RESPONSE OF DIFFERENT MUNGBEAN (*Vigna radiata* L.) VARIETIES TO LEAFLET CLIPPING

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CERTIFICATE

This is to certify that the thesis entitled ***"RESPONSE OF DIFFERENT MUNGBEAN (Vigna radiata L.) VARIETIES TO LEAFLET 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 IN AGRICULTURAL BOTANY,*** *embodies the results of a piece of bonafide research work carried out by* ***MD. RAIANUL HAQUE, Registration No: 19-10256,*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

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The Author

RESPONSE OF DIFFERENT MUNGBEAN (*Vigna radiata* L.) VARIETIES TO LEAFLET CLIPPING

ABSTRACT

An experiment was carried out in the research plot of Sher-e-Bangla Agricultural University in Dhaka from February to June 2022, to explore how leaf clipping and variety affected mungbean growth and yield. The treatments included three leaf clipping techniques, C_0=No leaf clipping (control), C_1= 33% Leaf clipping (Removal of one leaflet), C_2= 66% Leaf clipping (Removal of two leaflet) and four mungbean varieties, V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3 = BARI Mung-7, V_4 = BARI Mung-8. A two-factor randomized complete block design (RCBD) followed with three replications was used to set up the experiment. Leaf clipping, variety and their interactions had a significant effect on the growth, yield and yield components of mungbean. The tallest plants (13.82, 26.45, 40.77, 58.34 and 62.4 cm at 15, 25, 35, 45 and 55 DAS respectively) were obtained from C_1V_4 (BARI Mung-8 with 33% leaf clipping). The highest pod length (10.03 cm), the maximum number of pods plant^{-1} (16.63), the highest number of seeds pod^{-1} (12.47) were obtained from C_1V_4 (BARI Mung-8 with 33% leaf clipping) treatment combination. The maximum seed size (52.55 mg) was obtained from C_1V_2 (BARI Mung-6 with 33% leaf clipping) treatment. The highest seed yield (2.09 t ha^{-1}) was obtained from C_1V_3 (BARI Mung-7 with 33% leaf clipping) treatment, while the lowest (1.07 t ha^{-1}) from C_2V_2 (BARI Mung-6 with 66% leaf clipping) treatment combination. Most of the parameters performed at their peak in case of BARI Mung-7 and BARI Mung-8. In most of the cases 33% leaf clipping demonstrated the best performance in terms of growth, yield and yield contributing characters. In case of combined effect, BARI Mung-7 with removal of one leaflet (33% leaf clipping) provided the best results followed by BARI Mung-8 with removal of one leaflet (33% leaf clipping) in terms of growth, yield and yield contributing parameters.

Keywords: Mungbean, Leaflet clipping, Yield, Growth, Variety.

Dedicated to

My first teachers

My Parents and loving Sisters

List of Abbreviations

AEZ	=	Agro-Ecological Zone
AVRDC	=	Asian Vegetable Research and Development Center (World Vegetable Center)
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
BINA	=	Bangladesh Institute of Nuclear Agriculture
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAS	=	Days after sowing
g	=	gram (s)
ha^{-1}	=	Per hectare
HI	=	Harvest Index
kg	=	Kilogram
LAI	=	Leaf area index
LSD	=	Least Significant Difference
Max	=	Maximum
Min	=	Minimum
mg	=	Milligram
MT	=	Metric ton
mm	=	millimeter
MoP	=	Muriate of Potash
N	=	Nitrogen
NAA	=	Naphthalene acetic acid
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
NS	=	Not significant
ppm	=	Parts per million
RCBD	=	Randomized complete block design
RWC	=	Relative water content
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
t	=	Ton
TSP	=	Triple Super Phosphate
viz.	=	Videlicet (namely)
Wt.	=	Weight
WUE	=	Water use efficiency

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CHAPTER I

INTRODUCTION

Pulses are important crops because of their high nutritional content, capacity to fix nitrogen, and versatility in a variety of cropping patterns. Bangladesh only consumes 14.13 g of pulses per person daily (BBS-HIES), compared to the WHO's recommendation of 45 g for a balanced diet. The Fabaceae family and subfamily Faboideae contain the key pulse crop known as mungbean (*Vigna radiata* L.), which is important for both its nutritional and commercial importance. Mungbean ranks third among the pulses in Bangladesh in terms of cultivable area (109304.77 acres) occupied and yearly production (41189.26 MT) (BBS, 2021). For the majority of people in Bangladesh, especially those who living in poverty, pulses are their primary source of protein. For domestic animals, it is the best source of protein. Additionally, it has the ability to enhance soils by fixing nitrogen. Its seeds contain 51% carbohydrate, 26% protein, 3% minerals and 3% vitamins (Kaul, 1982). It is widely used as “Dal” in the country like other pulses. It contains almost double amount of protein as compared to cereals. It has a good digestibility and flavor. It is one of the most important pulse crop in our country for its high digestibility, good flavor and high protein content. The green plants are used as animal feed and the residues as manure. Mungbean is a crop of short duration and drought tolerant and can grow with a minimum supply of nutrients. In Bangladesh, mungbean grows well all over the country. Mungbean also improves physical, chemical and biological properties of soil by fixing nitrogen from atmosphere through symbiosis and hence it had played a central role in sustainable agriculture (Kannaiyan, 1999).The rice based cropping pattern has been found as an important cropping system in our country. Besides this, increasing area under wheat and maize cultivation has further reduced the area under pulses. The country is also facing an acute shortage of mungbean due to low yield. The reasons for low yield are varietal and agronomic management. Due to the shortage of land, the scope of its extensive cultivation is very limited. The agro-ecological condition of Bangladesh is favorable for mungbean cultivation almost throughout the year. The crop is usually cultivated during rabi season. Now a days this crop has been well accepted by the farmers in southern and barind area of Bangladesh.

Excessive leaf development in mungbean during the later growth stages was found to be detrimental to seed yield (Patel *et al.,* 1992). Production of leaves, particular in the lower part of the plant often causes mutual shading resulting in yield reduction. Total dry matter production is positively correlated with the amount of foliage displayed in upper 50% of the canopy (Hamid *et al.,* 1990). It seems like 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 having habit of excessive leaf development. Inadequate leaf production in the vegetative phase indicates that during the post-flowering phase, when the sink activity was high, most photosynthates required for the growth and development of pods comes from the current photosynthesis (Kuo *et al.,* 1978). In some situations, leaf is adequate and even more than required, but the functional efficiency is far lower due to utilizing resources as a respiratory burden of excessive leaves (Venkateswarlu and Visperas, 1987; Mondal, 2007). Removal of apical shoot above node 5 or removal of inflorescence or axillary bud at nodes 1-4 together with the apical shoot greatly increased pod number and seed weight of mungbean (Clifford, 1979).The leaves at flowering nodes are the major contributors to seed filling and development (AVRDC, 1974). 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*., 2006). Greater light penetration in the canopy through defoliation has reduced the abortion of flowers and immature pods and increased seed yield in mungbean (Mondal, 2007). It is therefore imperative that for high yield formation in mungbean, plants should have adequate foliage development prior to pod development stage. Genotypic differences in leaf area development in mungbean have been reported (Hamid *et al.,* 1994). Reverse results of defoliation was also reported in mungbean (Rao and Ghildiyal 1985). In spite of the best efforts for improving the mungbean varieties, the yield of this crop remains low. Besides this; Traditional varieties of pulse crop possess greater sources than sink, leads to poor crop performance especially when fertilization and cultural practices result in greater foliage and poor productivity (Hossain *et al*., 2006). Recently, Bangladesh Agricultural Research Institute (BARI) has developed eight and Bangladesh Institute of Nuclear Agriculture (BINA) has developed seven high yielding cultivars of mungbean, which are getting attention to the farmers. During kharif season the crop fits well into the existing cropping system of many areas in Bangladesh.

Due to inadequate irrigation infrastructure, poor seed quality, and poor management techniques, mungbean cultivation in Bangladesh faces difficulties. The capacity of a crop's source-sink system affects its production. Another issue for the production of pulses is the premature abscission of flowers and fruits, which results in diminished sink potential (Bari, 2000; Begum, 2002). As a result, whereas the majority of grain legumes, including mungbean, produce numerous blooms, only few of them actually establish pods (Egli and Brening, 2003; Islam, 2004; Rahman, 2004). Studies on the interaction between the source and sink in agricultural plants came to the conclusion that the main factor limiting sink yield is itself, and that source leaves typically do not appreciably impede sink development (Ghildiyal, 2001; Board 2004). The accumulation of dry matter in various vegetative sections and its transfer to growing pods are the two main factors influencing grain yield (Hamid *et al*., 1991). A crucial factor that is closely connected to the physiological process regulating yield and the formation of dry matter in plants is leaf area. In a general sense, the size, duration, and activity of the source and sink capacity affect seed output. After germination, an efficient plant will often reach its ideal leaf area index (LAI) to maximize light absorption (Kou *et al*., 1978). Defoliation is one example of a physiological treatment that might improve leaf growth, which in turn affects the dry matter buildup before flowering and, eventually, the yield and yield components. Changes in the amount of assimilates available due to defoliation may have an impact on the quantity and size of seeds per pod, and ultimately, the yield. In several crop species, defoliation has an impact on leaf photosynthetic rates. The average weight of pods per 20 plants was 680.8 g with defoliation before flowering, 624.8 g with defoliation during flowering and 539.4 g after pod formation (Ramio and Oliveria, 1975). Removal of the lower leaves of soybean at the early flowering stage decline in seed yield by 20%, but it was 80% with severe defoliation (Lockwood *et al*., 1977). 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 (Tickoo *et al*., 1984). Vegetative growth and seed yield of mungbean were markedly decreased due to 33.3 or 66.6% removal of the leaf area, but the removal of 16.6% of leaf area had no adverse effect on yield (Pandey and Singh, 1984). In broad bean (*Vicia faba*), the yield was decreased by 36.7% in plants when upper leaves were removed at the beginning of flowering (Xia, 1987). Removal of 16.6% of the leaves increased the grain yield compared with no defoliation, and more than 50% defoliation markedly decreased grain yield and delayed maturity compared with other soybeans (Timisina and Thapa, 1991). Removal of flowers and pods after the first week of flowering significantly reduced yields compared to no removal (Bera and Ghosh, 1994). Plant genotypes with profuse branching habit often show poor harvest index despite 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). In cowpea, the vegetative growth and seed yield were noticeably decreased following 66% or 100% removal of the leaf area (Biswas, 2000).

In Bangladesh, there are a few local and a few developed mungbean varieties. These mungbean cultivars differ in terms of yield performance due to genetic, agronomic, and physiological features. The development of new mungbean varieties with improved branching, canopy structure, dry matter partitioning, and grain yield is the subject of arduous research. There is a general pattern that the pulses frequently had excessive vegetative development, which decreased production (Patel *et al*., 1992). The issue of excessive vegetative growth may be solved by defoliation up to a certain point. Little research work has been done in these regard in Bangladesh. So, the present research work had been carried out with the following objectives-

1. To investigate the effect of leaf clipping on growth and yield of mungbean
2. To evaluate the varietal performance of mungbean
3. To study the combined effect of leaf clipping and variety towards the yield of mungbean

CHAPTER II

REVIEW OF LITERATURE

Researchers inside and outside of Bangladesh have conducted a significant amount of study on different aspects of mungbean cultivation, particularly in South East Asia, in order to increase mungbean production. Researches on the improvement and varietal development of mungbean have been undertaken at the Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA). Different research works related to the current study of mungbean production have been presented in this chapter.

2.1 Effect of leaf clipping on growth and yield of mungbean

Alam *et al.* (2008) conducted a research work at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, Rajshahi, Bangladesh during the period from 2005 to 2006 to study the effect of source-sink manipulation on grain yield with twenty wheat genotypes. For grains spike^{-1}, 1000-grain weight, and grain yield spike^{-1}, significant differences between genotypes were found. According to his findings, removing the flag leaf reduced grains spike^{-1}, 1000-grain weight, and grain yield spike^{-1} by 9.94%, 7.65%, and 16.88%, respectively, when compared to the control condition of leaving the leaf in place.

Alexander *et al.* (1982) investigated the effect of clipping frequency on competition between *Lolium perenne* and *Agrostis tenuiswas*. The yield of clippings of both species increased and then declined during the 12-week period of the experiment, but the clip yield of *Lolium* was always significantly greater than that of *Agrostis* Unclipped controls showed that *Lolium* was by far the superior rival. As the time between clippings got shorter, more of the biomass from *Agrostis* was added to the mixture. Increased clipping frequency had no impact on tiller production in *Lolium*, but it did in *Agrostis*.

In comparison to *Agrostis*, whose yield was essentially unaffected by vast fluctuations in clipping frequency, total yield of *Lolium* was significantly lowered by frequent clipping. The outcomes matched up with the field distributions of two species. They added that any attempt to track the advancement of competition experiment by monitoring clipping yield is likely to be hampered by the variations in height and responsiveness to clipping.

Ali *et al.* (2008) carried out an experiment where five spring wheat varieties were utilized to study the contribution of flag leaf and awns on grain yield and its attributes. The characters associated with the photosynthetic activity were examined in relation to the grain yield and its attributes. The study revealed significant variation among different varieties, treatments and varieties × treatment. The treatments (removal of flag leaf, awns & both) caused considerable reduction in grain yield and its related characters. Removal of flag leaf had less effect on yield and related components than awns detachment. Nonetheless the detachment of flag leaf + awns revealed greater effects than individual treatment. Flag leaf area, awn length, number of grains spike^{-1} and 1000 grain weight demonstrated positive and significant association with grain yield plant^{-1}. Number of grains spike^{-1}, grain weight spike^{-1} and 1000 grain weight exhibited the maximum heritability and genetic advance over different treatments. The study investigated the presence of strong source-sink association of both flag leaf and awns with grain yield hence these traits could be used as morphological markers for selection of wheat genotypes having superior photosynthetic activity and higher grain yield.

Arzadún (2006) in Argentinean Pampas, new wheat (*Triticum aestivum* L.) cultivars were routinely introduced to farmers for dual-purpose production. The objective of this study was to evaluate the effect of planting date, clipping height on forage, and grain yield for wheat cultivars. Treatments were arranged as a 3 × 3 × 3 factorial distributed in a split-split plot within a randomized complete block design. Main plots were planting date; split-plots were clipping height (3 cm, 7 cm, and no clipping); and split-split plots were a facultative cultivar Pincen, and two non-facultative cultivars Charrua and Bordenave 223 (Bve223). In 1995 and 1996 forage yield decreased in response to a delayed planting date from March to May, whereas in 1997 it was not affected by planting date. The 3-cm clipping height yielded 21% more forage than plots clipped at 7 cm. Bordenave- 223 and Charrua produced significantly more forage than Pincen each year. Grain yield increased as planting date progressed from March to May. Clipping at 3 cm reduced grain yield compared with no clipping, while during 2 to 3 years, 7 cm produced no significant change in grain yield compared with no clipping. In all years Bordenave 223 produced more grain than Charrua or Pincen. In conclusion, dual-purpose wheat planted during April had both good forage and grain production, and its success was influenced by cultivars.

Birsin *et al.* (2005) conducted an experiment in the experimental field of the Field Crops Department, Faculty of Agriculture, Ankara University during 1999 and 2001. Two wheat cultivars, Gerek-79 and Gün-9, were studied to examine the impacts of removing some photosynthetic structures including flag leaf, second upper leaf blade and awns on some yield related components. The experiment was laid out in a randomized complete block design of split-plot restriction with four replications. Removal of flag leaf resulted approximately 13, 34, 24 % reduction in grain spike^{-1}, grain weight spike^{-1} and 1000-grain weight, respectively and 2.8% increase in grain protein contents in both years. Studies indicated that significant reductions in these traits and increases in grain protein contents resulted from removal of second upper leaf blade and awns.

Biswas and Hamid (1992) reported the 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 an erratic growth pattern. The availability of assimilates after flowering to grain formation and the grain's capacity to receive those assimilates both play a significant role on mungbean grain output. Sink capacity can be defined as the yield of the final grain number and prospective grain size. Several researchers looked at the Mungbean's development traits. During the growing season, mungbean grows slowly before accelerating and reaching its peak during flowering. In the vegetative phase, dry matter accumulation can hardly support the growth traits. Mungbean senescence is quite slow, thus leaves continue to function into the later stages of reproductive development.

Busso *et al.* (1995) carried out an experiment where tiller demography and growth were determined for clipped and unclipped plants of crested wheatgrass (*Agropyron desertorum*) and bluebunch wheatgrass (*Pseudoroegneria spicata*) under drought, natural or irrigated conditions from 1984 until 1986. Mild water stress during the 1984 growing season did not reduce herbage accumulation at the end of that season on plants of both species. Green leaf number, rate of leaf initiation, height and total green leaf area were all reduced on tillers of both species when predawn leaf xylem pressure potentials fell below 2·5 MPa during two or more growth periods. In the 3rd year of repeated treatments, the lowest daughter tiller production and growth were observed under the simultaneous influence of drought and clipping. Repeated late and severe leaf clipping of these species under long-term droughts (2 or more years) could then be expected to rapidly reduce their persistence in the community.

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.

Chowdhary *et al.* (1999) also reported that removal of flag leaf significantly reduced number of grains spike^{-1}, 1000-grain weight and grain yield. Similarly, removal of all leaves caused reduction by 17.17%, 13.27% and 27.92% for grains spike^{-1}, 100-grain weight and grain yield spike^{-1} respectively.

Clifford (1979) suggested that removal of apical shoot above node 5 or removal of inflorescence or auxiliary buds at nodes 1-4 together with the apical shoot greatly increased pod number and seed weight of mungbean.

Davidson (1965) found that the effects on variety Olympic wheat of maintaining the leaf area index (LAI), once attained, at approximately 3 and 1, and of removing whole leaves or half of each leaf at ear emergence, were assessed by comparison with an uncut crop (maximum LAI= 12). Leaf clipping at ear emergence had no significant impact on grain yield. Leaf area maintenance at LAI values of 3 and 1 greatly reduced grain yield by decreasing both grain number spike-1 and mean grain weight by about 50%. These effects followed earlier reductions in the rate of development of the shoot apex. The results were discussed in relation to the yields obtained and conclusions reached by English workers, and to possible scope for yield improvement.

Elsahookie *et al*. (1988) were conducted an experiment to study the effect of leaf clipping on maize (*Zea mays* L.) performance, nine different treatments were tested on an open-pollinated genotype of maize. In the spring grown maize, grain yield plant^{-1} was increased up to 38% for plants with their upper half leaves were cut. Root weight plant^{-1}and modified flowering were also increased. Cutting the whole plant decreased grain yield and caused death of about 50% of plants. Meanwhile, leaf clipping decreased several agronomic traits in the fall grown maize. The results of modified flowering lead to the speculation that genes could change their location on the chromosome and/or material dose when plants be under stressed conditions.

Hamid (1989) showed that defoliation at the reproductive stage reduced pod set and grain yield, mid the reduction was proportional to the degree of defoliation. Defoliation affected leaf photosynthetic rates in a number of species.

Hamid (1994) demonstrated that the development of· tertiary branches and much of the secondary branches in mungbean is counterproductive. 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.

Hamzi *et al*. (2018) conducted a field experiment to study the relationship between sink and source in corn plants, experiment was conducted as a factorial experiment in a Randomized Complete Block Design with three replications. A total of 3 cultivars (301, 604 and 700) and four leaf clippings (without leaf clipping, ear leaf clipping, above ear leaf clipping, and below ear leaf clipping) were used during 2007 crop season. Results showed that oil, grain yield, globulin, glutamine, and carbohydrates were different among cultivars and treatment compositions. Leaf clipping did not affect oil, globulin and carbohydrates but yield and other quality traits were influenced by leaf clipping. Ear leaf clipping and below ear leaf defoliation were ranked second for yield production. The lowest yield was observed in above ear leaf clipping treatment. Overall, all leaf clipping treatments produced similar amounts of oil, globulin and carbohydrates. The highest glutamine was obtained in above ear leaf clipping that was similar with ear leaf clipping treatment. Control treatment had the lowest glutamine similar to ear leaf clipping and below ear leaf clipping treatments. Above ear leaf clipping strongly increased grain prolamine and albumin. The lowest prolamine was obtained from below ear leaf clipping and without leaf clipping treatments. But the minimum grain albumin was belonged to ear leaf clipping. Leaf clipping treatments were ranked in four different groups with aspect to grain albumin concentration whereas control and below leaf clipping treatments had no difference in grain prolamine.

Khalifa *et al.* (2008) conducted several field experiments during two summer seasons of 2003 and 2004 to study the effect of leaf cutting on physiological traits and yield of two rice cultivars hybrid (H5) (IR 70368 A /G 178) and inbred rice. The leaf cutting was followed from flag leaf as follows: 1.) L; Control = without leaf cutting, 2.) L_1; flag leaf cut, 3.) L_2; second leaf cut, 4.) L_3; third leaf cut, 5.) L_4; both flag leaf and second leaf cut. 6.) L_5; flag leaf, second leaf and third leaf cut together. A split plot design with four replications was used; the main plots were devoted to the cutting of leaves, while the subplots were assigned to the two rice cultivars. Chlorophyll, sugar, starch and grain yield parameters were severely affected by L_5, followed by L_4, L_1, L_3 and L_2 in sequence. However, as a single component affecting maximum to these parameters is the removal of flag leaf. The flag leaf contributed maximum to the yield of rice grains. L_5, L_4, L_1, L_2 and L_3 treatments grain yield (relative % of control) by 59.87, 94.92, 44.89, 29.58 and 19.98 % respectively. Flag leaf contributed to 45% of grain yield and is the single most component for yield loss. The contribution of removal of leaf in hybrid rice was minimum, suggesting the probability of maximum translocation of photosynthesis from stem to the grain during grain feeling stage of hybrid rice after leaf removal.

Kumar *et al*. (2016) investigated the virulence of *R. solanacearum* on adult host plants, infection studies of this pathogen on the seedling stages of hosts are less common. In a preliminary observation, inoculation of *R. solanacearum* F_1C_1 on 6- to 7-day-old tomato seedlings by a simple leaf-clip strategy resulted in a lethal pathogenic condition in seedlings that eventually killed these seedlings within a week post-inoculation. This prompted testing of the effect of this inoculation technique in seedlings from different cultivars of tomato and similar results were obtained. Colonization and spread of the bacteria throughout the infected seedlings was demonstrated using *gus*-tagged *R. solanacearum* F_1C_1. The same method of inoculating tomato seedlings was used with *R. solanacearum* GMI 1000 and independent mutants of *R. solanacearum* GMI 1000, deficient in the virulence genes *hrpB*, *hrpG*, *phcA* and *gspD*. Wildtype *R. solanacearum* GMI 1000 was found to be virulent on tomato seedlings, whereas the mutants were found to be non-virulent. This leaf-clip technique, for inoculation of tomato seedlings, has the potential to be a valuable approach, saving time, space, labour and costs.

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

Lambers (1987) evaluated that the total dry matter yield is the product of leaf photosynthetic activity. Grain yield the biomass production is not correlated with photosynthetic rate. And as a result selection for increased leaf photosynthetic rate has not apparently resulted in any substantial or consistent increase in yield.

Li *et al*. (2004) conducted an experiment to examine how the interactions of nutrient availability and partial ramet clipping affect growth, reproduction and biomass allocation of *Cyperus esculentus*, an invasive sedge. The plants sprouting from tubers were grown at low and high nutrient levels, and were subject either to no clipping, one, two or three clippings, with each clipping cutting half of the existing ramets at soil level. Results showed that nutrient availability and clipping frequency tended to independently affect most of growth, reproduction and biomass allocation parameters of *Cyperus esculentus* examined in that study. Increased supply of nutrients led to an increase in plant productivity and its associated traits.

All of the traits, except for the number of ramets, displayed a decreasing pattern with increasing clipping frequency, indicating that *Cyperus esculentus* had undercompensatory responses to ramet clipping. It is likely that the patterns of plants' response to clipping are species specific, and depend on morphological characters of species. Its susceptibility to ramet clipping can offer opportunities for controlling this invasive species through mechanical methods such as mowing. Clipping had little effects on biomass allocation; however, root weight fraction increased with increasing clipping frequency. While nutrient availability and clipping frequency had no influence on leaf carbon concentration at harvest, both of them increased leaf nitrogen concentration, and hence reduced leaf C/N ratio.

Marshal and Wardlaw (1973) reported 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.

Mahmood *et al*. (1997) carried out some studies to investigate the impact of the removal of green photosynthetic structures including flag leaf, 3rd nodal leaf and awns, on yield and some yield related parameters in two local wheat cultivars (Pasban 90 and Inqalab 91). The experiment was conducted in a triplicated randomized complete block design in split-plot fashion. The two varieties differed significantly for flag leaf area, 3rd nodal leaf area, seed set percentage, grains per spike and grain weight per spike. Effect of removing flag leaf (T_2), 3rd nodal leaf (T_3) and awns (T_4) was displayed as reduction in yield attributes. Removal of flag leaf resulted 16.4, 14.8, 34.5 and 20.0% reduction in seed set percentage, grains/spike, grain weight/spike and 100 grain weight, respectively. Reduction in these traits as a consequence of the removal of 3rd nodal leaf and awns was also significant. However the rate of the reduction was less than that of removal of flag leaf. Interaction of varieties and treatments was significant for seed set, grains/spike and 100-grain weight. Both of the varieties exhibits a marked reduction in the four traits studied when the flag leaf was removed. However, Inqalab 91 was found superior to Pasban 90. The result signified the contribution of flag leaf on yield related traits studied. In ranked order maximum contribution occurred from flag leaf followed by 3rd nodal leaf and awns at the last.

Mapfumo *et al.* (2007) were explored the viability of intensifying pearl millet and sorghum production through use of nurseries and transplanting to address the problem of poor stand establishment. The experiments were conducted over two seasons, the 1999/2000 and 2000/2001 seasons in the south eastern lowveld of Zimbabwe where the mean rainfall is less than 500 mm per annum. Treatments included two pearl millet cultivars (PMV2 and PMV3) and two sorghum cultivars (*Mutode* and *Macia*). These crops were transplanted with and without leaf clipping at three seedling ages (30, 40 and 50 days for pearl millet; 29, 39 and 49 days for sorghum). Transplants were raised in nursery seedbeds. In the 1999/2000 season, there were significant effects of cultivar ($P<0.05$) and leaf clipping ($P<0.01$) on pearl millet grain yield. Clipped seedlings yielded 932 kg ha^{-1} compared to 797 kg ha^{-1} for non-clipped seedlings while PMV3 yielded 902 kg ha^{-1} compared to 820 kg ha^{-1} for non-clipped seedlings. However, leaf clipping tended to increase yields for both cultivars. An increase in seedling age from 29 days also tended to reduce yields. It was concluded that leaf clipping of 30-day old seedlings at transplanting may enhance sorghum and pearl millet yields in the semi-arid tropics.

Mariko and Hogetsu (1987) reported that defoliated sunflower plants showed higher rates of photosynthesis than those of under foliated plants. Defoliation tends to influence the ageing of the remaining or new leaves. Old Leaves can be allowed to rejuvenate, matter ones to maintain their vigor and young ones to develop their photosynthesis rapidly. 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 tor mungbean also the partitioning 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 content.

Mondal *et al*. (1978) reported the mass flow hypothesis on the increasing photosynthesis, increase hydrostatic pressure and translocation rate. However, this is true only if sinks have the ability to utilize the increased production. There-wise, there would be a steady build-up of sugars in the system, causing a feedback inhibition resulting in reduced photosynthesis. The rate of photosynthesis 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.

Moriondo *et al.* (2003) conducted an experiment on defoliation of sunflower and no significant difference was observed in terms of plant height. Similarly, Johnson (1972) in his investigation on yield and other traits of sunflower found that defoliation treatments influenced neither plant height nor lodging. Defoliation affected seed number per head, so that 34.5% reduction in seed number occurred by removal of 6 leaves from lower part of the plant.

Muro *et al*. (2001) also came up with the same results. Removal of the plant leaves is an index for lowering photosynthesis capacity. Since at the present study defoliation was performed in the head visible stage, prior to seed number determination, the plant came up with a decrease.

Patel *et al.* (1992) reported that excessive leaf area development during the later growth stages was found to be detrimental to seed yield. Productions of leaves particularly in the lower part of the plant often caused mutual shading resulting in parasitism and eventually yield reduction.

Piening *et al*. (1969) carried out several experiments to compare yield losses in barley caused by partial defoliation and foliar infection by *Drechslera teres*, the causal agent of net blotch. When Gateway barley was grown under a low fertilizer regime, infection of lower leaves caused greater yield reductions than the removal of comparable leaves. In contrast, infection or removal of upper leaves reduced yields to about the same extent. Under a higher fertilizer regime, yield reductions from infection or defoliation were about equal (14%). These losses were considerably lower than those from plants on the low fertility regime and were similar to those caused by net blotch in the field. In leaf clipping experiments, root weights and yields were reduced proportionately to the amount of leaf tissue removed. The time required to head was also increased with increasing amounts of leaf clipping.

Remison *et al.* (1982) investigated the effects of N nutrition and leaf clipping after mid-silk of maize. Defoliation reduced weight of ears, grains, total dry matter above ground, harvest index and grain moisture. Crude protein was increased, especially with maximum clipping.

Wang *et al*. (2014) studied the effect of clipping height on rye grass regrowth was investigated by examining the roles of several plant hormones. Our study consisted of three treatment conditions: (1) darkness over whole plants, (2) darkness only over stubble leaf sheaths, and (3) light over whole plants. Results showed that under darkness over whole plant, low stubble height resulted in low leaf regrowth biomass. Similar leaf regrowth biomass was observed under conditions of darkness only over stubble leaf sheaths as well as light over whole plants. Each unit weight of stubble at different clipping heights has relatively similar potential of providing stored organic substance for leaf regrowth. Therefore, regrowth index, calculated as newly grown leaf biomass divided by unit stubble weight, was used to evaluate regrowth capacity at different clipping heights under minimal influence of organic substances stored in stubbles. Under light over whole plants and single clipping, low stubble height and high stubble height with root thinning resulted in low leaf biomass and high regrowth index. On the other hand, under light over whole plants and frequent clipping high leaf biomass and regrowth index were observed in high stubble height. In addition, we found that leaf zeatin and zeatin riboside (Z+ZR) affected ryegrass regrowth and that roots regulated leaf Z+ZR concentration. Thus, our results indicate that root-derived cytokinin concentration in leaves influences ryegrass regrowth at different clipping heights.

Wang *et al.* (1997) reported that removal of one half of the leaves reduced grain mass spike^{-1} and single grain mass. It was found that removal of all leaves had larger reducing effects than that of flag leaf alone. The varieties SAN-119, Shotabdi and Agrani were highly affected by defoliation treatments for grains spike^{-1} but Agrani and SAN-127 caused high reduction in 100-grain weight. The variety SAN-119, Agrani and Shotabdi showed high decrease in grain yield main spike^{-1} by defoliation treatments.

2.2 Effect of variety of mungbean

Ahmad *et al*. (2003) conducted a pot experiment in Bangladesh on the growth and yield of mungbean cultivars viz., BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5, BU mung-1, BU mung-2 and BINAI Mung-5 and found that BARI Mung-2 produced the highest seed yield while BARI Mung-3 produced the lowest.

Ali *et al.* (2014) investigated the effect of sowing time on yield and yield components of different mungbean varieties, a field experiment was conducted during 2012 at agronomic research area, University of Agriculture, Faisalabad, Pakistan. Their experiment was designed according to randomized complete block design under split plot arrangement in triplicate. Different sowing times (15th June, 25th June, 5th July and 15th July) were assigned to main plots and varieties (NM-2011, NM-2006, AZRI-2006 and NM-98) were allocated to subplots. Different mungbean varieties also responded significantly towards yield and yield components and NM-2011 variety outperformed in terms of maximum seed yield (1282.87 kg ha^{-1}) than rest of varieties.

Apurv and Tewari (2004) conducted a field experiment during kharif season of 2003 in Uttaranchal, India, to investigate the effect of *Rhizobium* inoculation and fertilizer on the yield and yield components of three mungbean cultivars (Pusa 105, Pusa 9531 and Pant mung-2). The variety Pusa 9531 showed higher yield components and grain yield than Pusa 105 and Pant mung-2. BARI (2005) found that small seeded entries had greater germination percentage than bold seeded ones which required less seed rate compared to bold seeded plants and even with same seed rate, small seeded entries accommodated more plants per unit area which contributed towards higher yield than the bold seeded ones.

BARI (2006) and BINA (2007) released several mungbean varieties and instructed that seed rate depend on seed size of a variety.

BARI (2005) and BINA (2005) further reported that optimum seed rate required 30-35 kg ha^{-1} for BARI Mung-2, BARI Mung-3, BARI Mung-4, Binamoog-2, Binamoog-3, Binamoog-4 and Binamoog-7 while optimum seed rate required 35-40 kg ha^{-1} for BARI Mung-5, BARI Mung-6, Binamoog-5 and Binamoog-6.

Bhati *et al*. (2005) evaluated an experiment from 2000 to 2003 to study the effects of cultivars and nutrient management strategies on the productivity of different kharif legumes (mungbean, mothbean and clusterbean) in the arid region of Rajasthan, India. The experiment with mungbean variety K-851 gave better yield than Asha and the local cultivar. In another experiment, mungbean cv. PDM-54 showed 56.9% higher seed yield and 13.7% higher fodder yield than the local cultivar.

Bhuiyan *et al*. (2008) examined a field studies with and without Bradyrhizobium was carried out with five mungbean varieties to observe the yield and yield attributes of mungbean. Five mungbean varieties viz. BARI Mung-2, BARI Mung-4, BARI Mung-5, BINAI Mung-2 and Barisal local, and the rhizobial inoculum (Bradyrhizobium strain BAUR-604) were used. The seeds and stover were dried and weighed adjusting at 14% moisture content and yields were converted to t/ha. The yield attributing data were recorded from 10 randomly selected plants. BARI Mung-2 produced the highest seed yield (1.03 t/ha in 2001 and 0.78 t/ha in 2002) and stover yield (2.24 t/ha in 2001 and 2.01 t/ha in 2002). Higher number of pods/plant was also recorded in BARI Mung-2, while BARI Mung-5 produced the highest 1000-seed weight.

BINA (1998) observed that among nine summer mungbean (*Vigna radiata* L.) cultivars, kalamung was the best performing cultivar with a potential grain yield of 793.65 kg ha^{-1} and the highest number of pods $plant^{-1}$(18.66) and high number of seeds pod^{-1}.

BINA (1998) reported that Binamoog-5 produced higher seed yield over Binamoog-2. Field duration of Binamoog-5 was about 78 days as against 82 days for Binamoog-2.

Chaisri *et al*. (2005) conducted a research work to study a yield trial involving 6 recommended cultivars (KPS 1, KPS 2, CN 60, CN 36, CN 72 and PSU 1) and 5 elite lines (C, E, F, G, H) in Lopburi Province, Thailand, during the dry (February-May 2002), early rainy (June-September 2002) and late rainy season (October 2002-January 2003). The Line C, KPS 1, CN 60, CN 36 and CN 72 gave high yields in the early rainy season, while line H, line G, line E, KPS 1 and line C gave high yields in the late rainy session.

Chaudhury *et al*. (1989) reported that mungbean cultivars had significant variation in dry matter accumulation in stem, leaf, seed and husk.

Hamed (1998) carried out two field experiments during 1995 and 1996 in Shalakan, Egypt, to evaluate mung bean cultivars Giza 1 and Kawny 1 under 3 irrigation intervals after flowering (15, 22 and 30 days) and 4 fertilizer treatments: inoculation with Rhizobium (R) + Azotobacter (A) + 5 (N1) or 10 kg N/ha (N), and inoculation with R only +5 (N3) or 10 kg N/ha (N4). Kawny 1 surpassed Giza 1 in pod number per plant (24.3) and seed yield (0.970 t/ha), while Giza 1 was superior in 100-seed weight (7.02g), biological and straw yields (5.53 and 4.61 t/ha, respectively). While Kawny 1 surpassed Giza 1 in oil yield (35.78 kg/ha), the latter cultivar recorded higher values of protein percentage and yield (28.22% and 264.6 kg/ha). The seed yield of both cultivars was positively and highly significantly correlated with all involved characters, except for 100-seed weight of Giza 1 and branch number per plant of Kawny 1.

Hossain and Solaiman (2004) investigated to find out the effects of *Rhizobium* inoculation on the nodulation, plant growth, yield attributes, seed and stover yields, and seed protein content of six mung bean (*Vigna radiata*) cultivars. The mungbean cultivars were BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5, BINAI Mung-2 and BU mung-1. *Rhizobium* strains TAL 169 and TAL 441 were used for inoculation of the seeds. Two-thirds of seeds of each cultivar were inoculated with *Rhizobium* inoculant and the remaining one-third of seeds were kept uninoculated. Among the cultivars, BARI Mung-4 performed the best in all aspects showing the highest seed yield of 1135 kg/ha.

Infante *et al*. (2003) carried out an experiment in mungbean cultivars ML 267, Acriollado and VC 1973 C under the agroecological conditions of Maracay, Venezuela, during May-July 1997. The differentiation of the development phases and stages, and the morphological changes of plants were studied. The variable totals of pod clusters, pods plant^{-1}, seeds pods-1 and pod length were also studied. The earliest cultivar was ML 267 with 34.87 days to flowering and 61.83 to maturity. There were significant differences for total pod clusters plant-1 and pods plant-1, where ML 267 and Acriollado had the highest values. The total seeds per pod of VC 1973C and Acriollado were significantly greater than ML 267. Acriollado showed the highest yield with 1438.33 kg/ha.

Islam *et al*. (2006) carried out an experiment at the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from March 2002 to June 2002 to evaluate the effect of biofertilizer (*Bradyrhizobium*) and plant growth regulators (GA3 and IAA) on growth of 3 cultivars of summer mungbean (*Vigna radiata* L.). Among the mungbean varieties, BINA moog 5 performed better than that of BINA moog 2.

Ahamed *et al*. (2011) conducted at the experimental field of Agricultural Botany Department, Sher-e- Bangla Agricultural University, Dhaka, Bangladesh from the period of August, 2009 to April, 2010 (Kharif-II season). Five mungbean varieties namely BARI Mung-2 (M_2), BARI Mung-3 (M_3), BARI Mung-4 (M_4), BARI Mung-5 (M_5) and BARI Mung-6 (M_6) were used in the experiment to observe their morphophysiological attributes in different plant spacings viz. 20×10 cm (D_1), 30×10 cm (D_2) and 40×10 cm (D_3). The highest plant height of BARI Mung-4 is 49.38 cm that is statistically with the height of BARI Mung-3 (i.e. 48.38 cm). Leaf area of BARI Mung-3 was the highest (147.57 cm^2). The variety BARI Mung-3 produced the lowest leaf area of 110.00 cm2. In the study BARI Mung-2 took 30.44 days for flowering that is statistically at per BARI Mung-6 (30.11) and BARI Mung-4 flower earliest (at 28.88 days after sowing) as compared to all other varieties.

Kabir and Sarkar (2008) carried out an experiment to study the effect of variety and planting density on the yield of mungbean in Kharif-I season (February to June) of 2003. The experiment comprised five varieties viz. BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5 and Binamoog-2. The experiment was laid out in a randomized complete block design with three replications. It was observed that BARI Mung-2 produced the highest seed yield and Binamoog-2 did the lowest.

Madriz-Isturiz and Luciani-Marcano (2004) conducted a field experiment in Venezuela during the rainy season of 1994-95 and dry season of 1995. Significant differences in the values of the parameters measured due to cultivar were recorded. The cultivars of mungbean named VC 1973C, Creole VC 1973A, VC 2768A, VC 1178B and Mililiter

267 were the most promising cultivars for cultivation in the area with the average yield was 1342.58 kg/ha.

Mondal (2004) conducted an experiment at farmer's field of Rangpur zone during kharif-I season to evaluate the performance of four mungbean varieties viz. BINAmoog-2, BINA moog-5, BARI Mung-2 and BARI Mung-5. Result revealed that Binamoog-5 had the highest seed yield (1091 kg ha^{-1}) than the other tested varieties because it produced the greater number of pods $plant^{-1}$ and 1000 seed weight. Moreover, Binamoog-5 matured 5 days earlier than the others.

Muhammad *et al*. (2006) conducted an experiment to study the nature of association between *Rhizobium phaseoli* and mungbean. Inocula of two *Rhizobium* strains, Tal-169 and Tal-420 were applied to four mungbean genotypes viz., NM-92, NMC-209, NM-98 and Chakwal Mung-97. A control treatment was also included for comparison. The experiment was carried out at the University of Arid Agriculture, Rawalpindi, Pakistan, during kharif, 2003. Both the strains in association with NM-92 had higher nodule dry weight, which was 13% greater than other strains × mungbean genotypes combinations.

Navgire *et al*. (2001) evaluated to study seeds of mungbean cultivars BM-4, S-8 and BM-86 were inoculated with Rhizobium strains M-11-85, M-6-84, GR-4 and M-6-65 before sowing in a field experiment conducted by in Maharashtra, India during the kharif season of 1993-94 and 1995-96. S-8, BM-4 and BM-86 recorded the highest mean nodulation (16.66), plant biomass (8.29 q ha^{-1}) and grain yield (4.79 q ha^{-1}) during the experimental years.

Parvez *et al*. (2013) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from October to January 2011 to study the performance of mungbean as affected by variety and level of phosphorus. The experiment comprised four varieties viz. BARI Mung-6, Binamoog-

4, Binamoog-6 and Binamoog-8 and four levels of phosphorus viz. 0, 20, 40 and 60 kg P_2O_5 ha^{-1} and laid out in a Randomized Complete Block Design with three replications. Their results revealed that the longest plant, highest number of branches $plant^{-1}$, number of total pods $plant^{-1}$, seeds $plant^{-1}$ and seed weight $plant^{-1}$ were obtained from BARI Mung-6. Binamoog-6 produced the highest seed yield which was as good as Binamoog-8. The second highest and the lowest seed yield were recorded from Binamoog-4 and BARI Mung-6, respectively. The highest stover yield was obtained from Binamoog-8 followed by Binamoog-4. The lowest stover yield was recorded from BARI Mung-6.

Raj and Tripathi (2005) conducted an experiment in Jodhpur, Rajasthan, India, during the kharif seasons, to evaluate the effects of cultivar (K-851 and RMG-62) as well as nitrogen (0 and 20 kg/ha) and phosphorus levels (0, 20 and 40 kg ha^{-1}) on the productivity of mungbean. The cultivars K-851 produced significantly higher values for seed and straw yields as well as yield attributes (plant height, pods $plant^{-1}$, seeds pod^{-1} and 1000-seed weight) compared with RMG-62. Higher net return and benefit : cost (B:C) ratio were also obtained with K-851 (Rs. 6544 ha^{-1} and 1.02, respectively) than RMG-62 (Rs. 4833 ha^{-1} and 0.76, respectively).

Rana and Singh (1992) in Kanpur, Uttar Pradesh of India reported that the yield was generally higher in *Vigna radiata* than *Vigna mango* and was the highest in cultivar PDM-11 than Sona mungbean.

Rasul *et al*. (2012) conducted a research work to establish the proper inter row spacing and suitable variety evaluation in Faisalabad, Pakistan. Three mung bean varieties V_1, V_2, V_3 (NM-92, NM-98, and M-1) were grown at three inter-row spacing (S_1- 30 cm, S_2- 60 cm and S_3- 90 cm) respectively. Among varieties V_2 exhibited the highest yield 727.02 kg ha^{-1} while the lowest seed yield 484.79 kg ha^{-1} was obtained with V_3.

Rehman *et al.* (2009) conducted a field experiment to study the effect of five planting dates viz. 30th March, 15th April, 15th May, 15th June and 15th July on two mungbean varieties i.e. NM-92 and M-1 were evaluated at NWFP Agricultural University, Peshawar during summer 2004.

Uddin *et al.* (2009) carried out a study in the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to investigate the interaction effect of variety and fertilizers on the growth and yield of summer Mungbean during the summer season of 2007. Five levels of fertilizer viz. control, N + P +K, Biofertilizer, Biofertilizer + N +P + K and Bio-fertilizer + P + K. and three varieties BARI Mung- 5, BARI Mung- 6 and Binamoog-5 were also used as experimental variables. Their experiment was laid out in Randomized Block Design with fifteen treatments where each treatment was replicated three times. BARI Mung-6 obtained highest number of nodule plant 1 and higher dry weight of nodule. They obtained highest number of pod plant^{-1}, seed plant^{-1}, 1000 seed weight and seed yield.

Sadi (2004) were conducted an experiment with 15 mungbean genotypes and observed that plant height, 1000-seed weight and harvest index were significantly influenced by variety (genotype). The highest seed yield was obtained in MB 45 compared to others.

Sarkar *et al*. (2013) reported that BARI Mung-2 contributed higher seed yield than BARI Mung-5 due to production of higher number of pods plant^{-1} in Bangladesh condition.

Shamsuzzaman *et al*. (2004) carried out an experiment with summer mungbean cultivars, i.e. Binamoog-2 and Binamoog-5, were grown during the kharif-1 season (February-May) of 2001, in Mymensingh, Bangladesh, under no irrigation ,irrigation once at 30 days after sowing (DAS), twice at 30 and 50 DAS, and thrice at 20, 30 and 50 DAS by. The two cultivars tested were synchronous in flowering, pod maturity and leaf senescence. Binamoog-2 performed slightly better than Binamoog-5, for most of the growth and yield parameters studied.

Thakuria and Shaharia (1990) reported that different varieties of mungbean differed significantly in seed yield and other yield related traits.

Vieiera *et al*. (2003) conducted an experiment to evaluate 25 mungbean genotypes during the summer season in Vicosa and Prudente de morais, Minas Gerais, Brazil. The yield varied from 1.2 to 2.0 t ha^{-1} in Prudente de morais.

CHAPTER III

MATERIALS AND METHODS

An experiment was carried out at the research plot of Sher-e-Bangla Agricultural University in Dhaka from February to June 2022, to see how leaf cutting and variety affected mungbean growth and yield. This chapter includes the description of the materials used and procedures followed in the present study.

3.1 Description of the experimental site

3.1.1 Site and soil

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

3.1.2 Climate and weather

The area's subtropical climate is distinguished by high temperatures and frequent rainfall during the Kharif season (April to September), and little rainfall and somewhat low temperatures during the Rabi season (October to March). The experiment was carried out in the Kharif-I season. **Appendix II** contains a map of the experimental site.

3.2 Planting materials

BARI Mung-5

BARI Mung-5 was one of the planting materials used. BARI Mung-5 was released and developed by BARI in 1997. The plant height of the cultivar ranges from 40 to 45 cm.

The average yield of this cultivar is about 1.2-1.5 t ha^{-1}. BARI Mung-5 for the experiment was collected from BARI, Joydepur, Gazipur.

BARI Mung-6

BARI Mung-6 was used as planting material. BARI Mung-6 was released and developed by BARI in 2003. The plant height of the cultivar ranges from 40 to 45 cm. Life span ranges from 55-58 days. The average yield of this cultivar is about 1.5-1.6 t ha^{-1}. The seeds of BARI Mung-6 for the experiment were collected from BARI, Joydepur, Gazipur.

BARI Mung-7

BARI Mung-7 is a high-yielding and disease tolerant variety developed by Pulse Research center in 2012 from a variety of crossing materials. After meticulous testing, it was certified as a new variety by SCA in 2015. Average plant height ranges from 55-60 cm, number of pods per plant ranges from 25-30. The color of the seed is green and large. This variety is resistant to leaf spot and yellow mosaic disease. Almost all the pods ripe at the similar time. Life span ranges from 60-62 days. The average yield of this variety is 1.7-1.9 t ha^{-1}. The seeds of BARI Mung-7 for the experiment were collected from BARI, Joydepur, Gazipur.

BARI Mung-8

BARI Mung-8 was developed by BARI in 2015. Average plant height ranges from 55-60 cm. Color of the seed is golden and small in size. This variety is resistant to *Cercosporaoa* leaf spot and yellow mosaic disease. Almost all the pods ripe at the same time. Life span ranges from 60-62 days. Average yield of this variety is

1.6-1.7 t ha^{-1} .The seeds of BARI Mung-8 for the experiment were collected from BARI, Joydepur, Gazipur.

3.3 Treatments under investigation

There were two factors in the experiment as mentioned below:

Factor A: Leaf clipping (3)

Mung bean leaves are trifoliate. So, removing one leaflet from each leaf of a mung bean plant represented 33% leaf defoliation and two leaflets, 66% leaf defoliation. There were two levels of leaf clipping along with the control (no leaf clipping).

Thus, there were three treatments on leaf clipping as follows:

C_0 = 0% leaflet clipping (control, i.e., no defoliation)

C_1 = 33% leaflet clipping

C_2 = 66% leaflet clipping

The leaf clipping was furnished at 40 days after sowing (DAS) for all the genotypes. Clipping of side leaflets were done.

Factor-B: Varieties (4)

V_1 = BARI Mung-5

V_2 = BARI Mung-6

V_3 = BARI Mung-7

V_4 = BARI Mung-8

3.3.1 Treatment combinations

There were 12 treatment combinations of different leaflet clipping and different varieties used in the experiment as mentioned below:

1. C_0V_1	5. C_1V_1	9. C_2V_1
2. C_0V_2	6. C_1V_2	10. C_2V_2
3. C_0V_3	7. C_1V_3	11. C_2V_3
4. C_0V_4	8. C_1V_4	12. C_2V_4

3.4 Experimental design and layout

The experiment was set up in a two factor randomized complete block design (RCBD) with three replications. There were 12 unit plots in each replication, and the treatment combinations were distributed randomly among them. The plot was measured 3 m^2 in size (2 m ×1.5 m). Unit plots and blocks were separated by 0.5 m spacing respectively. The layout of the experiment is presented in Appendix I

3.5 Land preparation

The experimental land was opened with a power tiller on February 14, 2022. Ploughing and cross ploughing were done followed by laddering. Land preparation was completed on March 9, 2022 and was ready for sowing of seeds.

3.6 Fertilizer application

The fertilizers were applied as basal dose at final land preparation where N, K_2O_5, P_2O_5, Ca and S were applied at the rate of 20.27 kg ha^{-1}, 33 kg ha^{-1}, 48 kg ha-1, 3.3 kg ha^{-1} and 1.8 kg ha^{-1} respectively in all plots. All fertilizers were applied by broadcasting method and mixed thoroughly with soil.

3.7 Sowing of seeds

Mungbean seeds were sown on March 11, 2022. In order to prevent seed-borne diseases, seeds were treated with Bavistin prior to sowing. In 2-3 cm deep furrows, the seeds were sown in rows. Soon after sowing the seeds, the soils were spread over the furrows. There was a 30 cm spacing between the rows and a 10 cm spacing between the plants.

3.8 Intercultural operations

3.8.1 Weed control

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

3.8.2 Thinning

Thinning was done at two times; first thinning was done at 8 DAS and second thinning was done at 15 DAS to maintain optimum plant population. Plant to plant distance was maintained 10 cm.

3.8.3 Irrigation and drainage

To promote the highest possible germination rate, irrigation was administered prior to sowing. There was a lack of rainfall in the early half of the trial period, but it was heavier in the later one. Therefore, it was crucial to drain the area of extra water at a later time. In order to uniformly optimize the vegetative growth of mungbean on all experimental plots, irrigation was administered at 15 and 30 DAS. The experimental plot's excess water from irrigation and rainfall was also properly drained.

3.8.4 Insect and pest control

Early on in their development, young seedlings were infested by a few worms (*Agrotis ipsilon*), and later on, pod borer (*Maruca testulalis*) attacked the plants.

After seedling germination, Ripcord 10 EC was sprayed at a rate of 1 ml per litre of water for 5 decimal lands twice, with 15 days interval, to control the insects. Plants were also attacked by yellow mosaic disease caused by yellow mosaic virus that was controled in proper way. Before sowing, seeds were treated with Bavistin 50 WP to protect seed borne diseases. Malathion 57 EC at the rate of 1.5 L ha^{-1} was sprayed when required.

3.9 Leaf clipping

The leaves of mungbean are trifoliate. Therefore, removing just one leaflet from each leaf of a mungbean plant amounted to 33% leaf defoliation, whereas removing two leaflets amounted to 66% leaf defoliation. Along with the control (no leaf clipping), there were two levels of leaf clipping. Consequently, there were three leaf-clipping treatments: 0% leaf clipping (control, or no defoliation, C_0), 33% leaf clipping (C_1), and 66% leaf clipping (C_2). For all varieties, the leaf clipping was provided at 40 days after sowing (DAS). Leaf clipping was done with the help of a knife. In C_2 (66% leaf clipping) complete removal of leaflet from its base was accomplished, keeping the top leaflet intact.

3.10 Harvesting and sampling

When roughly 80% of the pods had turned brown or black, the crop was harvested. The mature pods were manually harvested by hand picking from a designated place in the middle of each plot. From each plot, the pods were harvested three times.

3.11 Threshing

To separate the seeds from pods they were sun dried for three days by placing them on the open threshing floor. Seeds were separated from the pods by beating with bamboo sticks.

3.12 Drying, cleaning and winnowing

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

3.13 Parameters for data collection-

i. Plant height (cm)
ii. Number of leaves plant^{-1} (No.)
iii. Number of branches plant^{-1} (No.)
iv. Dry matter content plant^{-1} (g)
v. Pod length (cm)
vi. Number of pods plant^{-1} (No.)
vii. Number of seeds pod^{-1} (No.)
viii. Seed size (mg)
ix. Seed yield (t ha^{-1})
x. Stover yield (t ha^{-1})
xi. Biological yield (t ha^{-1})
xii. Harvest index (%)

3.14 Procedures of Data Collection

I. Plant height (cm)

The height of the selected plants was measured from the ground level to the tip of the plants at 15, 25, 35, 45, and 55 days after sowing.

II. Number of leaves plant^{-1} (No.)

Several leaves per plant were counted from each selected plant sample at 15, 25, 35, 45, and 55 days after sowing and mean values were calculated.

III. Number of branches plant^{-1} (No.)

The number of branches per plant was counted from each selected plant sample at 15, 25, 35, 45, and 55 days after sowing and mean values were calculated.

IV. Dry matter content (g)

The dry matter weight of the leaves, stems, roots, pod cover (fruit wall/pericarp), seeds, and other immature reproductive elements were added together to get the total dry matter of a plant at different stages.

V. Pod length (cm)

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

VI. Number of pods plant^{-1} (No.)

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

VII. Number of seeds pod^{-1} (No.)

By counting the number of seeds from 10 randomly chosen pods for each treatment, the average number of seeds per pod^{-1} was calculated.

VIII. Seed size (mg)

A composite sample was collected from each plot and 100 seeds were counted and weighed using an electric digital (electronic) balance. Then it was calculated for the weight of a single seed. Seed size or single seed weight was recorded in milligram (mg).

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

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

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

Stover yield was determined from the central 1 m^2 area of each plot. After threshing, the plant parts were sun-dried and weight was taken and finally converted to ton per hectare.

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

The total biological yield was calculated with the following formula-

Biological yield= Grain yield + Stover yield

XII. Harvest index (%)

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

Harvest index (HI %) = (Seed yield / Biological yield) × 100

3.15 Data analysis

With the aid of the computer package program STATISTIX 10 (STAT 10), the collected data on different parameters were compiled and statistically analyzed to determine the significant difference between various mungbean varieties and leaf clipping on growth and yield-contributing characteristics of mungbean, and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter contains a presentation and discussion of the findings of the study. The information has been portrayed in various tables and figures. The findings have been discussed, and potential explanations are provided under the following headings:

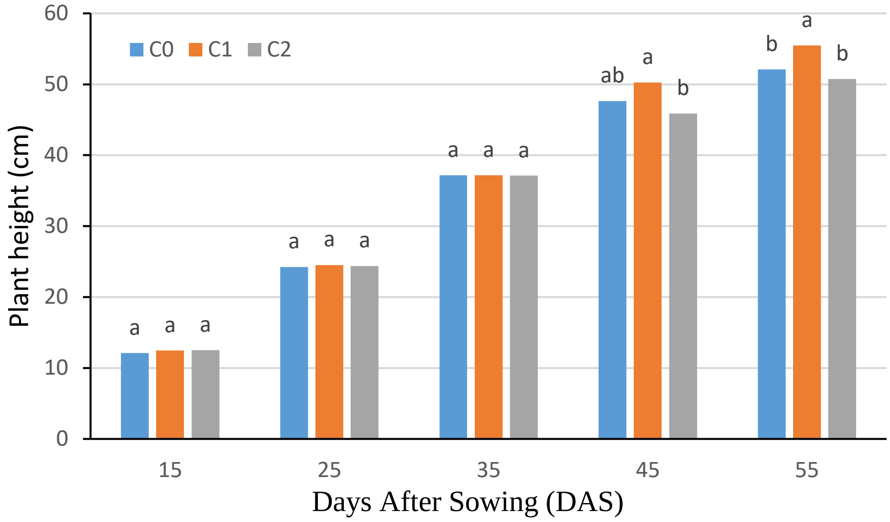
4.1 Plant height

There was a significant variation in plant height at 55 days after sowing (DAS) due to the leaf clipping. The tallest plant (12.11, 24.53, 37.19, 50.23 and 55.49 cm at 15, 25, 35, 45 and 55 DAS, respectively) were obtained from C_1 (33% leaf removal) and the shortest plant (12.51, 24.39, 37.11, 45.86 and 50.75 cm at 15, 25, 35, 45 and 55 DAS, respectively) from C_2 (66% leaf removal). (**Figure. 1**).The increasing trend of plant with leaf clipping was also observed by Wang *et.al.* (2014).

The plant height was significantly varied with the different varieties at different DAS (**Figure. 2**). The tallest plant (13.31, 25.28, 40.8, 54.67 and 58.33 cm at 15, 25, 35, 45 and 55 DAS respectively) were obtained from V_4 (BARI Mung-8) and the shortest plant (11.82, 23.17, 33.67, 41.43 and 48.5 cm at 15, 25, 35, 45 and 55 DAS, respectively) from V_2 (BARI Mung-6). This variation in plant height might be attributed due to the genetic characters. These findings validated the results of Farghali and Hossein (1995), who observed that plant height varied with different mungbean varieties.

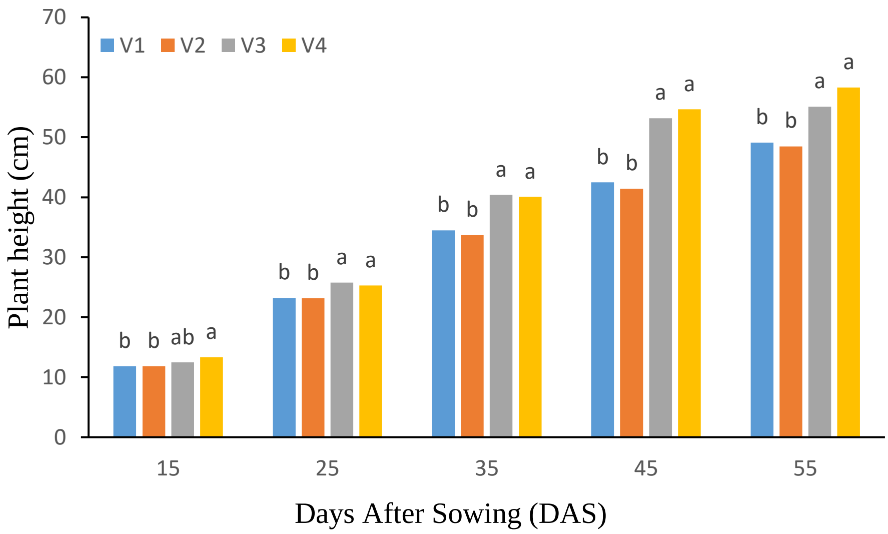
Interaction effect of leaf clipping and variety was significant in case of plant height of mungbean (**Table. 1**). The tallest plant (13.82, 26.45, 40.77, 58.34 and 62.4 cm at 15, 25, 35, 45 and 55 DAS respectively) was obtained from C_1V_4 (BARI Mung-8 with 33% leaf clipping) treatment combination, which was statistically similar to C_1V_3 (BARI Mung-7 with 33% leaf clipping) treatment combination in case of 25, 35 and 45 DAS while the shortest (11.79,22.62, 33.68, 39.19 and 45.52 cm at 15, 25, 35, 45 and 55

DAS respectively) with C_2V_2 (BARI Mung-6 with 66% leaf clipping) which was statistically similar with C_2V_1 (BARI Mung-5 with 66% leaf clipping) treatment combination in case of 35 and 45 DAS.



C_0= No removal, C_1= 33% leaf removal, C_2= 66% leaf removal

Figure. 1: Effect of leaf clipping on the plant height of mungbean at different days after sowing. (LSD= NS, NS, NS, 1.75, 2.68 at 15, 25, 35, 45, 55 DAS respectively)



V_1= BARI Mung-5, V_2= BARI Mung-6, V_3=BARI Mung-7, V_4=BARI Mung-8

Figure.2: Effect of varieties on the plant height of mungbean at different days after sowing (LSD=0.93, 1.85, 2.64, 3.03, 4.64 at 15, 25, 35, 45, 55 DAS respectively)

Table 1. Interaction effect of leaf clipping and variety on the plant height of mungbean at different days after sowing (DAS)

Interaction	Plant Height (cm) at				
	15 DAS	**25 DAS**	**35 DAS**	**45 DAS**	**55 DAS**
C_0V_1	11.52 b	22.78 de	34.13 c	42.42 d	48.09 de
C_1V_1	11.35 b	23.06 c-e	34.66 bc	44.88 cd	51.05 c-e
C_2V_1	12.68 ab	23.86 a-e	34.71 bc	40.15 d	48.25 de
C_0V_2	11.92 ab	23.19 c-e	33.99 c	41.50 d	49.36 d-e
C_1V_2	12.37 ab	23.69 b-e	33.30 c	43.05 d	50.62 c-e
C_2V_2	11.79 b	22.62 e	33.68 c	39.19 d	45.52 e
C_0V_3	11.92 ab	25.54 a-c	40.57 a	52.37 ab	54.45 b-d
C_1V_3	12.32 ab	25.34 a	40.0 a	54.67 ab	57.9 ab
C_2V_3	13.21 ab	26.45 a-d	40.66 a	52.59 ab	53.01 b-d
C_0V_4	13.15 ab	25.49 a-d	40.08 a	54.17 ab	56.35 a-c
C_1V_4	13.82 a	26.02 ab	40.77 a	58.34 a	62.4 a
C_2V_4	12.95 ab	24.61 a-e	39.4 ab	51.5 bc	56.24 a-c
$LSD_{(0.05)}$	1.31	2.70	3.74	4.38	6.79
CV (%)	9.88	6.56	8.18	8.24	7.60

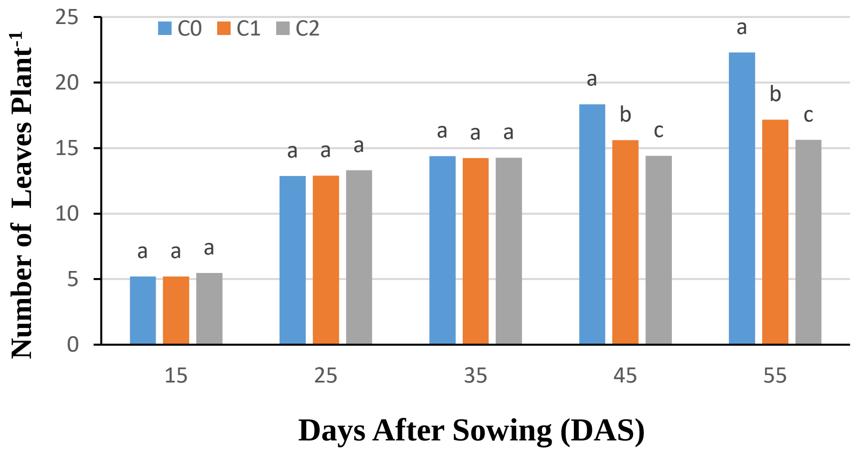
C_0=No leaf clipping, C_1=33% leaf clipping, C_2=66% leaf clipping,
V_1=BARI Mung-5, V_2=BARI Mung-6, V_3=BARI Mung-7, V_4= BARI Mung-8,
LSD=Least significance difference, CV=Coefficient of variation, DAS= Days after sowing

4.2 Number of leaves plant^{-1} (no.)

The number of leaves plant^{-1} were significantly influenced by leaf clipping at 45 and 55 DAS. The maximum number of leaves plant^{-1} (5.21, 12.87, 14.39, 18.34 and 22.29 at 15, 25, 35, 45 and 55 DAS, respectively) was obtained from C_0 (Control) treatment and the minimum (5.11, 12.30, 14.27, 14.42 and 15.63 at 15, 25, 35, 45 and 55 DAS, respectively) from C_2 (66% leaf clipping) treatment. **(Figure 3)**

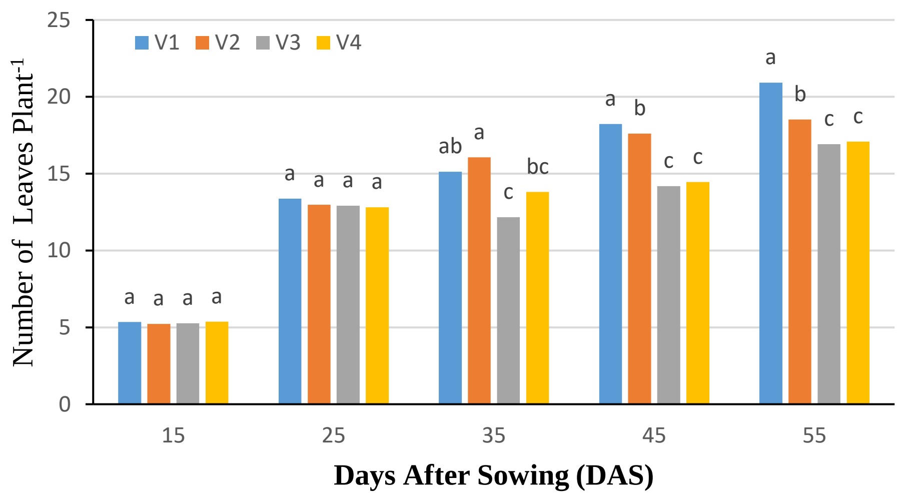
The number of leaves plant^{-1} were significantly influenced by variety. The V_1 (BARI Mung-5) produced maximum number of leaves (5.34, 13.38, 15.13, 18.24 and 20.93 at 15, 25, 35, 45 and 55 DAS, respectively) and the minimum (5.23, 12.91, 13.16, 14.19 and 16.92 at 15, 25, 35, 45 and 55 DAS, respectively) number of leaves plant^{-1} were recorded in V_3 (BARI Mung-7) **(Figure 4)**. Rahman (2012) observed that number of leaves were significantly greater in BARI Mung-5 and BARI Mung-6 than in the BARI Mung-7 with the magnitude being intermediate in the BARI Mung-8.

Interaction effect of leaf clipping and varieties had significant variation on number of leaves plant^{-1} of mungbean. The highest number of leaves plant^{-1} (5.09, 12.82, 14.82, 17.81 and 20.12 at 15, 25, 35, 45 and 55 DAS, respectively) was obtained from C_1V_1 (BARI Mung-5 with 33% leaf clipping) treatment which was statistically similar to C_0V_1 (BARI Mung-5 with no leaf clipping) treatment at 55 DAS while the lowest number of leaves plant^{-1} (4.46, 11.33, 11.74, 12.49 and 14.4 at 15, 25, 35, 45 and 55 DAS, respectively) from C_2V_4 (BARI Mung-8 with 66% leaf clipping) treatment combination which was statistically similar to C_1V_3 (BARI Mung-7 with 33% leaf clipping) treatment at 35 DAS and also similar to C_2V_3 (BARI Mung-7 with 66% leaf clipping) treatment combination at 55 DAS. **(Table 2)**



C_0= No removal, C_1= 33% leaf removal, C_2= 66% leaf removal

Figure. 3: Effect of leaf clipping on the number of leaves plant^{-1} of mungbean at different days after sowing. (LSD= NS, NS, NS, 1.75, 2.68 at 15, 25, 35, 45, 55 DAS respectively)



V_1= BARI Mung-5, V_2= BARI Mung-6, V_3=BARI Mung-7, V_4=BARI Mung-8

Figure. 4: Effect of varieties on the number of leaves plant^{-1} of mungbean at different days after sowing (LSD=0.93, 1.85, 2.64, 3.03, 4.64 at 15, 25, 35, 45, 55 DAS respectively)

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

Treatment combination	Number of Leaves Plant^{-1} (no.)				
	15 DAS	**25 DAS**	**35 DAS**	**45 DAS**	**55 DAS**
C_0V_1	5.42 a	13.55 a	16.71 a	20.72 a	24.59 a
C_1V_1	5.09 a	12.82 a	14.82 a-c	17.81 b	20.12 c
C_2V_1	5.45 a	13.75 a	13.84 a-c	16.18 cd	18.08 d
C_0V_2	5.12 a	13.11 a	16.33 a	19.98 a	21.61 b
C_1V_2	5.15 a	12.56 a	16.13 a	16.97 bc	18.07 d
C_2V_2	5.42 a	13.22 a	15.73 a	15.85 d	15.91 e
C_0V_3	5.11 a	12.6 a	12.35 bc	15.77 d	21.72 b
C_1V_3	5.13 a	13.25 a	11.87 c	13.67 e	14.89 e-g
C_2V_3	5.54 a	12.89 a	12.27 bc	13.15 ef	14.13 g
C_0V_4	5.18 a	12.18 a	12.18 bc	16.87 bc	21.27 bc
C_1V_4	5.47 a	12.95 a	14.08 a-c	13.98 e	15.61 ef
C_2V_4	4.46 b	11.33 a	11.74 c	12.49 f	14.4 fg
$LSD_{(0.05)}$	0.67	2.12	1.71	1.98	2.23
CV (%)	7.46	9.62	13.24	8.62	10.94

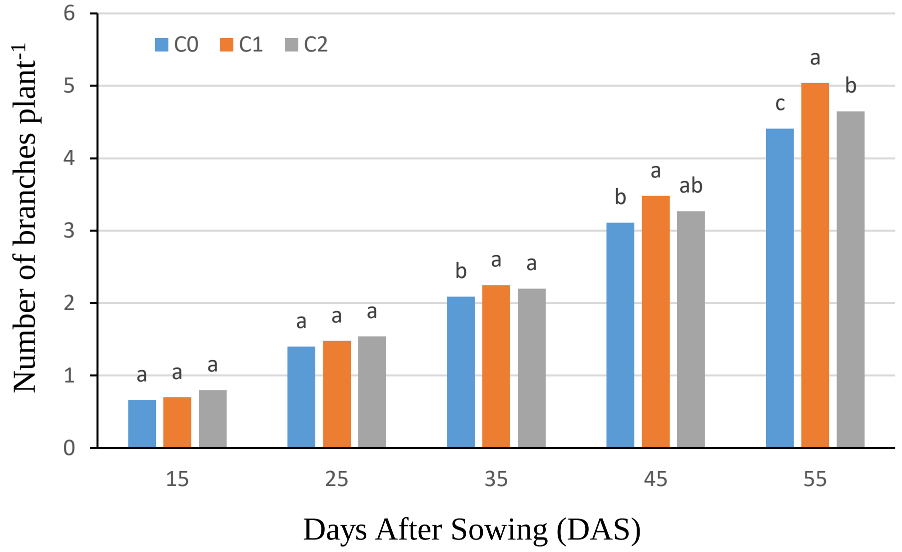
C_0=No leaf clipping, C_1=33% leaf clipping, C_2=66% leaf clipping,
V_1=BARI Mung-5, V_2=BARI Mung-6, V_3=BARI Mung-7, V_4= BARI Mung-8,
LSD=Least significance difference, CV=Coefficient of variation, DAS= Days after sowing

4.3 Number of branches plant^{-1}

Number of branches plant^{-1} was significantly varied with leaf clipping treatment at 45 and 55 DAS **(Fig. 5)**. The maximum number of branches plant^{-1} (0.70, 1.48, 2.25, 3.48 and 5.04 at 15, 25, 35, 45 and 55 DAS, respectively) was obtained from C_1 (33% leaf clipping) treatment and the minimum number of branches plant^{-1} (0.66, 1.40, 2.09, 3.11 and 4.41 at 15, 25, 35, 45 and 55 DAS, respectively) from C_0 (control) treatment.

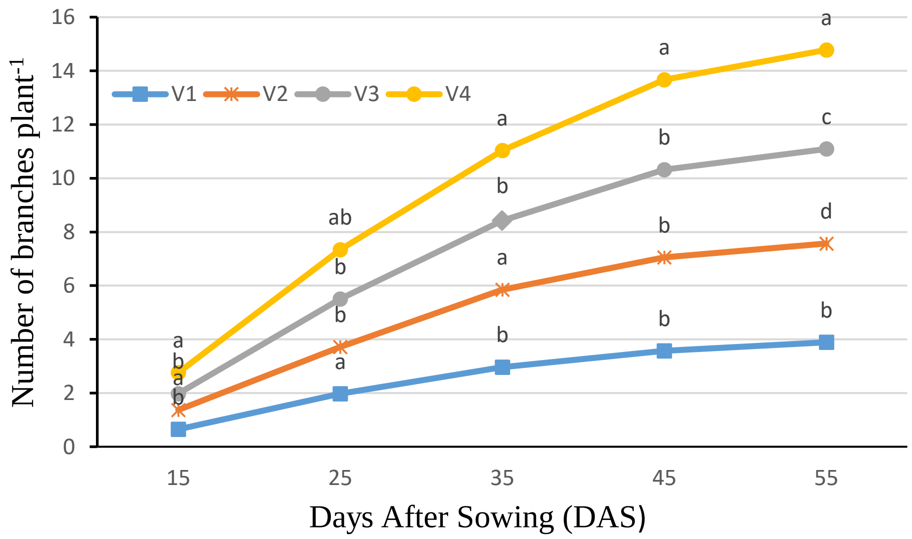
The number of branches plant^{-1} was also significantly influenced by variety at 15, 25, 35, 45, 55 DAS **(Fig 6)**. The maximum number of branches plant^{-1} (0.78, 1.52, 2.27, 3.69 and 5.32 at 15, 25, 35, 45 and 55 DAS, respectively) was found in V_4 (BARI Mung-8) whereas the minimum number of branches plant^{-1} (0.61, 1.4, 2.04, 3.07 and 4.15 at 15, 25, 35, 45 and 55 DAS, respectively) was recorded in V_3 (BARI Mung-7). The results obtained from the present findings were similar with the findings of Muhammad *et al*. (2006), Parvez *et al*. (2013) who also observed with their studies that, BARI Mung-8 showed the highest number of branches plant^{-1} compared to BARI Mung-5, BARI Mung-6 and BARI Mung-7.

Interaction effect of leaf clipping and variety was significant on number of branches plant^{-1} at 15, 25, 35, 45 and 55 DAS **(Table 3)**. The highest number of branches plant^{-1} (0.87, 1.58, 2.37, 4.12 and 6.12 at 15, 25, 35, 45 and 55 DAS, respectively) was obtained from C_1V_4 (BARI Mung-8 with 33% leaf clipping) treatment combination, while the lowest (0.57, 1.30, 1.99, 2.87 and 3.86 at 15, 25, 35, 45 and 55 DAS, respectively) from C_2V_3 (BARI Mung-7 with 66% leaf clipping) treatment combination.



C_0= No removal, C_1= 33% leaf removal, C_2= 66% leaf removal

Figure. 5: Effect of leaf clipping on the number of branches plant^{-1} of mungbean at different days after sowing. (LSD= NS, NS, NS, 0.72, 1.18 at 15, 25, 35, 45, 55 DAS respectively)



V_1= BARI Mung-5, V_2= BARI Mung-6, V_3=BARI Mung-7, V_4=BARI Mung-8

Figure.6: Effect of varieties on the number of branches plant^{-1} of mungbean at different days after sowing (LSD=0.07, 0.11, 0.13, 0.17 and 0.19 at 15, 25, 35, 45, 55 DAS respectively)

Table 3: Interaction effect of leaf clipping and variety on the number of branches plant^{-1} of mungbean at different DAS

Interaction	Number of Branches Plant^{-1}				
	15 DAS	**25 DAS**	**35 DAS**	**45 DAS**	**55 DAS**
C_0V_1	0.59 e	1.45 ab	2.06 cd	3.12 bc	4.23 d
C_1V_1	0.63 de	1.46 ab	2.05 cd	3.04 bc	5.2 b
C_2V_1	0.7 c	1.57 a	2.07 cd	3.11 bc	4.77 c
C_0V_2	0.74 bc	1.45 ab	2.18 bc	3.27 bc	4.31 d
C_1V_2	0.78 b	1.51 ab	2.33 ab	3.51 b	4.34 d
C_2V_2	0.85 a	1.49 ab	2.29 ab	3.19 bc	4.42 d
C_0V_3	0.68 cd	1.37 ab	1.97 d	3.10 bc	4.31 d
C_1V_3	0.6 e	1.52 ab	2.39 a	3.19 bc	5.01 bc
C_2V_3	0.57 e	1.30 b	1.99 d	2.87 c	3.86 e
C_0V_4	0.73 bc	1.40 ab	2.15 bc	3.33 bc	4.78 c
C_1V_4	0.87 a	1.58 a	2.37 a	4.12 a	6.12 a
C_2V_4	0.78 b	1.58 a	2.35 ab	3.54 b	5.07 b
$LSD_{(0.05)}$	0.11	0.16	0.17	0.21	0.24
CV (%)	5.78	8.79	4.73	8.49	7.01

C_0=No leaf clipping, C_1=33% leaf clipping, C_2=66% leaf clipping,
V_1=BARI Mung-5, V_2=BARI Mung-6, V_3=BARI Mung-7, V_4= BARI Mung-8,
LSD=Least significance difference, CV=Coefficient of variation, DAS= Days after sowing

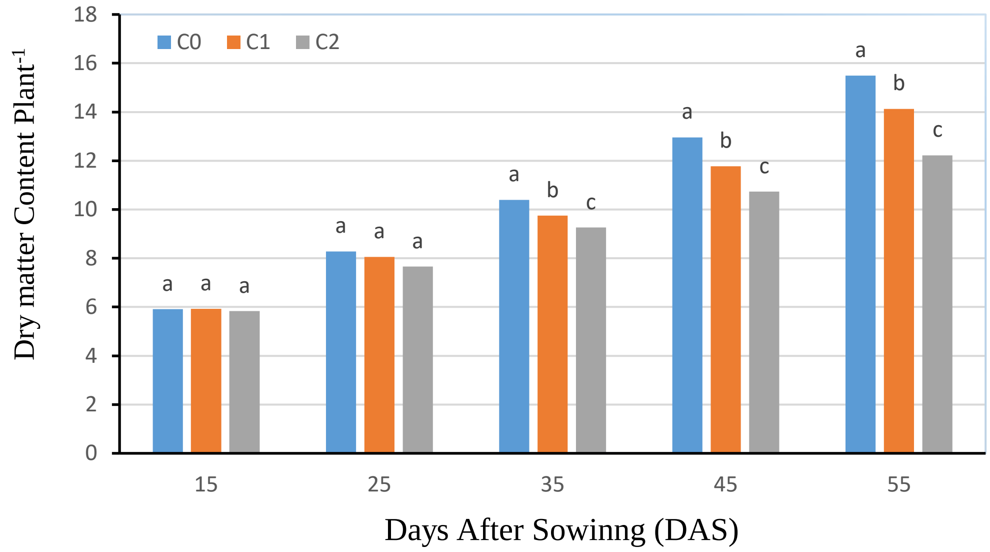
4.4 Dry matter Content (g)

The total dry matter was significantly influenced by leaf clipping at 45, 55 days after sowing (DAS). The total dry matter was highest (5.92, 8.28, 10.4, 12.96 and 15.49 g at 15, 25, 35, 45 and 55 DAS, respectively) at C_0 treatment (control) and it was lowest (5.83, 7.66, 9.26, 10.73 and 12.22 g at 15, 25, 35, 45 and 55 DAS, respectively) at C_2 treatment (66% leaf clipping). **(Figure. 7)**

The total dry mater weight was also significantly influenced by variety at 15, 25, 35, 45, and 55 DAS. Among the four mungbean varieties the highest total dry mater (6.39, 8.13, 11.03, 13.13 and 14.98 g at 15, 25, 35, 45 and 55 DAS, respectively) was recorded in V_4 (BARI Mung-8), whereas the lowest total dry matter (5.52, 7.82, 8.91, 10.11 and 12.62 g at 15, 25, 35, 45 and 55 DAS respectively) was in V_1 (BARI Mung-5).

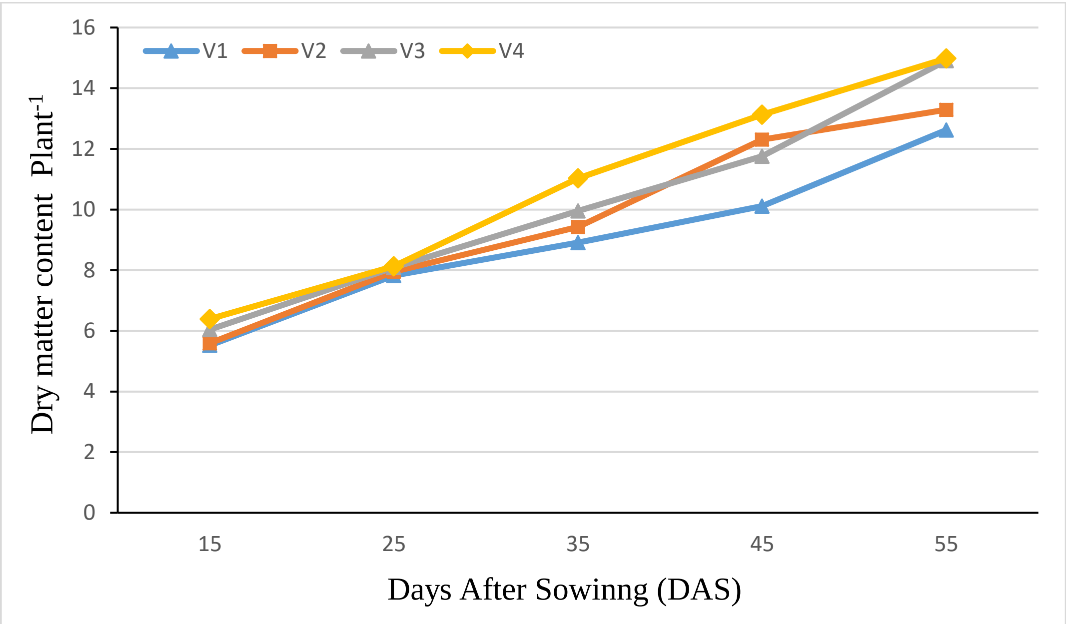
(Figure. 8)

The interaction effect of leaf clipping and variety on total dry matter were significant at 15, 25, 35, 45 and 55 DAS respectively. The highest total dry matter (6.56, 8.39, 12.93, 15.67 and 18.10 g at 15, 25, 35, 45 and 55 DAS, respectively) was found in C_0V_4 (BARI Mung-8 with control) and the lowest value (5.44, 7.22, 8.33, 9.54 and 11.37 g at 15, 25, 35, 45 and 55 DAS, respectively) was found in C_2V_1 (BARI Mung-5 with 66% leaf clipping) treatment combination. **(Table. 4)**



C_0= No removal, C_1= 33% leaf removal, C_2= 66% leaf removal

Figure.7: Effect of treatments on the dry matter content plant^{-1} of mungbean at different days after sowing (LSD=NS, NS, 0.48, 0.26 and 0.34 at 15, 25, 35, 45, 55 DAS respectively)



V_1= BARI Mung-5, V_2= BARI Mung-6, V_3=BARI Mung-7, V_4=BARI Mung-8

Figure.8: Effect of varieties on the dry matter content plant^{-1} of mungbean at different days after sowing (LSD=0.49, 0.38, 0.83, 0.47 and 0.59 at 15, 25, 35, 45, 55 DAS respectively)

Table 4. Interaction effect of leaf clipping and variety on the total dry matter weight plant^{-1} at different days after sowing

Interaction	Total dry matter weight plant^{-1} (g) at				
	15 DAS	**25 DAS**	**35 DAS**	**45 DAS**	**55 DAS**
C_0V_1	5.34 e	8.2 ab	8.97 ef	10.73 e-g	13.52 c-e
C_1V_1	5.77 c-e	8.03 ab	9.17 de	10.14 fg	12.97 d-f
C_2V_1	5.44 e	7.22 b	8.33 f	9.45 g	11.37 f
C_0V_2	5.69 c-e	8.28 a	9.63 c-e	12.07 bc	14.79 b-d
C_1V_2	5.58 de	8.14 ab	9.45 c-e	12.28 b-d	13.46 c-e
C_2V_2	5.5 e	7.43 ab	9.20 d-e	11.92 b-e	11.61 ef
C_0V_3	6.01 b-d	8.26 a	10.09 bc	12.74 bc	15.56 b
C_1V_3	6.01 b-d	7.99 ab	9.74 cd	11.45 c-f	15.02 bc
C_2V_3	6.08 ab	8.04 ab	10.00 bc	11.08 d-f	14.13 b-d
C_0V_4	6.56 a	8.39 a	12.93 a	15.67 a	18.1 a
C_1V_4	6.30 ab	8.08 ab	10.67 b	13.26 b	15.09 bc
C_2V_4	6.31 ab	7.93 ab	9.5 c-e	10.44 fg	11.73 ef
$LSD_{(0.05)}$	0.69	0.54	1.18	0.64	0.84
CV (%)	4.49	7.21	4.13	6.92	8.58

C_0=No leaf clipping, C_1=33% leaf clipping, C_2=66% leaf clipping, V_1=BARI Mung-5, V_2=BARI Mung-6, V_3=BARI Mung-7, V_4= BARI Mung-8, LSD=Least significance difference, CV=Coefficient of variation, DAS= Days after sowing

4.5 Pod Length

There was a significant variation with the pod length of mungbean due to the leaf clipping **(Table 5).** The longest pod length 8.72 cm was obtained from C_1 (33% leaf clipping) treatment compared to C_2 (66% leaf clipping) treatment where the pod length was 7.65 cm.

One of the most significant yield-contributing characteristics of mungbean is pod length. The length of the pods varied significantly among the varieties. **(Table 6)**. The longest pod length (8.94 cm) was recorded in V_4 (BARI Mung-8), which was statistically similar to V_2 (BARI Mung-6). The shortest pod length (7.05 cm) was observed in V_3 (BARI Mung-7). These findings concur with those of Sarkar *et al.* (2004), who found that pod length differed between varieties. The genetic makeup of the varieties may be the most likely cause of this variation. Similar findings were made by Aslam *et al.* (2004), who also noted considerable variability in pod length across different mungbean varieties.

Interaction effect of leaf clipping and variety was significant on pod length of mungbean **(Table. 7)**. The highest pod length (10.03 cm) was obtained from C_1V_4 (BARI Mung-8 with 33% leaf clipping) treatment combination, while the lowest (6.79 cm) from C_2V_1 (BARI Mung-5 with 66% leaf clipping) treatment combination.

4.6 Number of Pod Plant^{-1}

Due to the leaf clipping, there was a substantial variation in the quantity of pods plant^{-1}. In the C_1 (33% leaf clipping) treatment, the maximum number of pods plant^{-1} (14.72) were produced, while in the C_2 (66% leaf clipping) treatment condition, the least number of pods plant^{-1} (13.03) was achieved **(Table. 5).** Removal of apical shoot above node 5 or removal of inflorescence or axillary bud at nodes 1-4 together with the apical shoot greatly increased pod number and seed weight of mungbean (Clifford, 1979).

Variety had a big influence on the number of pods plant^{-1} produced. The largest number of pod plant^{-1} (16.17) was observed in V_4 (BARI Mung-8), while the lowest number of pod plant^{-1} (12.57), which was statistically similar to V_1 (BARI Mung-5), was recorded in V_2 (BARI Mung-6). **(Table. 6)**

Mondal *et al*. (2004) found mungbean to have genotypic differences in effective pods plant^{-1}. Similar findings were made by Aslam *et al*. (2004), who also noted significant differences in the number of pods per plant^{-1} across the various mungbean varieties. Parvez *et al.* (2013), Raj and Tripathi (2005), Shamsuzzaman *et al*. (2004), Madriz-Isturiz and Luciani- Marcano (2004), and Brar *et al.* (2004) all came to similar conclusions. They discovered that variety had a significant effect on the number of mungbean pods plant $^{-1}$.

The interaction between variety and leaf clipping had a significant impact on number of pods plant^{-1}. The C_1V_4 (BARI Mung-8 with 33% leaf clipping) treatment combination produced the maximum number of pods plant^{-1} (16.63), whereas C_2V_2 (BARI Mung-6 with 66% leaf clipping) produced the fewest pods plant^{-1}(11.28) which was statistically similar to C_0V_1 (BARI Mung-5 with no leaf clipping) **(Table 7)**.

4.7 Number of seeds pod^{-1}

There was a significant variation in the number of seeds pod^{-1} due to the leaf clipping treatment. The maximum number of seeds pod^{-1} 11.32 was obtained from C_1 treatment and the minimum 10.48 was from C_2 **(Table. 5).**

The number of seeds pod^{-1} of mungbean was significantly varied with varieties **(Table 6).** The highest number of seeds pod^{-1} (11.42) was recorded in V4 (BARI Mung-8) and the lowest number of seed pod^{-1} (9.66) was obtained from V_1 (BARI Mung-5). A result was found by Infante *et al.* (2003) which was similar to this study. They found significant difference on number of seeds pod^{-1} among the varieties. Genotypic variations in seeds pod^{-1} was also observed by Thakuria and Saharia (1990) in mungbean.

Interaction effect of different varieties and leaf clipping had a significant effect on number of seeds pod^{-1} **(Table 7)**. The highest number of seeds pod^{-1} (12.47) was obtained from C_1V_4 (BARI Mung-8 with 33% leaf clipping) treatment combination which was statistically similar with C_1V_3 (BARI Mung-7 with 33% leaf clipping) while the lowest (9.16) from C_0V_1 (BARI Mung-5 with control) treatment combination which was statistically similar to C_2V_1 (BARI Mung-5 with no leaf clipping).

4.8 Seed size (mg)

There was a significant variation in seed size due to the leaf clipping. The maximum seed size (44.02 mg) was obtained from C_1 and the minimum (40.24 g) from C_2, **(Table 5).**

Variety had significant variation in seed size and it was also observed in studied varieties of mungbean **(Table 6).** The highest seed size (50.26 mg) was recorded in V_2 (BARI Mung-6). In contrast, the lowest seed size (29.42 mg) was recorded in V_4 (BARI Mung-8). Genotypic variation in seed size was also observed by Tomar *et al.* (1995) in mungbean that also supported the present experimental results. Similar results were found by Ali *et al*. (2004) and they observed significant differences between mungbean genotypes for seed size.

Interaction effect of different varieties and leaf clipping had a significant variation on seed size. The highest seed size (52.55 mg) was obtained from C_1V_2 (BARI Mung-6 with 33% leaf clipping) treatment while the lowest (27.34 g) from C_2V_4 (BARI Mung-8 with 66% leaf clipping) which was statistically similar to C_0V_4 treatment combination **(Table 7).**

Table 5. Effect of leaf clipping on the yield contributing characters of mungbean

Treatment	Pod length (cm)	Pod plant^{-1} (No.)	Seed pod^{-1} (No.)	Seed size (mg)
C_0	7.93 b	13.43 b	10.76 b	40.93 b
C_1	8.72 a	14.72 a	11.41 a	44.02 a
C_2	7.65 b	13.03 c	9.95 c	40.24 b
$LSD_{(0.05)}$	0.28	0.44	0.28	1.17
CV (%)	4.08	3.77	3.14	3.34

C_0=No leaf clipping, C_1=33% leaf clipping, C_2=66% leaf clipping,
LSD=Least significance difference, CV=Coefficient of variation

Table 6. Effect of variety on the yield contributing characters of mungbean

Treatment	Pod length (cm)	Pod plant^{-1} (No.)	Seed pod^{-1} (No.)	Seed size (mg))
V_1	7.05 c	12.64 b	9.66 c	40.25 c
V_2	8.76 a	12.57 b	10.74 b	50.26 c
V_3	7.57 b	14.66 a	11.02 b	46.99 b
V_4	8.94 a	16.17 a	11.42 a	29.42 a
$LSD_{(0.05)}$	0.32	0.51	0.32	1.37
CV (%)	4.08	3.77	3.14	3.34

V_1=BARI Mung-5, V_2=BARI Mung-6, V_3=BARI Mung-7, V_4= BARI Mung-8

LSD=Least significance difference, CV=Coefficient of variation

Table 7. Interaction effect of leaf clipping and varieties on the yield contributing characters of mungbean

Treatment	Pod length (cm)	Pod plant^{-1} (No.)	Seed pod^{-1} (No.)	Seed size (mg)
C_0V_1	7.04 de	12.26 i	9.16 f	39.64 d
C_1V_1	7.3 de	13.24 e-g	10.49 de	41.57 d
C_2V_1	6.79 e	12.41 gh	9.33 f	39.53 d
C_0V_2	8.6 bc	12.94 f-g	11.2 bc	49.16 b
C_1V_2	9.15 b	13.50 d-f	11.02 cd	52.55 a
C_2V_2	8.5 c	11.28 i	10.0 e	49.06 b
C_0V_3	7.41 d	14.46 c	11.23 bc	46.51 c
C_1V_3	8.43 c	15.59 b	11.65 b	49.46 b
C_2V_3	7.12 de	13.94 c-e	10.19 e	45.02 c
C_0V_4	8.66 bc	14.34 d	11.48 bc	28.39 f
C_1V_4	10.03 a	16.63 a	12.47 a	32.53 e
C_2V_4	8.13 c	14.52 c	10.29 e	27.34 f
$LSD_{(0.05)}$	0.56	0.87	0.57	2.35
CV (%)	4.08	3.77	3.14	3.34

C_0=No leaf clipping, C_1=33% leaf clipping, C_2=66% leaf clipping,
V_1=BARI Mung-5, V_2=BARI Mung-6, V_3=BARI Mung-7, V_4= BARI Mung-8,
LSD= Least significance difference, CV= Coefficient of variation

4.9 Seed yield (t ha $^{-1}$)

There was significant variation in the seed yield t ha $^{-1}$due to the leaf clipping. The maximum seed yield (1.75 t ha $^{-1}$) was obtained from C_1 (33% Leaf clipping) and the minimum (1.18 t ha^{-1}) was obtained in C_2 (66% leaf clipping) **(Table 8).** There is a general pattern that the pulses frequently had excessive vegetative development, which decreased yield production (Patel *et al*., 1992). From leaflet clipping uniform light penetration, reduced respiratory burden contributed to higher seed yield in some varieties.

The yield of mungbean was significantly varied with different varieties. Yield is a function of various yield components such as number of pod plant^{-1}, seed pod^{-1} and seed size. The highest seed yield (1.72 t ha^{-1}) was recorded in V_3 (BARI Mung-7). In contrast, the lowest seed yield (1.21 t ha^{-1}) was recorded in V_1 (BARI Mung-5) which was statistically similar to V_2 (BARI Mung-6) **(Table 9).**

The probable reason of this difference might be due to higher number of pod length, number of seeds pod^{-1}. Genotypic variation in seed yield was also observed by Haque (1995) and Borah (1994). Aslam *et al*. (2004) observed significant differences between mungbean genotypes for seed yield kg ha^{-1}. Khan *et al*. (2001), Reddy *et al.,* (1990) also reported significant differences between mungbean genotypes for yield (kg ha^{-1}).

Interaction effect of different varieties and leaf clipping had a significant variation on seed yield t ha^{-1}. The highest seed yield (2.09 t ha^{-1}) was obtained from C_1V_3 (BARI Mung-5 with 33% leaf clipping) treatment combination while the lowest (1.07 t ha^{-1}) from C_2V_2 (BARI Mung-5 with 66% leaf clipping) treatment combination which is statistically similar to C_2V_4 (BARI Mung-8 with 66% leaf clipping), **(Table 10).**

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

The experimental result varied with growth and yield of mungbean by leaf clipping on stover yield (t ha^{-1}) of mungbean **(Table 8).** Results showed that the maximum stover yield 2.78 t ha^{-1} was recorded from C_0 (Control), whereas the lowest stover yield 2.15 t ha^{-1} was achieved from C_2 (66% leaf clipping).

Varieties on stover yield in mungbean genotypes had a significant variation **(Table 9)**. Results revealed that the highest stover yield 2.91 t ha^{-1} was recorded fromV_3 (BARI Mung-7). Whereas, the lowest stover yield 2.27 t ha^{-1} was achieved from V_2 (BARI Mung-6) which is statistically similar to V_1 (BARI Mung-5). The results of Parvez *et al*. (2013) and Hossain and Solaiman (2004) were consistent with the fact that varietal performance exhibited a significant variation in stover yield.

Significant variation was observed in the interaction effect of different types of varieties and leaf clipping on stover yield **(Table 10)**. Results revealed that the highest stover yield 3.09 t ha^{-1} was recorded from C_0V_3 (BARI Mung-7 with no removal) which is closely related with C_1V_3 (BARI Mung-7 with 33% removal).The lowest stover yield (1.89 t ha^{-1}) was recorded from C_2V_1,(BARI Mung-5 with 66% leaf clipping) treatment combination which was statistically similar to C_2V_2 (BARI Mung-6 with 66% leaf clipping), and C_2V_4 (BARI Mung-8 with 66% leaf clipping) treatment combination.

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

There was a significant influence in the biological yield of mungbean due to leaf clipping. The maximum biological yield (4.30 t ha^{-1}) was found from C_1 (33% leaf clipping), and the minimum biological yield (3.34 t ha^{-1}) from C_2, (66% leaf clipping) condition **(Table 8).** Biological yield is related to seed yied and stover yield, as both yields increased biological yield also increased.

Biological yield of mungbean was significantly influenced by variety **(Table 9)**. The maximum biological yield (4.63 t ha^{-1}) was found in V_3 (BARI Mung-7). The lowest biological yield 3.57 t ha^{-1} was observed from V_2 (BARI Mung-6) which was statistically similar with V_1 (BARI Mung-5). According to the findings of Parvez *et al.,* (2013) and Hossain and Solaiman (2004), varietal performance shown a significant variation in biological yield.

Mungbean biological yield was significantly influenced by the interaction of variety and leaf clipping, **(Table 10).** The highest biological yield (5.10 t ha^{-1}) was obtained from C_1V_3 (BARI Mung-7 with 33% leaf clipping). The lowest biological yield (3.04 t ha^{-1}) was recorded from C_2V_1 (BARI Mung-5 with 66% leaf clipping), which showed statistically similar results to C_2V_4 (BARI Mung-8 with 66% leaf clipping), and also statistically equivalent to C_2V_2 (BARI Mung-6 with 66% leaf clipping) treatment combination.

4.12 Harvest index (%)

There was a significant influence in the harvest index of mungbean due to leaf clipping (Table 10). The maximum harvest index (40.52%) was found from C_1 (Leaf clipping) and the minimum harvest index (33.43 %) from C_0 (control) condition. **(Table8)**

Harvest index of mungbean was significantly influenced by variety **(Table 9)**. The maximum harvest index (37.57%) was found in V_4 (BARI Mung-8). The lowest harvest index (35.34%) was observed from V_1 (BARI Mung-5).

Interaction of variety and leaf clipping had a significant influence on harvest index of mungbean **(Table 10).** The highest harvest index (42.54%) was obtained from C_1V_4 (BARI Mung-8 with 33% leaf clipping), while the lowest harvest index (30.68%) was obtained from C_0V_1 (BARI Mung-5 with control) treatment combination.

Table 8. Effect of leaf clipping on the seed, stover, biological yield and harvest index of mungbean

Treatment	Seed Yield ($t\ ha^{-1}$)	Stover Yield ($t\ ha^{-1}$)	Biological Yield ($t\ ha^{-1}$)	Harvest Index (%)
C_0	1.39 b	2.78 a	4.16 b	33.43 c
C_1	1.75 a	2.55 b	4.30 a	40.52 a
C_2	1.18 c	2.15 c	3.34 c	35.53 b
$LSD_{(0.05)}$	0.08	0.10	0.37	1.50
CV (%)	6.52	3.81	3.47	4.87

C_0=No leaf clipping, C_1=33% leaf clipping, C_2=66% leaf clipping,
LSD=Least significance difference, CV=Coefficient of variation

Table 9. Effect of variety on the seed, stover, biological yield and harvest index of mungbean

Treatment	Seed Yield ($t\ ha^{-1}$)	Stover Yield ($t\ ha^{-1}$)	Biological Yield ($t\ ha^{-1}$)	Harvest Index (%)
V_1	1.21 c	2.36 b	3.66 c	35.34 b
V_2	1.29 c	2.27 c	3.57 c	36.12 ab
V_3	1.72 a	2.91 a	4.63 a	36.95 ab
V_4	1.47 b	2.42 b	3.89 b	37.57 a
$LSD_{(0.05)}$	0.09	0.19	0.13	1.74
CV (%)	6.52	3.81	3.47	4.87

V_1=BARI Mung-5, V_2=BARI Mung-6, V_3=BARI Mung-7, V_4= BARI Mung-8
LSD=Least significance difference, CV=Coefficient of variation

Table 10. Interaction effect of leaf clipping and variety on the seed, stover, 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 (%)
C_0V_1	1.19 fg	2.7 cd	3.89 ef	30.68 f
C_1V_1	1.51 cd	2.49 e	4.03 de	37.58 b-d
C_2V_1	1.15 fg	1.89 g	3.04 g	37.75 bc
C_0V_2	1.29 ef	2.55 de	3.84 ef	33.51 ef
C_1V_2	1.52 cd	2.26 f	3.78 f	4021 ab
C_2V_2	1.07 g	2.00 g	3.06 g	34.64 de
C_0V_3	1.65 c	3.09 a	4.73 b	34.79 c-e
C_1V_3	2.09 a	2.92 b	5.01 a	39.75 b
C_2V_3	1.42 de	2.71 c	4.14 d	34.31 e
C_0V_4	1.45 de	2.73 c	4.12 cd	34.75 c-e
C_1V_4	1.87 b	2.52 e	4.38 c	42.54 a
C_2V_4	1.12 g	2.01 g	3.12 g	35.41 c-e
$LSD_{(0.05)}$	0.15	0.16	0.23	3.01
CV (%)	6.52	3.81	3.47	4.87

C_0=No leaf clipping, C_1=33% leaf clipping, C_2=66% leaf clipping,

V_1=BARI Mung-5, V_2=BARI Mung-6, V_3=BARI Mung-7, V_4= BARI Mung-8,

LSD=Least significance difference, CV=Coefficient of variation

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was carried out at the Sher-e-Bangla Agricultural University in Dhaka from February to June 2022 to assess how leaf clipping and variety affected the growth and yield of mungbean. In this experiment, the treatment consisted of three leaf clipping *viz*. C_0=No leaf clipping (Control), C_1= 33% Leaf clipping, C_2= 66% Leaf clipping and four mungbean varieties *viz*. V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3 = BARI Mung-7, V_4 = BARI Mung-8. A Randomized Complete Block Design (RCBD) with three replications was used to set up the experiment. Data were gathered about several mungbean growth, physiological, and yield-contributing characteristics. The collected data underwent statistical analysis to determine its treatment effects. While using various levels of leaf clipping and with variety, a significant difference between the treatments was discovered.

Plant height was significantly influenced by leaflet clipping. The maximum number of leaves plant^{-1} (5.21, 12.87, 14.39, 18.34 and 22.29 at 15, 25, 35, 45 and 55 DAS, respectively), the minimum number of branches plant^{-1} (0.66, 1.40, 2.09, 3.11 and 4.41 at 15, 25, 35, 45 and 55 DAS, respectively), highest total dry matter production (5.92, 8.28, 10.4, 12.96 and 15.49 g at 15, 25, 35, 45 and 55 DAS, respectively), maximum stover yield 2.78 t ha^{-1} and the minimum harvest index (33.43 %) was observed in C_0 (Control) treatment. Again the tallest plant (12.11, 24.53, 37.19, 50.23 and 55.49 cm at 15, 25, 35, 45 and 55 DAS, respectively), the maximum number of branches plant^{-1} (0.70, 1.48, 2.25, 3.48 and 5.04 at 15, 25, 35, 45 and 55 DAS, respectively), the longest pod length (8.72 cm), the maximum number of pods plant^{-1} (14.72), the maximum number of seeds pod^{-1} (11.32), the maximum seed size (44.02 mg), the maximum seed yield (1.75 t ha $^{-1}$), the maximum biological yield (4.30 t ha^{-1}), highest harvest index

(40.52%) was obtained from C1 (33% leaf clipping) treatment. And the C_2 (66% leaf clipping) treatment resulted the shortest plant height (12.51, 24.39, 37.11, 45.86 and 50.75 cm at 15, 25, 35, 45 and 55 DAS, respectively), the minimum numbers of leaves plant^{-1} (5.11, 12.30, 14.27, 14.42 and 15.63 at 15, 25, 35, 45 and 55 DAS, respectively), lowest total dry matter production (5.83, 7.66, 9.26, 10.73 and 12.22 g at 15, 25, 35, 45 and 55 DAS, respectively), minimum pod length (7.65 cm), least number of pods plant^{-1} (13.03), the minimum number of seeds pod^{-1} (10.48), the minimum seed size (40.24 mg), minimum seed yield (1.18 t ha^{-1}), lowest stover yield (2.15 t ha$^{-1)}$ and the minimum biological yield (3.34 t ha^{-1}).

All the parameters were significantly varied due to the different varieties. The V_1 (BARI Mung-5) produced maximum number of leaves plant^{-1} (5.34, 13.38, 15.13, 18.24 and 20.93 at 15, 25, 35, 45 and 55 DAS, respectively), lowest total dry matter (5.52, 7.82, 8.91, 10.11 and 12.62 g at 15, 25, 35, 45 and 55 DAS respectively), minimum number of seed pod^{-1} (9.66), lowest seed yield (1.21 t ha^{-1}), the lowest harvest index (35.34%). The shortest plant (11.82, 23.17, 33.67, 41.43 and 48.5 cm at 15, 25, 35, 45 and 55 DAS, respectively) lowest number of pod plant^{-1} (12.57), the highest seed size (50.26 mg), lowest stover yield (2.27 t ha^{-1}), the lowest biological yield (3.57 t ha^{-1}) was achieved from V_2 (BARI Mung-6). The minimum number of leaves plant^{-1} (5.23, 12.91, 13.16, 14.19 and 16.92 at 15, 25, 35, 45 and 55 DAS, respectively), minimum number of branches plant^{-1} (0.61, 1.4, 2.04, 3.07 and 4.15 at 15, 25, 35, 45 and 55 DAS, respectively), the shortest pod length (7.05 cm), the highest seed yield (1.72 t ha^{-1}), highest stover yield (2.91 t ha^{-1}) and the maximum biological yield (4.63 t ha^{-1}) was obtained from V_3 (BARI Mung-7). And V_4 (BARI Mung-8) resulted the tallest plant (13.31, 25.28, 40.8, 54.67 and 58.33 cm at 15, 25, 35, 45 and 55 DAS respectively), longest pod length (8.94 cm), the maximum number of branches plant^{-1} (0.78, 1.52, 2.27, 3.69 and 5.32 at 15, 25, 35, 45 and 55 DAS, respectively), highest total dry mater (6.39, 8.13, 11.03, 13.13 and 14.98 g at 15, 25, 35, 45 and 55 DAS, respectively), maximum number of pod plant^{-1} (16.17), highest number of seeds pod^{-1} (11.42), lowest seed size (29.42 mg) and the highest harvest index (37.57%).

Interaction effect of leaf clipping and variety was significant on all parameters. The tallest plant (13.82, 26.45, 40.77, 58.34 and 62.4 cm at 15, 25, 35, 45 and 55 DAS respectively) was obtained from C_1V_4 (BARI Mung-8 with 33% leaf clipping) while the shortest (11.79,22.62, 33.68, 39.19 and 45.52 cm at 15, 25, 35, 45 and 55 DAS respectively) with C_2V_2 (BARI Mung-6 with 66% leaf clipping). The highest number of leaves plant^{-1} (5.09, 12.82, 14.82, 17.81 and 20.12 at 15, 25, 35, 45 and 55 DAS, respectively) was obtained from C_1V_1 (BARI Mung-5 with 33% leaf clipping) treatment and the lowest number of leaves plant^{-1} (4.46, 11.33, 11.74, 12.49 and 14.4 at 15, 25, 35, 45 and 55 DAS, respectively) from C_2V_4 (BARI Mung-8 with 66% leaf clipping). The highest number of branches plant^{-1} (0.87, 1.58, 2.37, 4.12 and 6.12 at 15, 25, 35, 45 and 55 DAS, respectively) was obtained from C_1V_4 (BARI Mung-8 with 33% leaf clipping) treatment combination, in the contrary the lowest number of branches plant^{-1} (0.57, 1.30, 1.99, 2.87 and 3.86 at 15, 25, 35, 45 and 55 DAS, respectively) from C_2V_3 (BARI Mung-7 with 66% leaf clipping) treatment combination. Highest total dry matter (6.56, 8.39, 12.93, 15.67 and 18.10 g at 15, 25, 35, 45 and 55 DAS, respectively) was found in C_0V_4 (BARI Mung-8 with control) and the lowest value (5.44, 7.22, 8.33, 9.54 and 11.37 g at 15, 25, 35, 45 and 55 DAS, respectively) was found in C_2V_1 (BARI Mung-5 with 66% leaf clipping) treatment combination.

Maximum pod length (10.03 cm) was obtained from C_1V_4 (BARI Mung-8 with 33% leaf clipping) treatment combination, in contrast with the lowest (6.79 cm) from C_2V_1 (BARI Mung-5 with 66% leaf clipping) treatment combination. The C_1V_4 (BARI Mung-8 with 33% leaf clipping) treatment combination produced the maximum number of pods plant^{-1} (16.63), whereas C_2V_2 (BARI Mung-6 with 66% leaf clipping) produced the fewest pods plant^{-1} (11.28). The highest number of seeds pod^{-1} (12.47) was obtained from C_1V_4 (BARI Mung-8 with 33% leaf clipping) treatment combination while the lowest (9.16) from C_0V_1 (BARI Mung-5 with control) treatment combination. The highest seed size (52.55 mg) was obtained from C_1V_2 (BARI Mung-6 with 33% leaf clipping) treatment while the lowest (27.34 g) from C_2V_4 (BARI Mung-8 with 66% leaf clipping). The highest seed yield (2.09 t ha^{-1}) was obtained from C_1V_3 (BARI Mung-5 with 33% leaf clipping) treatment combination while the lowest (1.07 t ha^{-1}) from C_2V_2 (BARI Mung-5 with 66% leaf clipping) treatment combination. The highest stover yield (3.09 t ha^{-1}) was recorded from C_0V_3 (BARI Mung-7 with no removal) while the lowest stover yield (1.89 t ha^{-1}) was recorded from C_2V_1, (BARI Mung-5 with 66% leaf clipping) treatment combination. Maximum biological yield (5.10 t ha^{-1}) was obtained from C_1V_3 (BARI Mung-7 with 33% leaf clipping) and the lowest biological yield (3.04 t ha^{-1}) was recorded from C_2V_1 (BARI Mung-5 with 66% leaf clipping). The highest harvest index (42.54%) was obtained from C_1V_4 (BARI Mung-8 with 33% leaf clipping), while the lowest harvest index (30.68%) was obtained from C_0V_1 (BARI Mung-5 with control) treatment combination.

Conclusion

From the above findings it can be concluded that-

- Leaf clipping has significant effect on the growth and yield of mungbean. In most of the cases 33% leaf clipping (C_1) showed the best performance regarding growth, yield and yield contributing parameters. On the contrary, in 66% leaf clipping (C_2) the values decreased drastically.
- BARI Mung-7 (V_3) and BARI Mung-8 (V_4) gave the best performance in most of the parameters.
- In case of interaction effect, BARI Mung-8 with 33% removal of leaf (C_1V_4) performed well in parameters like plant height, number of branches, dry matter content. The highest seed yield 2.09 t ha^{-1} was obtained from BARI Mung-7 and 33% leaf clipping (C_1V_3). Therefore, the C_1V_3 treatment combination can be considered the best treatment combination concerning the current study.

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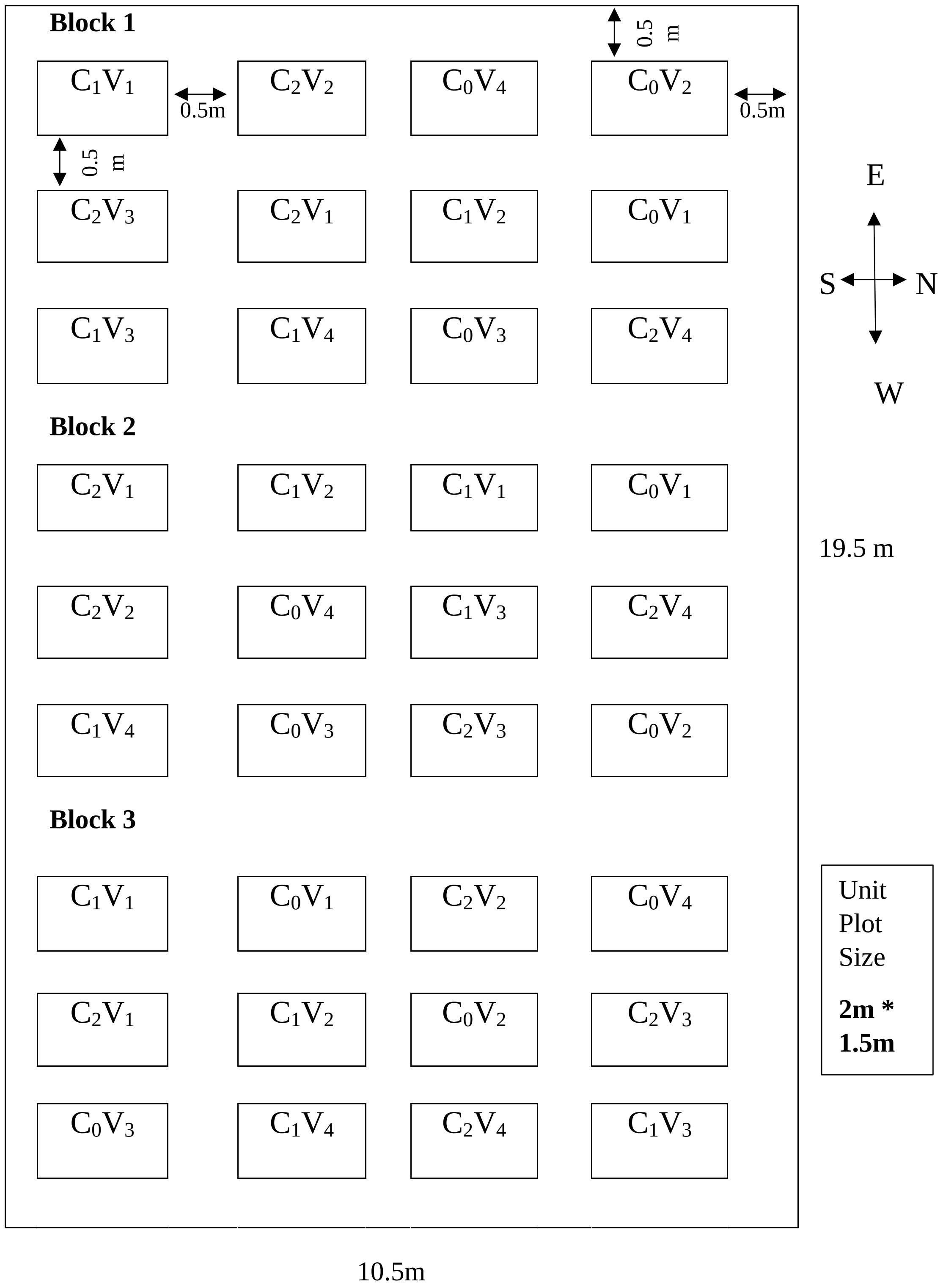
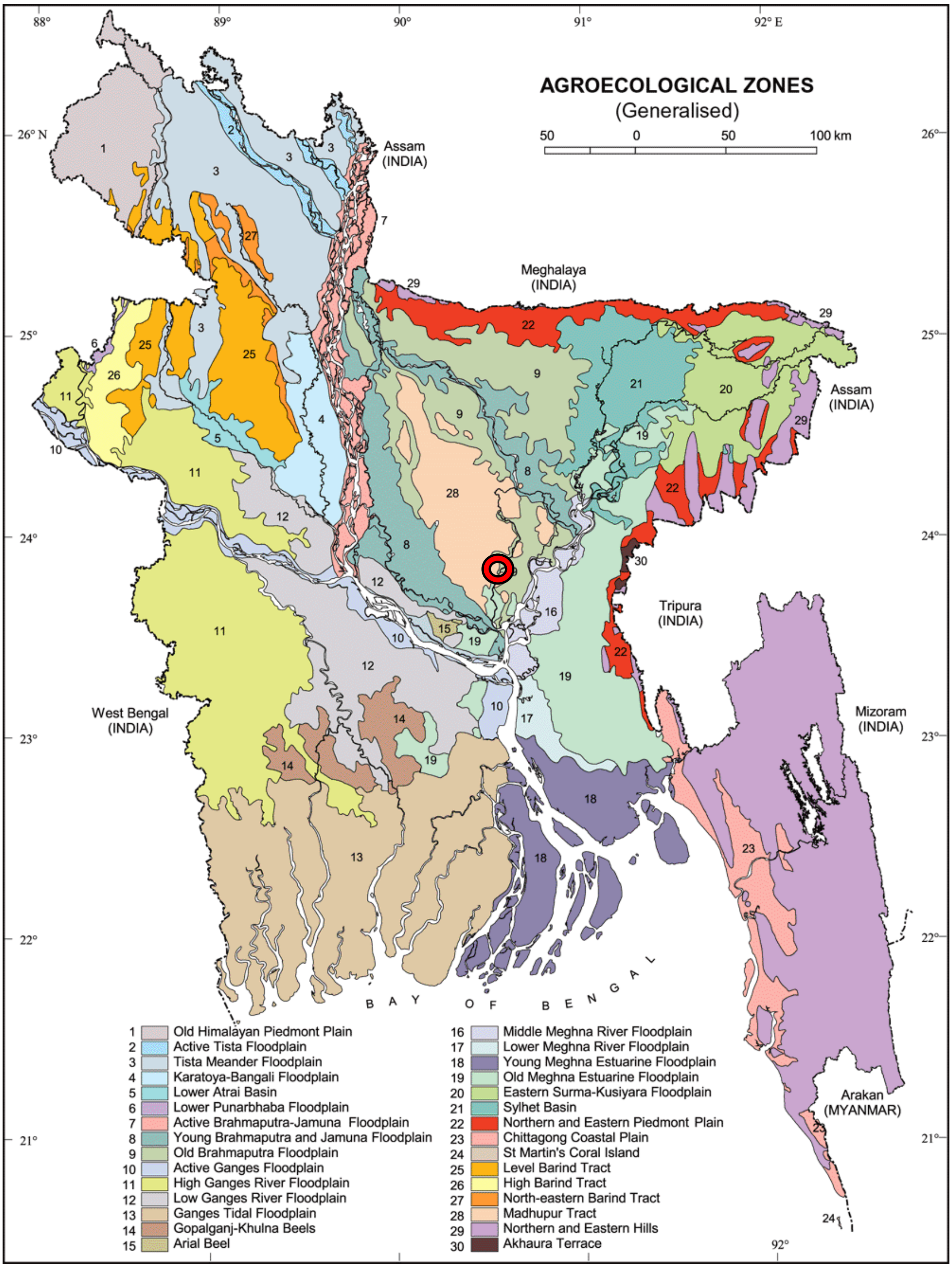
Appendices

Appendix I. Layout and design of the experimental plot



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



Appendix III. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from February to June, 2022

Month	Air Temperature (^{0}C)		Relative Humidity (%)	Rainfall (mm)
	Maximum	Minimum		
February	30.1	20.2	60	71
March	31.2	21.3	62	90
April	33.4	23.2	67	160
May	34.7	25.9	70	185
June	35.4	22.5	80	277

* Monthly average,
* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix IV. Characteristics of the soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Research plot of Sher-e-Bangla Agricultural University Farm, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

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

Physical characteristics:

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

Chemical Composition:

Soil Characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.07
Phosphorus	22.08 μg/g soil
Sulphur	25.98 μg/g soil
Magnesium	1.00 meq/100 g soil
Boron	0.48 μg/g soi
Copper	3.54 μg/g soil
Zinc	3.32 μg/g soil
Potassium	0.30 μg/g soil

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

Appendix V. Analysis of variance of the data on plant height of mungbean as affected by leaf clipping and variety

Source of variation	df	Mean square value at different days after sowing				
		15	**25**	**35**	**45**	**55**
Replication	2	2.57	5.73	10.61	58.94	34.79
Leaf clipping (A)	2	0.59^{NS}	0.23^{NS}	0.027^{NS}	57.71*	71.75*
Variety (B)	3	10.35*	17.17*	115.13*	442.16*	203.7*
Leaf clipping (A) x Variety (B)	6	0.37*	1.37*	0.808*	3.53*	4.62*
Error	22	1.49	2.55	4.25	5.58	12.09

* Significant at 5% level of significance
^{NS} Non significant

Appendix VI. Analysis of variance of the data on number of leaves plant^{-1} of mungbean as affected by leaf clipping and variety

Source of variation	df	Mean square value at different days after sowing				
		15	**25**	**35**	**45**	**55**
Replication	2	0.068	0.070	0.142	0.668	1.054
Leaf clipping (A)	2	0.028^{NS}	0.071^{NS}	152.65^{NS}	638.32*	967.314*
Variety (B)	3	0.873^{NS}	4.419^{NS}	2.871*	14.110*	26.735*
Leaf clipping (A) x Variety (B)	6	0.014*	1.039*	0.069*	1.650*	4.317*
Error	22	0.080	0.565	1.020	0.613	2.721

* Significant at 5% level of significance
^{NS} Non significant

Appendix VII. Analysis of variance of the data on number of branches plant^{-1} of mungbean as affected by leaf clipping and variety

Source of variation	df	Mean square value at different days after sowing				
		15	25	35	45	55
Replication	2	0.001	0.003	0.001	0.001	0.001
Leaf clipping (A)	2	0.001^{NS}	0.00^{NS}	0.11*	0.136*	967.314*
Variety (B)	3	0.057*	0.062*	0.59*	0.050*	0.076*
Leaf clipping (A) x Variety (B)	6	0.000*	0.000*	0.002*	0.001*	0.001*
Error	22	0.003	0.008	0.009	0.016	0.020

* Significant at 5% level of significance
^{NS} Non significant

Appendix VIII. Analysis of variance of the data on dry matter content plant^{-1} of mungbean as affected by leaf clipping and variety

Source of variation	df	Mean square value at different days after sowing				
		15	25	35	45	55
Replication	2	1.091	2.105	0.528	5.459	7.793
Leaf clipping (A)	2	0.119^{NS}	0.167^{NS}	9.100*	45.47*	53.217*
Variety (B)	3	1.374*	0.975*	3.320*	6.737*	6.914*
Leaf clipping (A) x Variety (B)	6	1.374*	0.975*	3.320*	6.737*	6.914*
Error	22	0.166	0.102	0.483	0.145	0.246

* Significant at 5% level of significance
^{NS} Non significant

Appendix IX. Analysis of variance of the data on yield contributing characters of mungbean as affected by leaf clipping and variety

Source of variation	df	Mean square value at different days after sowing			
		Pod length (cm)	Pod plant^{-1} (No)	Seed pod^{-1} (No)	Seed size (mg)
Replication	2	0.067	0.396	1.254	43.681
Leaf clipping (A)	2	2.707*	6.418*	6.469*	68.75*
Variety (B)	3	3.919*	9.83*	5.544*	34.60*
Leaf clipping (A) x Variety (B)	6	0.014*	0.044*	0.034*	0.654*
Error	22	0.310	0.564	0.228	7.050

* Significant at 5% level of significance
^{NS} Non significant

Appendix X. Analysis of variance of the data on seed, stover, biological yield and harvest index of mungbean as affected by leaf clipping and variety

Source of variation	df	Mean square value at different days after sowing			
		Seed yield	Stover yield	Biological yield	Harvest index
Replication	2	0.016	0.030	0.087	0.234
Leaf clipping (A)	2	0.743*	0.234*	0.184*	393.134*
Variety (B)	3	0.312*	0.130*	0.113*	151.295*
Leaf clipping (A) x Variety (B)	6	0.003*	0.001*	0.002*	1.174*
Error	22	0.005	0.24	0.054	4.417

* Significant at 5% level of significance
^{NS} Non significant