobium activity at the higher demand of plant nutrients to enhance the growth of young meristem.

Table 3. Combined effect of foliar spray and leaf clipping on nodules plant^{-1} of mungbean

Treatment combinations	Nodules plant^{-1} (no.)	
	45 DAS	**60 DAS**
F_0C_0	3.25 ef	2.80 a-d
F_0C_1	5.23 a	3.40 a
F_0C_2	4.33 b-d	2.40 c-f
F_0C_3	4.09 c-e	3.40 a
F_1C_0	3.17 f	2.27 d-f
F_1C_1	4.63a-c	2.60 c-e
F_1C_2	4.54 a-c	3.00 a-c
F_1C_3	5.08 ab	2.80 a-d
F_2C_0	3.68 d-f	1.87 f
F_2C_1	5.16 ab	2.40 c-f
F_2C_2	5.08 ab	2.67 b-e
F_2C_3	5.24 a	2.53 c-e
F_3C_0	5.25 a	3.27 ab
F_3C_1	5.38 a	2.87 a-d
F_3C_2	4.84 a-c	2.07 ef
F_3C_3	5.30 a	3.3 a
$LSD_{0.05}$	**0.85**	**0.60**
CV (%)	**10.85**	**13.10**

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of significance
F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

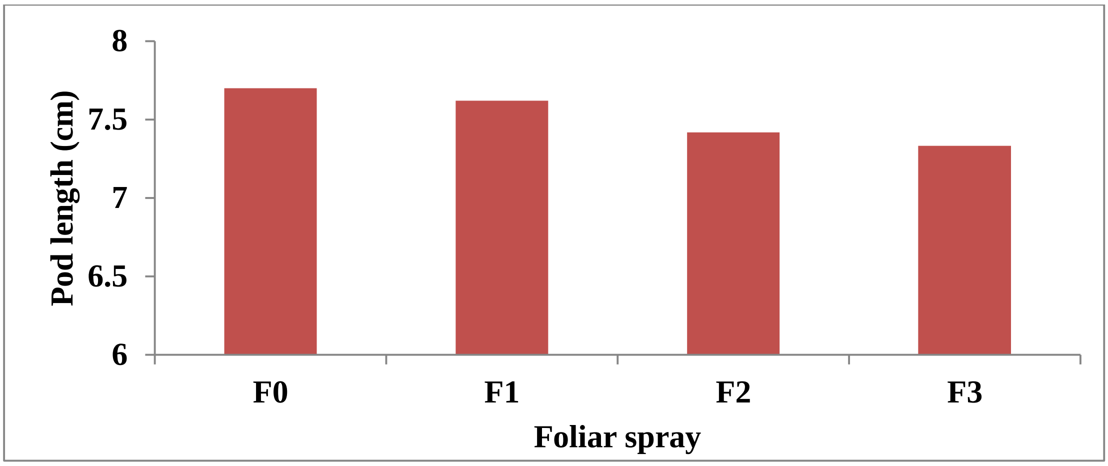
C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

4.2 Yield contributing parameters

4.2.1 Pod length (cm)

4.2.1.1 Effect of foliar spray

Statistically non-significant variation was recorded for pod length due to fertilizer management in respect of foliar spray of urea (Appendix VII and Fig.10). Results revealed that the highest pod length (7.70 cm) was recorded from F_0 (Recommended fertilizer + No foliar spray) followed (7.62 cm) by F_1 (Recommended fertilizer + 1% urea foliar spray at flower initiation) where the lowest pod length (7.33 cm) was observed from F_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation) which was statistically identical (7.42 cm) with F_2 (Recommended fertilizer + 2% urea foliar spray at flower initiation). Azadi *et al*., (2013) conducted an experiment to evaluate and determine the appropriate nitrogen fertilization on the morphological characteristics and seed yield of mungbean using three cultivars. In that study different levels of nitrogen fertilizer (control, 50, 100, 150) kg/ha urea were used as sub-plot factor. The result showed that stem diameter, number of node and seed yield showed significant difference among various amounts of nitrogen fertilizer where pod length varied non-significantly. There may be assumed that, being pod length a genotypic inherited character, agronomic practices like foliar spray may have little response on pod length.



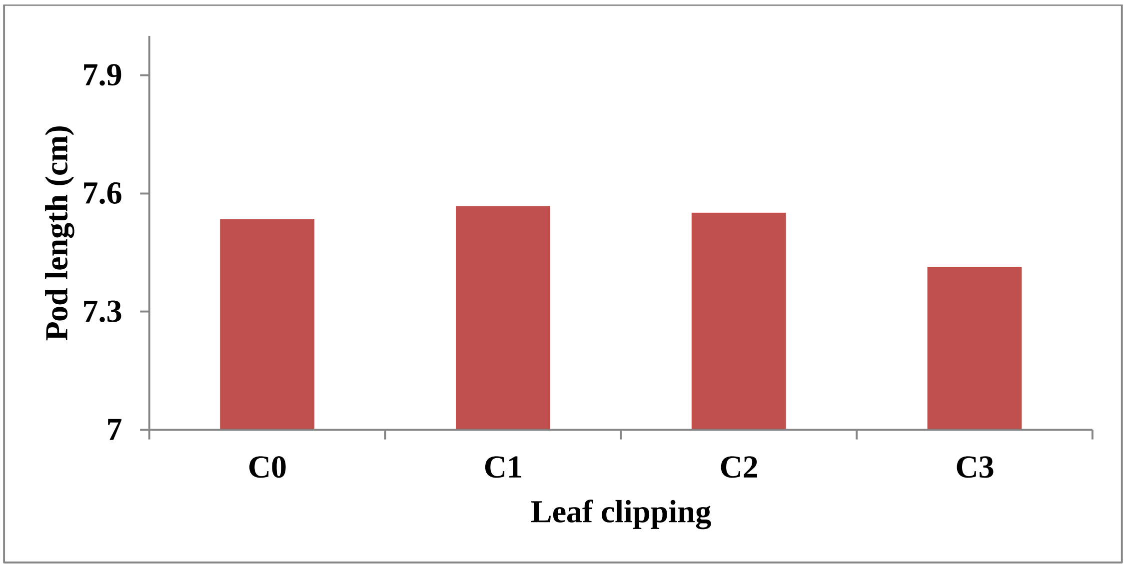
F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

Figure 10. Effect of foliar spray on pod length (cm) at harvest of mungbean ($LSD_{0.05}$ = NS at harvest).

4.2.1.2 Effect of leaf clipping

Pod length of mungbean showed statistically non-significant variation due leaf clipping of mungbean (Appendix VII and Fig. 11). Numerically highest pod length (7.57 cm) was observed from C_1 (Clipping 1 basal leaf) which was similar to C_2 (7.55 cm) and C_0 (7.54 cm) and the lowest pod length (7.41 cm) was observed from C_3 (Clipping total apical leaves having no inflorescence). There may be assumed that, being pod length a genotypic inherited character, agronomic practices like leaf clipping may have little response on pod length.

In Thailand, Kupkanchanakul and Roontun (1989) found that leaf removal in deepwater rice at vegetative stage did not significantly affect grain yield, yield components and agronomic characteristics.



C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

Figure 11. Effect of leaf clipping on pod length (cm) at harvest of mungbean (LSD $_{0.05}$ = NS at harvest).

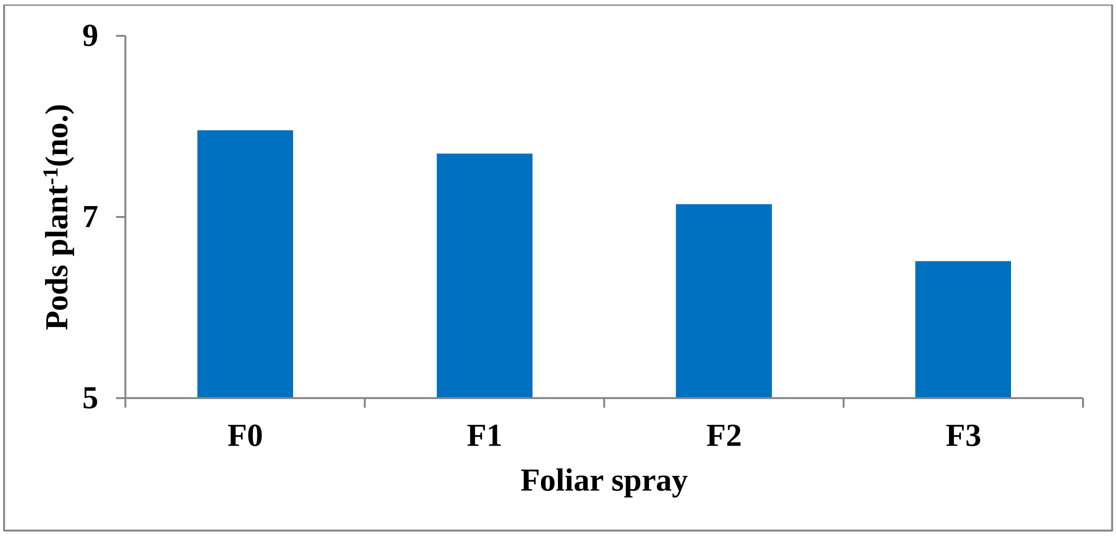
4.2.1.3 Combined effect of foliar spray and leaf clipping

Pod length of mungbean was non-significantly influenced by interaction effect of fertilizer management through foliar spray of urea and leaf clipping (Appendix VII and Table 4). It was found that the numerically longest pod length (7.82 cm) was recorded from the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf). Numerically the shortest pod length (7.14 cm) was found from F_3C_0 (Recommended fertilizer + 3% urea foliar spray at flower initiation × No leaf clipping). There may be assumed that, being pod length a genotypic inherited character, agronomic practices like foliar spray and leaf clipping may have little response on pod length.

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

4.2.2.1 Effect of foliar spray

Statistically significant variation was recorded for number of pods plant^{-1} due to fertilizer management in respect of foliar spray of urea (Appendix VII and Fig.12). Results revealed that the highest number of pods plant^{-1} (7.96) was recorded from F_0 (Recommended fertilizer + No foliar spray) followed (7.70) by F_1 (Recommended fertilizer + 1% urea foliar spray at flower initiation) where the lowest number of pods plant^{-1} (6.51) was observed from F_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation) which was statistically similar (7.14) with F_2 (Recommended fertilizer + 2% urea foliar spray at flower initiation). Patel and Patel (1994) carried out a field experiment 20 kg N ± 40 kg $P_2 0_5$ ha^{-1} (recommended rate) the fertilizer application gave the highest pods per plant and seed yield which however, was not significantly different from the foliar application of urea (1.5%) + di-ammonium phosphate (0.5%) at 30 and 40 DAS. Recommended N application during final land preparation may be a great support to growing of nodule which increase its productivity but foliar spray at flowering may have little effect on pod number.

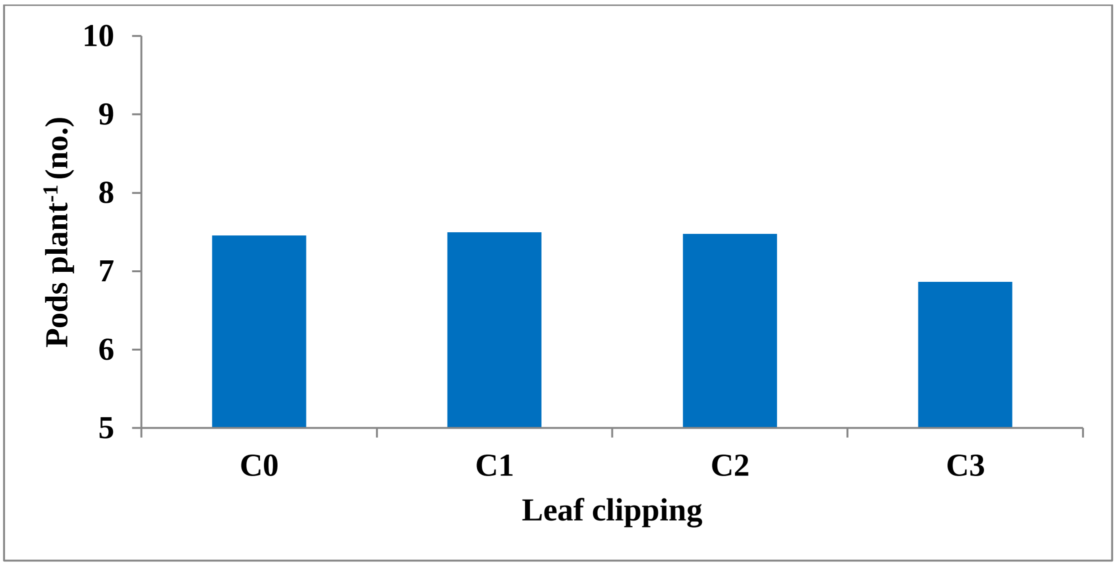


F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

Figure 12. Effect of foliar spray on pods plant^{-1}(no.) at harvest of mungbean (LSD $_{0.05}$ = 0.42 at harvest).

4.2.2.2 Effect of leaf clipping

Pods plant^{-1} of mungbean showed statistically non-significant variation due leaf clipping of mungbean (Appendix VII and Fig.13). Numerically highest number of pods plant^{-1} (7.49) was observed from C_1 (Clipping 1 basal leaf) which was statistically similar to C_2 (7.55) and C_0 (7.46) and the lowest number of pods plant^{-1} (6.87) was observed from C_3 (Clipping total apical leaves having no inflorescence). These results are in conformity with Bernacchi *et al.* (2007) who observed that transpiration was proportional to leaf conductance in soybean under constant environmental conditions. Significant variation was not observed in photosynthesis in top one leaf-defoliated plant as compared to control. These results are in conformity with Verma *et al*. (1992) and Board and Harville (1998). Unproductive basal leaf clipping may not varies the photosynthesis than control but top leaves removal may adversely affect dry matter production.



C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

Figure 13. Effect of leaf clipping on pods plant^{-1}(no.) at harvest of mungbean (LSD $_{0.05}$ = NS at harvest).

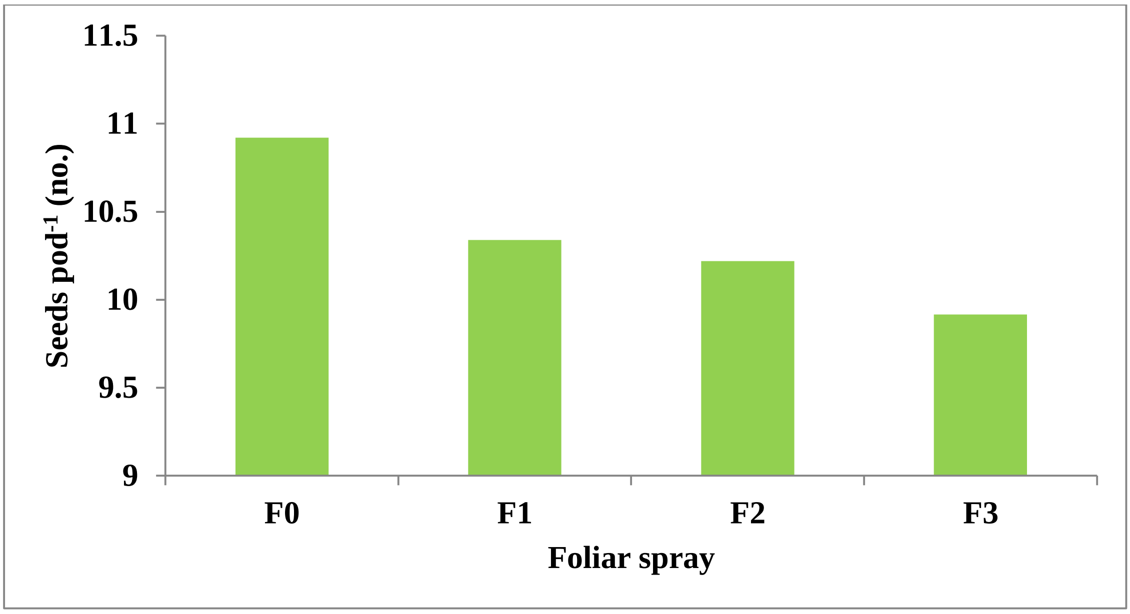
4.2.2.3 Combined effect of foliar spray and leaf clipping

Pods plants^{-1} of mungbean was significantly influenced by interaction effect of fertilizer management through foliar spray of urea and leaf clipping (Appendix VII and Table 4). It was found that the highest number of pods plant^{-1} (9.81) was recorded from the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf) which was statistically similar to F_0C_3, F_3C_0, and F_3C_3. The lowest number of pods plant^{-1} (5.66) was found from F_1C_3 (Recommended fertilizer + 1% urea foliar spray at flower initiation × Clipping total apical leaves having no inflorescence) which was statistically similar to F_0C_0, F_0C_2, F_1C_1, F_1C_3, F_2C_0, F_2C_1, F_2C_2, F_2C_3, F_3C_1, and F_3C_2. In cowpea, partial source removal induces increase in pod and seed yield (Hossain *et al.*, 2006a) through the production of higher flowers plant^{-1} with reduced rate of floral abscission (Hossain *et.al*, 2006b). Patel and Patel (1994) carried out a field experiment found that 20 kg N ± 40 kg P_20_5 ha^{-1} (recommended rate) gave the highest pods per plant and seed yield which however, was not significantly different from the foliar application of urea (1.5%) + diammonium phosphate (0.5%) at 30 and 40 DAS. Pods plant^{-1} is the most important factor determining yield of mungbean. Combinedly foliar spray and leaf clipping may support the plant to stop floral and pod dropping, hence increase the pod yield.

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

4.2.3.1 Effect of foliar spray

Statistically significant variation was recorded for number of seeds pod^{-1} due to fertilizer management in respect of foliar spray of urea (Appendix VII and Fig.14). Results revealed that the highest number of seeds pod^{-1} (10.92) was recorded from F_0 (Recommended fertilizer + No foliar spray) followed (10.34) by F_1 (Recommended fertilizer + 1% urea foliar spray at flower initiation) where the lowest number seeds pod^{-1} (9.92) was observed from F_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation) which was statistically similar (10.22) with F_2 (Recommended fertilizer + 2% urea foliar spray at flower initiation). This result was close to Mahajan *et al.* (2016). They found that soil application of RDF + foliar spray of 2 percent urea twice at flowering and pod formation stages significantly increased the yield contributing characters *viz*., number of pods plant $^{-1}$ and number of seeds pod^{-1} in sesame. It may be due to higher retention of photosynthates available to reproductive organ which may come from increased assimilation through quick supply of added N.

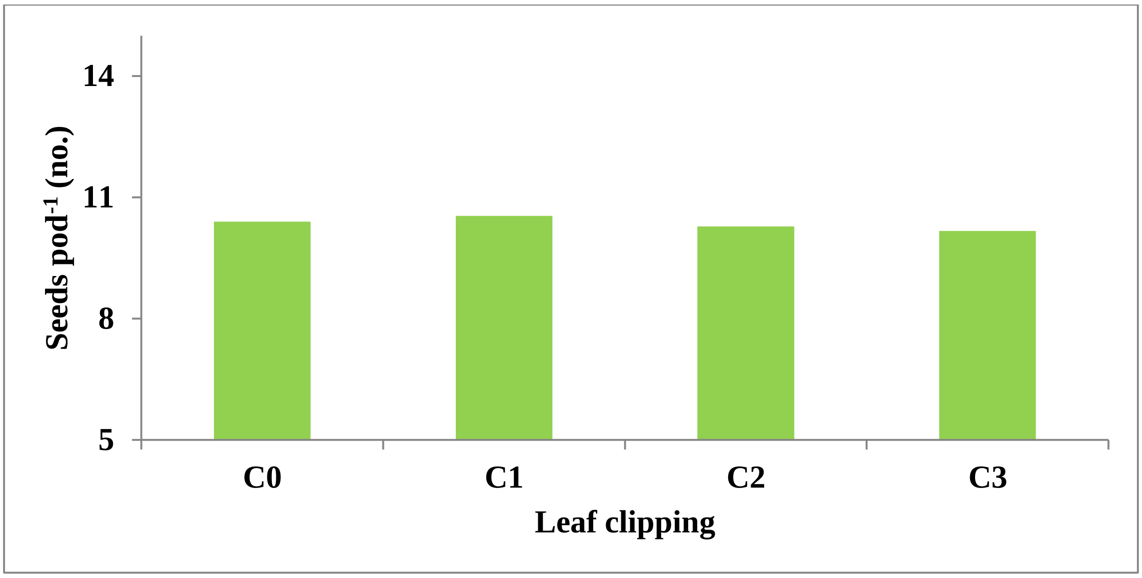


F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

Figure 14. Effect of foliar spray on seeds pod^{-1}(no.) at harvest of mungbean (LSD $_{0.05}$ = 0.88 at harvest).

4.2.3.2 Effect of leaf clipping

Seeds pod^{-1} of mungbean showed statistically non-significant variation due leaf clipping of mungbean (Appendix VII and Fig.15). Numerically highest number seeds pod^{-1} (10.54) was observed from C_1 (Clipping 1 basal leaf) which was statistically similar to C_0 (10.40) and C_2 (10.28) and the lowest number of seeds pod^{-1} (10.17) was observed from C_3 (Clipping total apical leaves having no inflorescence). This observation agreed with those of Pandey (1983) who worked in cowpea and Hintz and Fehr (1990) who worked in soybean. These results are in conformity with Bernacchi *et al.* (2007) who observed that transpiration was proportional to leaf conductance in soybean under constant environmental conditions. Significant variation was not observed in photosynthesis in top one leaf-defoliated plant as compared to control. It may be due to leaf clipping may stop floral dropping, hence empty or partially filled pod production reduced.



C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

Figure 15. Effect of leaf clipping on seeds pod^{-1} (no.) at harvest of mungbean (LSD $_{0.05}$ = NS at harvest).

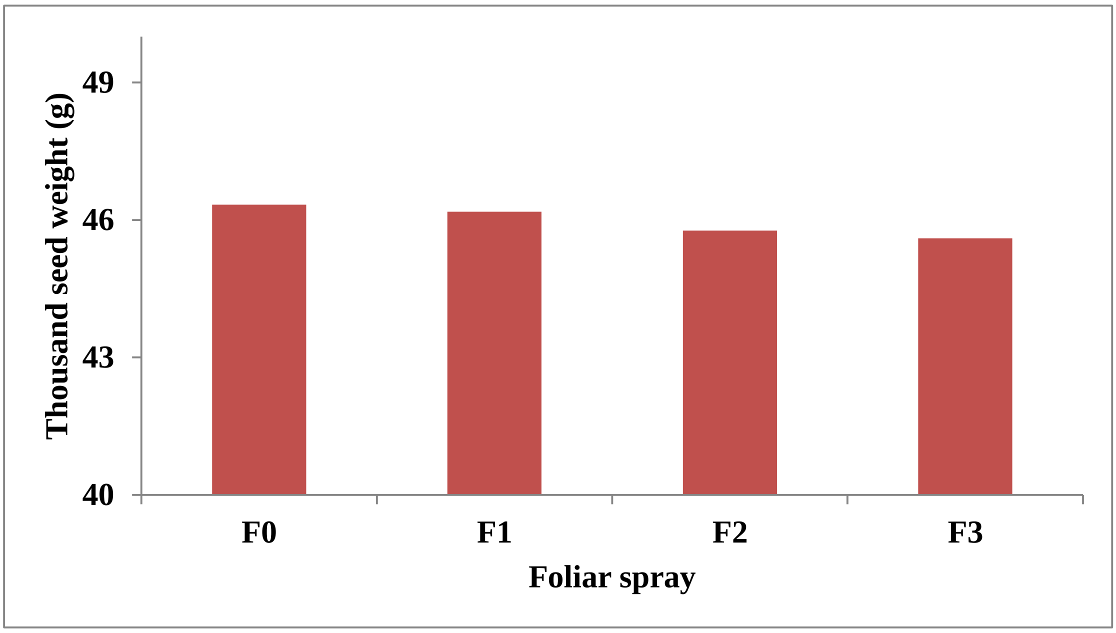
4.2.3.3 Combined effect of foliar spray and leaf clipping

Seeds pod^{-1} of mungbean was significantly influenced by interaction effect of fertilizer management through foliar spray of urea and leaf clipping (Appendix VII and Table 4). It was found that the highest number of seeds pod^{-1} (12.08) was found from the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf) which was statistically similar to F_1C_2, F_2C_0, F_2C_1, F_2C_2, F_2C_3, F_3C_0, and F_3C_3. The lowest number of seeds pod^{-1} (9.20) was found from F_0C_3 (Recommended fertilizer + No foliar spray × Clipping total apical leaves having no inflorescence) which was statistically similar to F_0C_0, F_0C_2, F_1C_0, F_1C_1, F_1C_2, F_1C_3, F_2C_1, F_2C_3, F_3C_0, F_3C_1, F_3C_2, and F_3C_3. Combined foliar spray and leaf clipping may support the plant to stop floral dropping, hence empty or partially filled pod production reduced.

4.2.4 Thousand seeds weight (g)

4.2.4.1 Effect of foliar spray

Statistically non-significant variation was recorded for thousand seeds weight due to fertilizer management in respect of foliar spray of urea (Appendix VII and Fig.16). Results revealed that the highest thousand seeds weight (46.33 g) was recorded from F_0 (Recommended fertilizer + No foliar spray) followed (46.18) by F_1 (Recommended fertilizer + 1% urea foliar spray at flower initiation) where the lowest thousand seeds weight (45.60 g) was observed from F_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation) which was statistically identical (45.77 g) with F_2 (Recommended fertilizer + 2% urea foliar spray at flower initiation). Rajender *et al.* (2002) showed 1000-seed weight increased with increasing N rates. As foliar spray quickly supply nutrient to its destination, pods don't suffer from malnutrition. So filled grain may be increased.

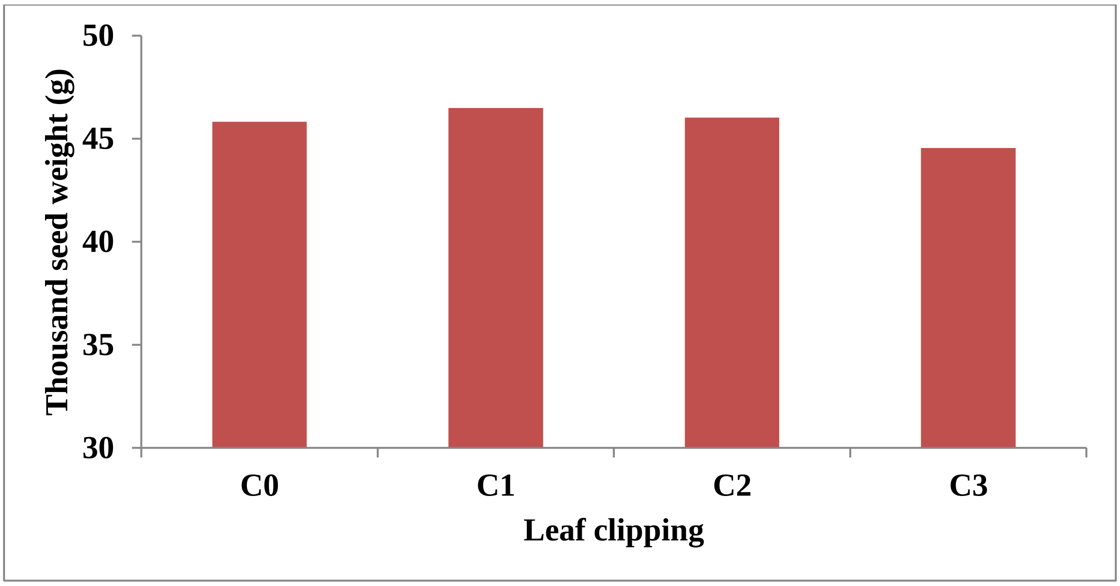


F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

Figure 16. Effect of foliar spray on thousand seed weight (g) at harvest of mungbean (LSD $_{0.05}$ = NS at harvest).

4.2.4.2 Effect of leaf clipping

Thousand seeds weight of mungbean showed statistically non-significant variation due leaf clipping of mungbean (Appendix VII and Fig.17). Numerically highest thousand seeds weight (46.49 g) was observed from C_1 (Clipping 1 basal leaf) which was statistically similar to C_2 (46.02 g) and C_0 (45.82 g) and the lowest thousand seed weight (44.54 g) was observed from C_3 (Clipping total apical leaves having no inflorescence). The new leaves and the lower empty leaves might have played the role of relative sink as new leaves consume energy for their development and lower shaded leaves require energy for their existence. During seed development, there might have existed a competition for assimilates among the developing seeds and the relative sinks (new leaves and lower shaded empty leaves). The removal of these relative sinks probably reduced this competition resulting in significant increase in 1000 seed weight. Similarly Clifford (1979) found increased grain weight after the removal of axillary buds.



C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

Figure 17. Effect of leaf clipping on thousand seed weight (g) at harvest of mungbean (LSD $_{0.05}$ = NS at harvest).

4.2.4.3 Combined effect of foliar spray and leaf clipping

Thousand seeds weight of mungbean was non-significantly influenced by interaction effect of fertilizer management through foliar spray of urea and leaf clipping (Appendix VII and Table 4). It was found that the highest thousand seeds weight (48.07 g) was recorded from the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf). The lowest thousand seeds weight (43.32 g) was found from F_1C_0 (Recommended fertilizer + 1% urea foliar spray at flower initiation × No leaf clipping). Combined effect of foliar spray and leaf clipping may vary pods per plant, seeds per pod significantly but due to various seed size there may not occur major differences in thousand seeds weight than control.

Table 4. Combined effect of foliar spray and leaf clipping on pod length, pods plant^{-1}, seeds pod^{-1} and thousand seed weight of mungbean

Treatment combinations	Pod length (cm)	Number of pods plant^{-1}	Number of seeds pod^{-1}	Thousand seed weight (g)
F_0C_0	7.59	5.81 f	10.05 bc	47.35
F_0C_1	7.82	9.81 a	12.08 a	48.07
F_0C_2	7.61	6.04 f	10.02 bc	43.36
F_0C_3	7.78	9.14 a-c	9.20 c	46.54
F_1C_0	7.72	8.19 b-d	10.08 bc	43.32
F_1C_1	7.23	6.80 ef	10.30 bc	45.31
F_1C_2	7.35	7.91 c-e	10.60 a-c	44.73
F_1C_3	7.36	5.66 f	9.88 bc	45.04
F_2C_0	7.21	6.49 f	11.12 ab	45.48
F_2C_1	7.77	6.85 d-f	10.50 a-c	45.74
F_2C_2	7.76	6.90 d-f	11.22 ab	44.95
F_2C_3	7.75	5.80 f	10.84 a-c	46.92
F_3C_0	7.14	9.49 ab	10.37 a-c	47.14
F_3C_1	7.32	6.36 f	9.27 c	44.97
F_3C_2	7.55	6.61 ef	9.28 c	45.13
F_3C_3	7.32	9.36 ab	10.75 a-c	47.46
$LSD_{0.05}$	**NS**	**1.37**	**1.73**	**NS**
CV (%)	**9.58**	**11.07**	**9.94**	**9.25**

In a column mean values having similar letter are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of significance

F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

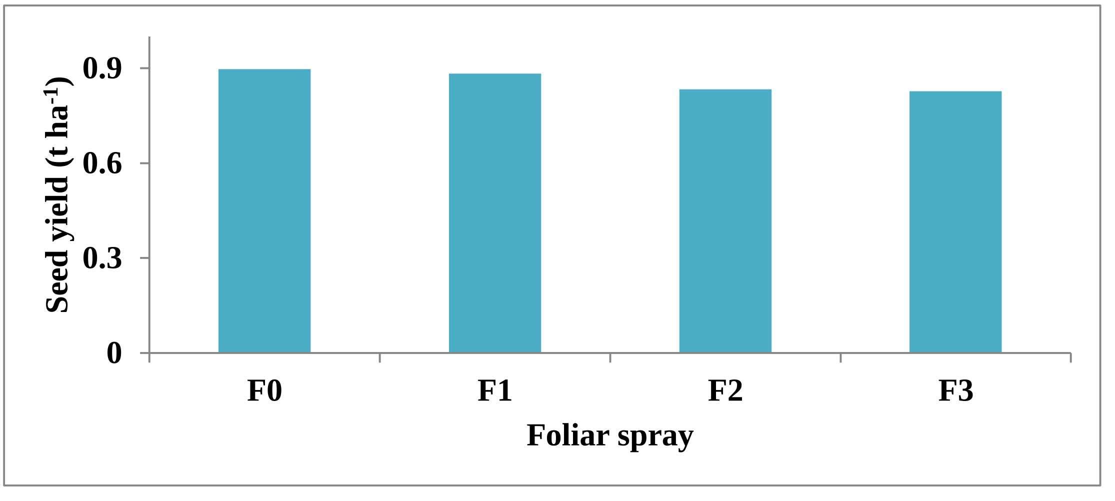
C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

4.3 Yield parameters

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

4.3.1.1 Effect of foliar spray

Statistically non-significant variation was recorded for seed yield due to fertilizer management in respect of foliar spray of urea (Appendix VIII and Fig.18). Results revealed that numerically the highest seed yield (0.90 t ha^{-1}) was recorded from F_0 (Recommended fertilizer + No foliar spray) followed (0.88 t ha^{-1}) by F_1 (Recommended fertilizer + 1% urea foliar spray at flower initiation) where the lowest seed yield (0.83 t ha^{-1}) was observed from F_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation). Similar observations were reported by Rahman *et al.* (2014) who observed that foliar spray of N, P and K significantly increased pods/plant, seeds / pod, biomass and grain yield in common bean. It may be resulted that foliar spray of N, P and K is the suitable application for the maximum yield of mungbean. It is assumed that only basal N is adequate for increase nodule no. and nodule size, dry matter accumulation. Hence, foliar spray be less responsed.

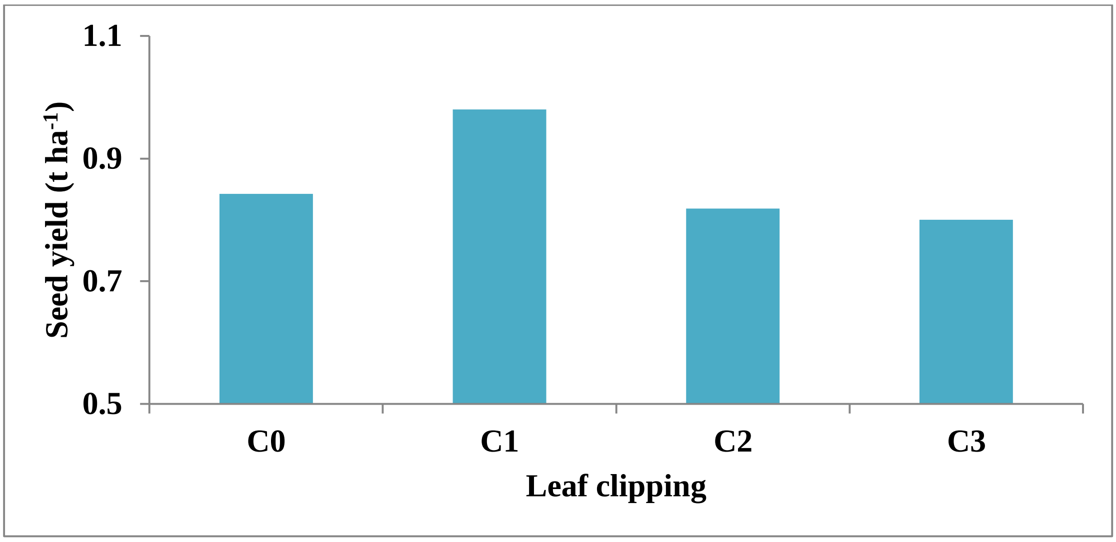


F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

Figure 18. Effect of foliar spray on seed yield (t ha^{-1}) at harvest of mungbean (LSD $_{0.05}$ = NS at harvest).

4.3.1.2 Effect of leaf clipping

Seed yield of mungbean showed statistically significant variation due leaf clipping of mungbean (Appendix VIII and Fig.19). Significantly highest seed yield (0.98 t ha^{-1}) was observed from C_1 (Clipping 1 basal leaf) which was statistically similar to C_0 (0.84 t ha^{-1}) and C_2 (0.82 t ha^{-1}) and the lowest seed yield (0.8 t ha^{-1}) was observed from C_3 (No leaf clipping). It may be due to removal of empty leaves reduced the competition for assimilates for the development of seeds in pod, which might had helped to increase the seed size as well as seed yield. Clifford (1979) reported an increased seed weight by removing axillary buds in mungbean. Talwar *et al*. (1992) also reported higher yield by removing flowers and gynophores in groundnut.



C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

Figure 19. Effect of leaf clipping on seed yield (t ha^{-1}) at harvest of mungbean (LSD $_{0.05}$ = 0.08 at harvest).

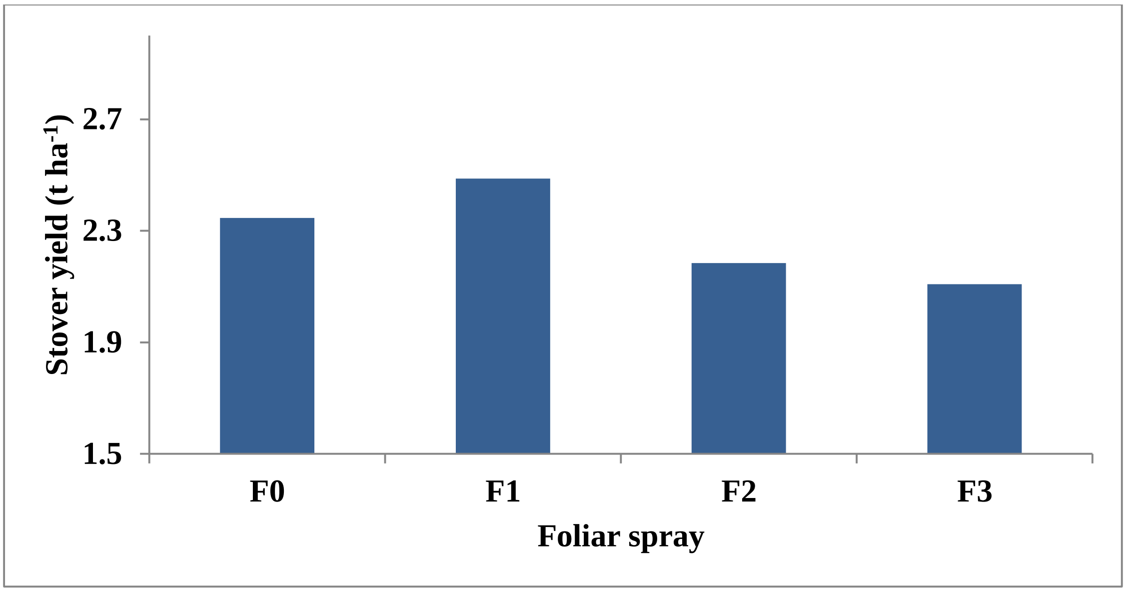
4.3.1.3 Combined effect of foliar spray and leaf clipping

Seed yield of mungbean was significantly influenced by combination effect of fertilizer management through foliar spray of urea and leaf clipping (Appendix VIII and Table 5). It was found that the highest seed yield (1.26 t ha^{-1}) was recorded from the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf) which was statistically similar to F_3C_3 (1.16t ha^{-1}). The lowest seed yield (0.60 t ha^{-1}) was found from F_0C_0 (Recommended fertilizer + No foliar spray × No leaf clipping) which was statistically similar to F_0C_2, F_0C_3, F_1C_1, F_1C_3, F_2C_0, and F_3C_2. As seed production is closely associated with the production of pods plants^{-1} which may be influenced by source – sink manipulation and nutritional sufficiency, foliar spray and leaf clipping may act in this circumstances.

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

4.3.2.1 Effect of foliar spray

Statistically significant variation was recorded for stover yield due to fertilizer management in respect of foliar spray of urea (Appendix VIII and Fig.20). Results revealed that the significantly highest stover yield (2.49 t ha^{-1}) was recorded from F_1 (Recommended fertilizer + 1% urea foliar spray at flower initiation) followed (2.35 t ha^{-1}) by F_0 (Recommended fertilizer + No foliar spray) where the lowest stover yield (2.11 t ha^{-1}) was observed from F_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation) which was statistically identical (2.18 t ha^{-1}) with F_2 (Recommended fertilizer + 2% urea foliar spray at flower initiation). Mahajan *et al*. (1994) found that soil application of 1% urea foliar spray at flower initiation increased stover yield significantly of groundnut. During flowering when nodules undergo inactive or destroyed, added foliar application of N may quickly serve the plant in that crisis period, resulting higher dry matter accumulation.

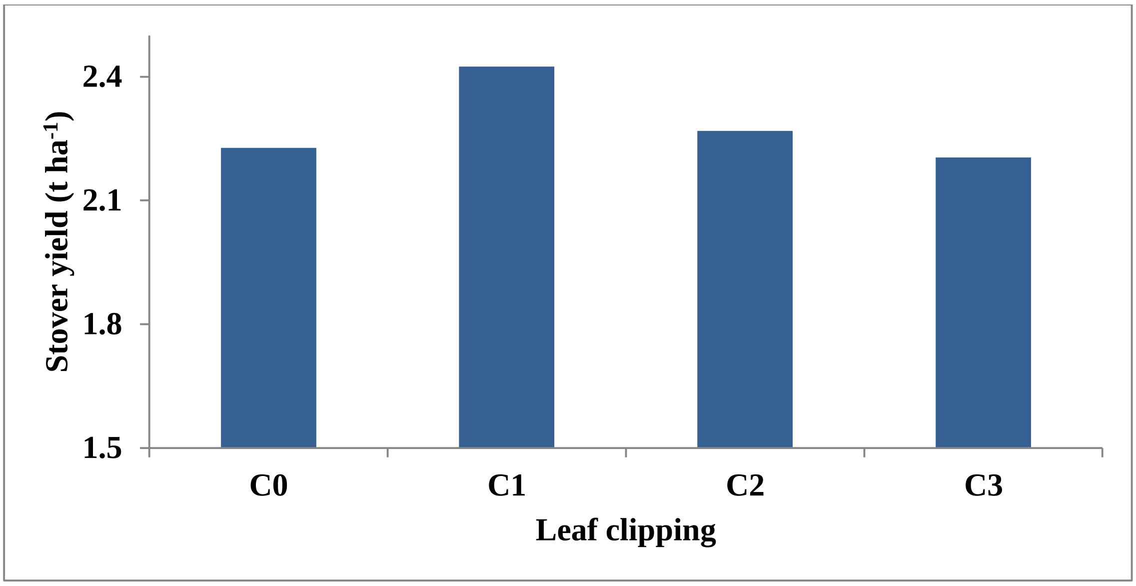


F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

Figure 20. Effect of foliar spray on Stover yield (t ha^{-1}) at harvest of mungbean (LSD $_{0.05}$ = 0.09 at harvest).

4.3.2.2 Effect of leaf clipping

Stover yield of mungbean showed statistically significant variation due leaf clipping of mungbean (Appendix VIII and Fig. 21). The highest stover yield (2.42 t ha^{-1}) was observed from C_1 (Clipping 1 basal leaf) which was statistically similar to C_2 (2.27 t ha^{-1}) and C_0 (2.23 t ha^{-1}) and the lowest stover yield (2.20 t ha^{-1}) was observed from C_3 (Clipping total apical leaves having no inflorescence). Higher rate of photosynthesis in remaining leaves of partially clipped plants compared to the leaves in intact plants may contribute the compensation to source loss by clipping in soybean (Rao and Ghildiyal, 1985). Leaf clipping at flower initiation stage induces the capacity to compensate source loss through the re-growth of leaves.



C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

Figure 21. Effect of leaf clipping on Stover yield (t ha^{-1}) at harvest of mungbean (LSD $_{0.05}$ = 0.22 at harvest).

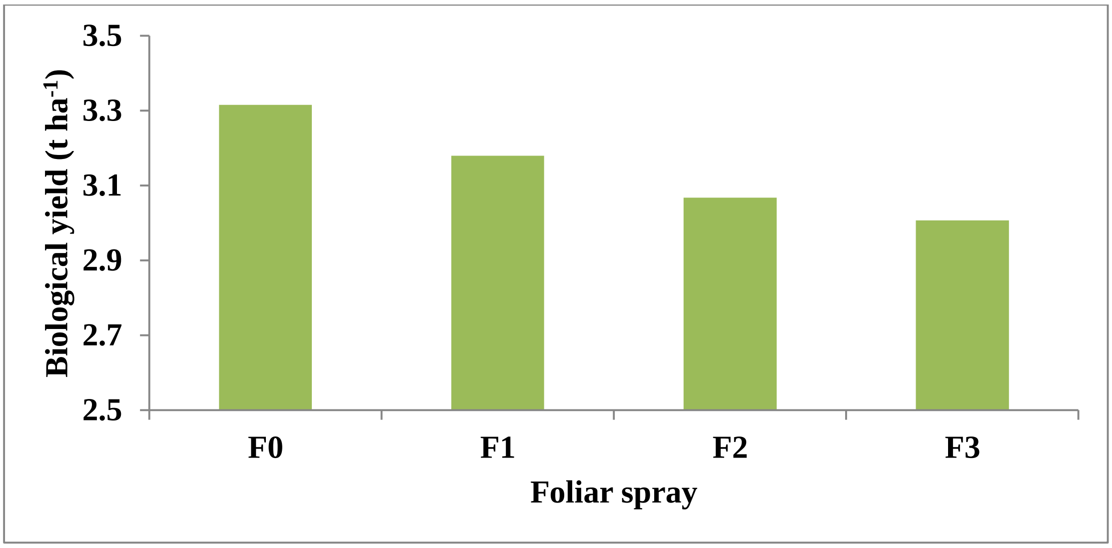
4.3.2.3 Combined effect of foliar spray and leaf clipping

Stover yield of mungbean was significantly influenced by interaction effect of fertilizer management through foliar spray of urea and leaf clipping (Appendix VIII and Table 5). It was found that the highest stover yield (2.62 t ha^{-1}) was recorded from the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf) which was statistically similar to F_0C_2, F_0C_3, F_1C_0, F_1C_1, F_1C_2, F_1C_3, F_2C_1, F_2C_2 and F_3C_3. The lowest stover yield (1.76 t ha^{-1}) was found from F_2C_3 (Recommended fertilizer + 2% urea foliar spray at flower initiation × Clipping total apical leaves having no inflorescence) which was statistically similar to F_0C_0, F_3C_0, F_3C_1 and F_3C_2. Rahman *et al.* (2014) carried out a trial and observed that foliar spray of N, P and K significantly increased pods/plant, seeds / pod, biomass and grain yield. It may be resulted that foliar spray of N, P and K is the suitable application for the maximum yield of mungbean also.

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

4.3.3.1 Effect of foliar spray

Statistically significant variation was recorded for stover yield due to fertilizer management in respect of foliar spray of urea (Appendix VIII and Fig. 22). Results revealed that the highest biological yield (3.32 t ha^{-1}) was recorded from F_0 (Recommended fertilizer + No foliar spray) followed (3.18 t ha^{-1}) by F_1 (Recommended fertilizer + 1% urea foliar spray at flower initiation) where the lowest biological yield (3.07 t ha^{-1}) was observed from F_2 (Recommended fertilizer + 2% urea foliar spray at flower initiation) which was statistically identical (3.00 t ha^{-1}) with F_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation). Mahajan *et al*. (1994) found that soil application of 1% urea foliar spray at flower initiation increased biological yield significantly of groundnut. During flowering when nodules tends to destroyed, foliar application of N may quickly serve the plant in that crisis period, resulting higher dry matter accumulation.

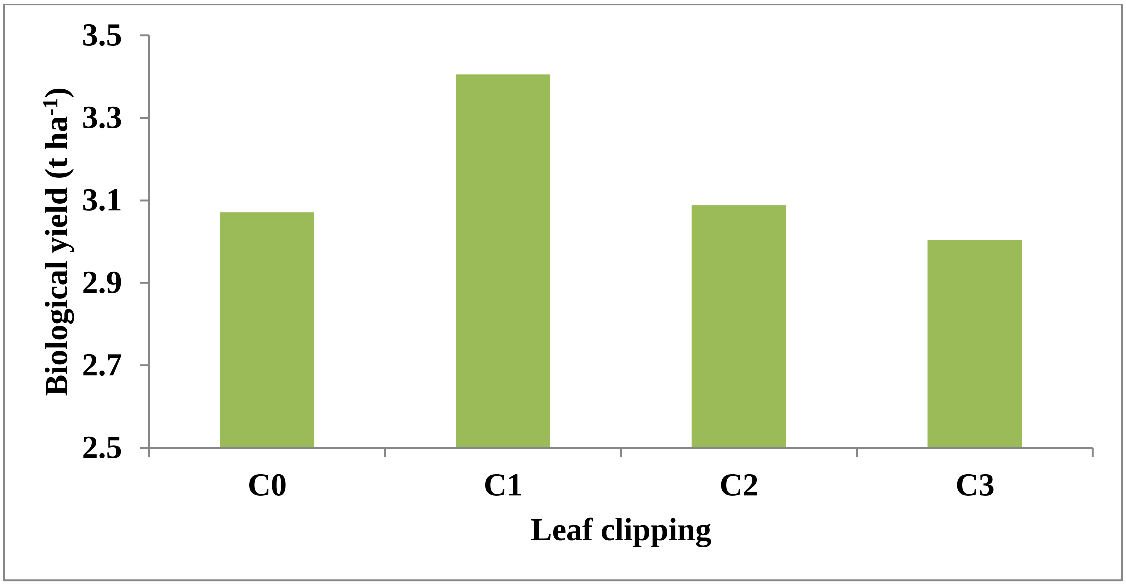


F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

Figure 22. Effect of foliar spray on biological yield (t ha^{-1}) at harvest of mungbean (LSD $_{0.05}$ = 0.11 at harvest).

4.3.3.2 Effect of leaf clipping

Biological yield of mungbean showed statistically significant variation due leaf clipping of mungbean (Appendix VIII and Fig.23). The highest biological yield (3.40 t ha^{-1}) was observed from C_1 (Clipping 1 basal leaf). The lowest biological yield (3.00 t ha^{-1}) was observed from C_3 (Clipping total apical leaves having no inflorescence), which was statistically similar to C_2 (3.09 t ha^{-1}) and C_0 (3.07 t ha^{-1}). The high source - sink ratio caused by defoliation increased the photosynthetic rates in the remaining leaves in okra, mungbean, soybean and groundnut (Bhatt and Rao, 2003; Pandey and Singh, 1984; Chen and Lia, 1991; Ghosh and Sengupta, 1986). It may be supposed that above ground dry matter $plant^{-1}$ varied significantly as leaf clipping changes the photosynthetic efficacy.



C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

Figure 23. Effect of leaf clipping on biological yield (t ha^{-1}) at harvest of mungbean (LSD $_{0.05}$ = 0.26 at harvest).

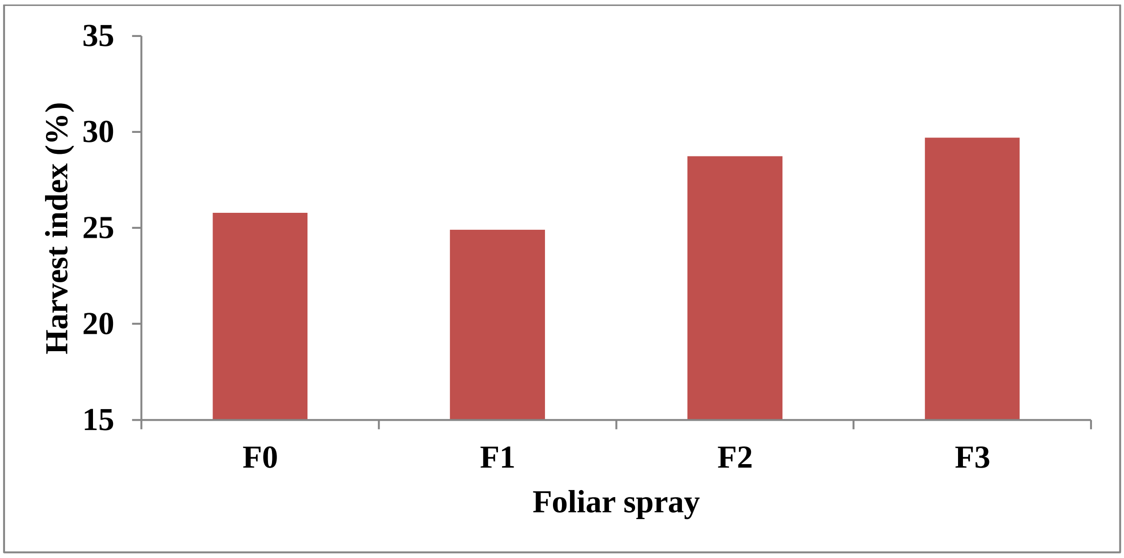
4.3.3.3 Combined effect of foliar spray and leaf clipping

Biological yield of mungbean was significantly influenced by interaction effect of fertilizer management through foliar spray of urea and leaf clipping (Appendix VIII and Table 5). It was found that the highest biological yield (3.88 t ha^{-1}) was recorded from the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf) which was statistically similar to F_1C_0, F_2C_1 and F_3C_3. The lowest biological yield (2.53 t ha^{-1}) was found from F_3C_2 (Recommended fertilizer + 3% urea foliar spray at flower initiation × Clipping 2 basal leaves) which was statistically similar to F_0C_0, F_2C_0, F_2C_3, F_3C_0, F_3C_1 and F_3C_2. As photosynthesis and transpiration increased due to recommended fertilizer and leaf clipping which ultimately resulting in high biomass production.

4.3.4 Harvest index (%)

4.3.4.1 Effect of foliar spray

Statistically significant variation was recorded for harvest index due to fertilizer management in respect of foliar spray of urea (Appendix VIII and Fig.24). Results revealed that the highest harvest index (29.7%) was recorded from F_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation) followed (28.73%) by F_2 (Recommended fertilizer + 2% urea foliar spray at flower initiation) where the lowest harvest index (24.9%) was observed from F_1 (Recommended fertilizer + 1% urea foliar spray at flower initiation) which was statistically similar (25.79%) with F_0 (Recommended fertilizer + No foliar spray). Mahajan *et al*. (1994) found that soil application of nitrogen increased harvest index significantly of groundnut. As nitrogen is a constituent of protein, foliar spray may increase total dry matter than control. Consequently, HI may fall than control and excess supply of foliar applied N.

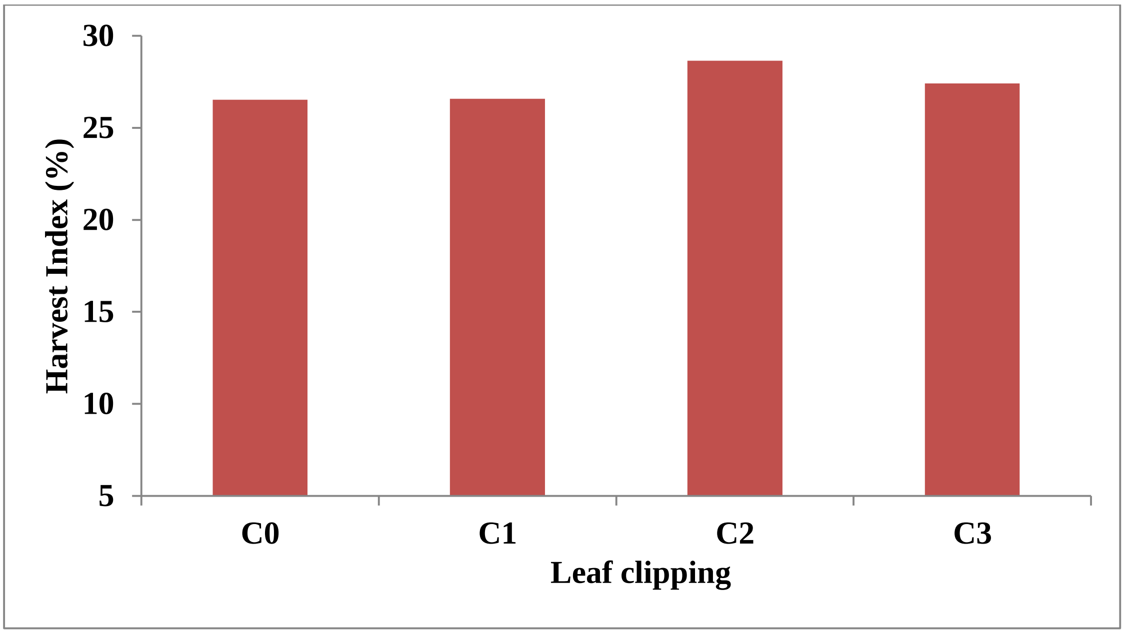


F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

Figure 24. Effect of foliar spray on harvest index (%) at harvest of mungbean (LSD $_{0.05}$ = 2.73 at harvest).

4.3.4.2 Effect of leaf clipping

Harvest index of mungbean showed statistically non-significant variation due leaf clipping of mungbean (Appendix VIII and Fig. 25). The highest harvest index (28.64%) was observed from C_2 (Clipping 2 basal leaves), which was statistically similar (27.42%) with C_3. The lowest harvest index (26.52%) was observed from C_0 (No leaf clipping), which was statistically similar to C_2 (26.58%). Removal of subtending leaves had detrimental effect on HI, whereas the removal of empty leaves exerted positive effects on HI, Higher HI due to the removal of flowers and gynophores in groundnut was reported by Talwar *et al.* (1992). Leaf clipping may reduce biological yield than control but increase grain yield. Hence, it increase HI which may be similar to undisturbed plant.



C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

Figure 25. Effect of leaf clipping on harvest index (%) at harvest of mungbean (LSD $_{0.05}$ = 2.13 at harvest).

4.3.4.3 Combined effect of foliar spray and leaf clipping

Harvest index of mungbean was significantly influenced by interaction effect of fertilizer management through foliar spray of urea and leaf clipping

(Appendix VIII and Table 5). It was found that the highest harvest index (32.55%) was recorded from the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping of 1 basal leaf) which was statistically similar to F_2C_1, F_2C_2, F_2C_3, F_3C_0, F_3C_1 and F_3C_3. The lowest harvest index (22.77%) was found from F_1C_1 (Recommended fertilizer + 1% urea foliar spray at flower initiation × Clipping 1 basal leaf) which was statistically similar to F_0C_0, F_0C_2, F_0C_3, F_1C_0, F_1C_2, F_1C_3 and F_2C_0. Hamid (1994) demonstrated that the development of tertiary branches and much of the secondary branches in mungbean is counter productive. Plant with high dry matter production capacity does not mean high seed yield potential. Increase in yields over the past decade has been possible mainly through favorable partitioning into grains. It may be shown for mungbean also the partitioning of dry matter seemed to be more favorable for increasing harvest index. If the retention of dry matter in vegetative organs is high without increase reproductive units resulting poor harvest index. From the above discussion, required N supply along with leaf clipping may act in this circumstances to overcome this problem.

Table 5. Combined effect of foliar spray and leaf clipping on seed yield, stover yield, biological yield and harvest index of mungbean

Treatment combinations	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
F_0C_0	0.60 h	1.94 de	2.53 fg	23.66 fg
F_0C_1	1.26 a	2.62 a	3.88 a	32.55 a
F_0C_2	0.74 f-h	2.47 a-c	3.21 b-e	22.99 g
F_0C_3	0.74 f-h	2.35 a-d	3.09 c-e	23.97 fg
F_1C_0	0.96 cd	2.61 ab	3.58 a-c	26.86 c-g
F_1C_1	0.76 f-h	2.57 ab	3.32 b-e	22.77 g
F_1C_2	0.88 d-f	2.43 a-c	3.31 b-e	26.56 d-g
F_1C_3	0.71 gh	2.33 a-d	3.05 d-f	23.39 fg
F_2C_0	0.71 gh	2.19 b-e	2.90 e-g	24.43 e-g
F_2C_1	1.08 bc	2.42 a-c	3.50 a-d	30.96 a-c
F_2C_2	0.97 cd	2.37 a-d	3.34 b-e	29.19 a-d
F_2C_3	0.77 e-g	1.76 e	2.53 fg	30.33 a-d
F_3C_0	0.93 c-e	2.07 c-e	3.01 d-g	31.14 ab
F_3C_1	0.82 d-g	2.09 c-e	2.91 e-g	28.30 a-e
F_3C_2	0.68 gh	1.80 e	2.49 g	27.34 b-f
F_3C_3	1.16 ab	2.47 a-c	3.62 ab	32.01 a
$LSD_{(0.05)}$	**0.17**	**0.43**	**0.52**	**4.27**
CV (%)	**11.58**	**11.23**	**9.93**	**9.28**

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of significance
F_0 = Recommended fertilizer + No foliar spray,
F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation
F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation
F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation

C_0 = No leaf clipping
C_1 = Clipping 1 basal leaf
C_2 = Clipping 2 basal leaves
C_3 = Clipping total apical leaves having no inflorescence

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was carried out at Sher-e-Bangla Agricultural University, Dhaka, during the period from March to May 2018 to study growth and yield response of mungbean to added urea foliar spray and leaf clipping. The experiment composed of four levels of fertilizer management in respect of foliar spray of urea *viz*. F_0 = Recommended fertilizer + No foliar spray, F_1 = Recommended fertilizer + 1% urea foliar spray at flower initiation, F_2 = Recommended fertilizer + 2% urea foliar spray at flower initiation and F_3 = Recommended fertilizer + 3% urea foliar spray at flower initiation and four levels of leaf clipping *viz*. C_0 = No leaf clipping, C_1 = Clipping 1 basal leaf, C_2 = Clipping 2 basal leaves and C_3 = Clipping total apical leaves having no inflorescence. The experiment was laid out in Split-plot design with three replications. Harvesting was done manually from each plot. Data were recorded on different growth and yield and yield contributing parameters.

Different growth and yield parameters of mungbean were significantly influenced by different fertilizer management in respect of foliar spray of urea practices. It was found that the maximum plant height (8.22, 22.41, 45.23, 47.40 and 51.96 cm, at 15, 30, 45, 60 DAS and harvest respectively) were recorded from F_0 (Recommended Fertilizer + No Foliar Spray). The highest above ground dry matter plant^{-1} (1.38, 4.85, 10.36 and 11.89 g at 30, 45, 60 DAS and harvest respectively), the highest pods plant^{-1} (7.95), pod length (7.70 cm), seeds pod^{-1} (10.92), 1000 seed weight (46.33 g), seed yield (0.90 t ha^{-1}), biological yield (3.32 t ha^{-1}) were recorded from F_0 (Recommended Fertilizer + No Foliar Spray). On the other hand, the minimum plant height (7.65, 20.56, 44.42, 46.73 and 49.23 cm, at 15, 30, 45, 60 DAS and harvest respectively) were recorded from F_2 (Recommended fertilizer + 2% urea foliar spray at flower initiation), but the lowest above ground dry matter plant^{-1} (1.10, 3.57, 8.87 and 10.57 g 30, 45, 60 DAS and harvest respectively), the lowest pods plant^{-1} (6.51), nodules plant^{-1} (4.23 and 2.88 at 45 and 60 DAS respectively), pod length (7.33 cm), seeds pod^{-1} (9.92), 1000 seed weight (45.6 g), seed yield (0.83 t ha^{-1}**), s**tover yield (2.11 t ha^{-1}), biological yield (3.01 t ha^{-1}) and highest harvest index (29.7%) were obtained from F_3 (Recommended fertilizer + 3% urea foliar spray at flower initiation).

Different growth, yield and yield contributing parameters were also significantly influenced by leaf clipping of mungbean. In terms of growth parameters, the C_1 (Clipping 1 basal leaf) gave the maximum plant height (8.25, 22.53, 45.9, 48.21 and 51.46 cm at 15, 30, 45, 60 DAS and at harvest, respectively), highest above ground dry matter plant^{-1} (1.36, 4.66, 10.56 and 11.85 g at 30, 45, 60 DAS and at harvest, respectively) and maximum number of nodules plant^{-1} (5.1 and 3.02 at 45 and 60 DAS, respectively) where C_3 (Clipping total apical leaves having no inflorescence) gave the minimum plant height (7.37, 20.69, 43.62, 46.37 and 48.74 cm at 15, 30, 45, 60 DAS and harvest, respectively), lowest dry matter plant^{-1} (1.09, 3.95, 8.94 and 10.27 g at 30, 45, 60 DAS and at harvest, respectively) and lowest nodules plant^{-1} (3.84, and 2.53 at 45 and 60 DAS respectively). In terms of yield and yield contributing parameters, the highest pods plant^{-1} (7.50), pod length (7.57 cm), seeds pod^{-1} (10.54), 1000 seed weight (46.49 g), seed yield (0.98 t ha^{-1}), stover yield (2.53 t ha^{-1}), biological yield (3.41 t ha^{-1}) and lowest harvest index (26.58%) were obtained from C_1 (Clipping 1 basal leaf) where the lowest pods plant^{-1} (6.87), pod length (7.41 cm), seeds pod^{-1} (10.17), 1000 seed weight (44.54 g), seed yield (0.8 Tha^{-1}), stover yield (2.20 t ha^{-1}) and biological yield (3.00 t ha^{-1}) were also obtained from C_3 (Clipping total apical leaves having no inflorescence) while the highest harvest index (28.64%) was obtained from C_2 (Clipping 2 basal leaves).

Different growth and yield parameters of mungbean were also significantly influenced by the interaction of fertilizer management practices in respect of foliar spray and leaf clipping. Results revealed that the maximum plant height (61.20 cm at harvest) and the highest nodules plant^{-1} (5.23 and 3.40 at 45 and

60 DAS respectively) were recorded from the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf). The highest above ground dry matter content plant^{-1} (13.93 and 14.76 g at 60 DAS and harvest respectively), the highest pods plant^{-1} (9.81), pod length (7.82 cm), seeds pod^{-1} (12.08), 1000 seed weight (48.07 g), seed yield (1.26 t ha^{-1}), stover yield (2.62 t ha^{-1}), biological yield (3.88 t ha^{-1}) and harvest index (32.55%) were recorded from the treatment combination of F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf). Again, the minimum plant height (6.60, 17.92 and 41.33 cm, at 15, 30 and 45 DAS respectively) were found form F_2C_3 and 42.50 cm at 60 DAS, 45.10 cm at harvest were found form F_2C_3. The lowest above ground dry matter plant^{-1} (8.41 g) at harvest were found from F_0C_0. The lowest nodules plant^{-1} (3.68 and 1.87 at 45 and 60 DAS respectively) were found from F_2C_0. The lowest pods plant^{-1} (5.80) were found from F_2C_3, pod length (7.14 cm) were found from F_3C_0, seeds pod^{-1} (9.20) were found from F_0C_3, 1000 seed weight (43.32 g) were found from F_1C_0, seed yield (0.60 t ha^{-1}) were found from F_0C_0, stover yield (1.76 t ha^{-1}) were found from F_2C_3, biological yield (2.49 t ha^{-1}) were found from F_3C_2 and lowest harvest index (22.77%) were found from the treatment combination of F_1C_1.

Based on the experimental results, it may be concluded that added foliar spray had no or even negative influence on yield improvement of mungbean whereas clipping had positive effect. Treatment F_0C_1 (Recommended fertilizer + No foliar spray × Clipping 1 basal leaf) gave maximum seed yield (1.26 t ha^{-1}) which was seemed to the suggestive for setting higher yield of mungbean.

RECOMMENDATIONS

Such study may be conducted at different mungbean growing areas of Bangladesh for justification of the treatment variability towards improvement of the crop.

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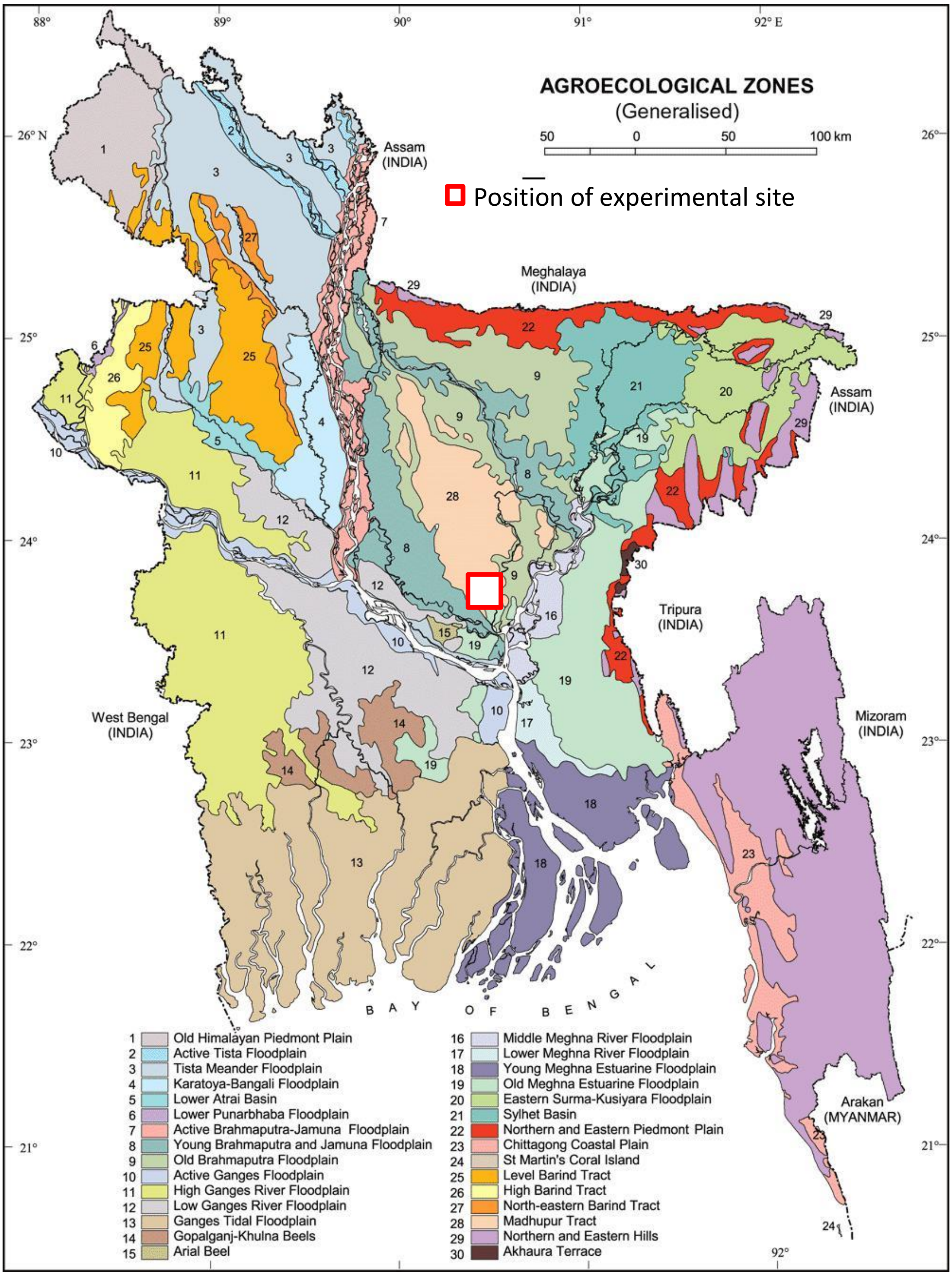
APPENDICES

Appendix I. Map showing the experimental sites under study



Appendix II. Monthly records of air temperature, relative humidity and Total rainfall during the period from March to May 2018.

Month	RH (%)	Air temperature (^0C)		Total Rainfall (mm)
		Max.	Min.	
March	57	34	16	65
April	66	35	20	155
May	68	34	23	165

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207.

Appendix III. Morpho-physiological and chemical characteristics of experimental soil

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Source: Soil Resource Development Institute (SRDI), Farmgate, Dhaka.

B. Physical and chemical properties of the initial soil

Characteristics	Value
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

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

Appendix IV. Mean square values of the data on plant height of mungbean as influenced by combined effect of foliar spray and leaf clipping

Source of variation	df	Mean squares of plant height at different days after sowing (DAS)				
		15	30	45	60	At harvest
Replication	2	2.509	30.753	347.712	314.870	447.133
Foliar spray (A)	3	1.073^{NS}	9.243^{NS}	1.797^{NS}	1.584^{NS}	18.285^{NS}
Error	6	1.172	20.055	19.754	25.732	12.181
Leaf clipping (B)	3	2.256^{*}	8.862^{*}	12.193^{*}	7.801^{NS}	16.024^{NS}
Foliar spray (A) X Leaf clipping (B)	9	1.324^{*}	9.580^{*}	49.005^{*}	51.245^{*}	78.407^{*}
Error	24	0.959	2.339	6.375	10.786	11.050

*Significant at 5% level of significance
NS =Non significant

Appendix V. Mean square values of the data on above ground dry matter plant^{-1} of mungbean as influenced by combined effect of foliar spray and leaf clipping

Source of variation	df	Mean squares of above ground dry matter plant^{-1} at different days after sowing (DAS)			
		30	45	60	At harvest
Replication	2	0.202	0.246	4.998	2.273
Foliar spray (A)	3	0.239^{*}	3.873^{*}	5.588^{*}	4.396^{*}
Error	6	0.015	0.493	0.807	1.307
Leaf clipping (B)	3	0.148^{*}	1.034^{*}	6.477^{*}	5.206^{*}
Foliar spray (A) X Leaf clipping (B)	9	0.112^{*}	1.520^{*}	10.181^{*}	14.303^{*}
Error	24	0.011	0.232	0.785	1.379

*Significant at 5% level of significance

Appendix VI. Mean square values of the data on nodules plant^{-1} of mungbean as influenced by combined effect of foliar spray and leaf clipping

Source of variation	df	Mean squares of nodules plant^{-1} at different days after sowing (DAS)	
		45	60
Replication	2	0.946	0.175
Foliar spray (A)	3	2.316*	0.930*
Error	6	0.599	0.070
Leaf clipping (B)	3	3.758*	0.643*
Foliar spray (A) X Leaf clipping (B)	9	0.705*	0.585*
Error	24	0.254	0.128

*Significant at 5% level of significance

Appendix VII. Mean square values of the data on pod length, number of pods plant^{-1}, number of seeds pod^{-1} and thousand seed weight of mungbean as influenced by combined effect of foliar spray and leaf clipping

Source of variation	df	Mean squares at different days after sowing (DAS)			
		Pod length	Number of pods plant^{-1}	Number of seeds pod^{-1}	Thousand seed weight
Replication	2	0.049	4.929	1.163	60.867
Foliar spray (A)	3	0.351^{NS}	4.936*	2.115*	7.342^{NS}
Error	6	0.280	0.174	0.778	27.133
Leaf clipping (B)	3	0.058^{NS}	1.140^{NS}	0.305^{NS}	8.306^{NS}
Foliar spray (A) X Leaf clipping(B)	9	0.145^{NS}	8.395*	2.175*	4.719^{NS}
Error	24	0.519	0.658	1.058	17.896

*Significant at 5% level of significance
NS =Non significant

Appendix VIII. Mean square values of the data on seed yield, stover yield, biological yield and harvest index of mungbean as influenced by combined effect of foliar spray and leaf clipping

Source of variation	df	Mean squares at different days after sowing (DAS)			
		Seed yield	Stover yield	Biological yield	Harvest index
Replication	2	0.019	0.287	0.456	2.269
Foliar spray (A)	3	0.015^{NS}	0.343*	0.221*	63.355*
Error	6	0.009	0.008	0.013	7.465
Leaf clipping (B)	3	0.080*	0.118*	0.385*	12.127*
Foliar spray (A) X Leaf clipping (B)	9	0.144*	0.227*	0.642*	34.594*
Error	24	0.010	0.066	0.097	6.411

*Significant at 5% level of significance
NS =Non significant

PLATES

Plate 1: Vegetative stage of mungbean

Plate 2: Reproductive stage

Plate 3: Harvesting stage and Harvested Pod