EFFECT OF LEAF CLIPPING AND DIFFERENT FERTILIZER DOSES ON THE YIELD OF MUNGBEAN

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CERTIFICATE

This is to certify that the thesis entitled, *"EFFECT OF LEAF CLIPPING AND DIFFERENT FERTILIZER DOSES ON THE YIELD OF MUNGBEAN"* submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY** embodies the result of a piece of bonafide research work carried out by **MOUSUMI SULTANA**, Registration No. **00917** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June 23, 2009
Place: Dhaka, Bangladesh

(Prof. Dr. Md. Jafar Ullah)
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Dedicated To

My

Beloved Parents

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ABSTRACT

A field experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from March 2007 to June 2007 to study the influence of different leaf clipping and fertilizer doses on growth and yield of mungbean. The trial comprised four treatments on leaf clipping (No removal, removal of new leaves developed after first flowering, removal of subtending leaves beneath the inflorescences and removal of empty leaves), and three treatments on fertilizer doses per hector (10 kg N + 20 kg P_2O_5 + 15 kg K_2O, 20 kg N + 40 kg P_2O_5 + 30 kg K_2O and 30 kg N + 60 kg P_2O_5+ 45 kg K_2O). Results showed that the leaf clipping treatments had significant effect on growth and yield parameters. Removal of empty leaves resulted in the highest plant height, dry matters from leaf, stem, root and inflorescences with yield and all the yield attributes as well. The fertilizer doses also affected the studied parameter significantly. The highest values on most of the growth and yield parameters were obtained with 20 kg N + 40 kg P_2O_5 + 30 kg K_2O/ha. In case of interaction of treatments, removal of empty leaves coupled with 20 kg N + 40 kg P_2O_5 + 30 kg K_2O (ha) showed significantly highest values on stem dry weight (10.69 g/ plant), root dry weight (2.49 g/plant), stover weight (2.10 g/plant), pod length (12.98 cm), number of seeds/pod (12.31), 1000 seed weight (40.67 g), grain yield (1.12 t/ha) and harvest index (34.78 %). The higher yield was attributed to the absence of leaves having no inflorescence on their axils and also to the balanced fertilization.

LIST OF CONTENTS

Contents (cont'd......)

LIST OF TABLES

Table (cont'd......)

LIST OF APPENDICES

LIST OF ACRONYMS

Abbreviation		Full meaning
AEZ	=	Agro – Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
°C	=	Degree Celsius
CV	=	Co – efficient of Variation
cv.	=	Cultivar
DAS	=	Days after sowing
et al.	=	and others *(et alibi)*
etc	=	et cetera
e.g.	=	For example
FAO	=	Food and Agriculture Organization
g	=	gram (s)
kg	=	Kilogram
ha	=	Hectare (s)
hr	=	Hour
i.e.	=	That is
LER	=	Land Equivalent Ratio
LSD	=	Least Significant Difference
kg/ha	=	Kilogram per hectare
L	=	Litre
m	=	Meter
mm	=	Millimeter
MOP	=	Muriate of Potash
m^2	=	Square meter
m^{-2}	=	Per square meter
MT	=	Metric Ton
ml	=	Mililitre
p^H	=	Hydrogen ion conc.
ppm	=	Parts per million
RH	=	Relative Humidity
RCBD	=	Randomized Complete Block Design
t/ha	=	Ton per hectare
TSP	=	Triple Super Phosphate
viz.	=	Namely
@	=	At the rate of
%	=	Percent

CHAPTER 1
INTRODUCTION

CHAPTER 1

INTRODUCTION

Pulse is a group of food legumes supplying protein to human diet. It is a part and parcel of Asian diet (Fernandez and Shanmugasundaram, 1988). Bangladesh grows various types of pulse crops. Among them grasspea, lentil, mungbean, blackgram, chickpea, fieldpea and cowpea are important. Pulse protein is rich in amino acids like isoleucine, leucine, lysine, valine etc. According to FAO (1999), a minimum intake of pulse by a human should be 80 g per head per day, whereas it is only 14.19 g in Bangladesh (BBS, 2005). This is because of the fact that national production of the pulses is not adequate to meet the national demand.

Among the pulse crops, mungbean (*Vigna radiata* (L.) Wilczek) is an important grain legume. As an excellent source of vegetable protein it is extensively grown in the tropical and subtropical regions. It is a C_3 plant which originated in the South and Southeast Asia (India, Burma, Thailand region). In Bangladesh it is used as whole or split seeds and is used as dal (soup) but in other countries, sprouted seeds are also widely used as vegetables. The green plants are used as animal feed and residues are used as green manure. The crop is potentially useful in improving cropping systems as catch crop due to its rapid growth and early maturation. It can also fix atmospheric nitrogen through its symbiotic relationship between the host mungbean roots and soil bacteria and thus improve soil fertility.

Mungbean is a warm season crop. It is grown mainly in semi-arid to sub humid low lands with 600 to 1000 mm annual rainfall, 20^0 to 30^0C mean temperature during the period of crop production and at elevation not exceeding 1,800 to 2,000 m (Poehlman, 1991). It can also tolerate high temperatures up to 40^0C but does well at 30 - 35^0 C, on a wide range of soil types but are best in deep, well drained loam or sandy loam soil (Gowda and Kaul, 1982).

Its grain contains 51% carbohydrates, 26% protein, 10% moisture, 4% mineral and 3% vitamins (Khan, 1981; Kaul, 1982). Among the pulses in Bangladesh, mungbean ranks fifth in area and production. In Bangladesh it was grown on 4400 hectares of land producing 30,000 metric tones (BBS, 2006).

The climatic conditions of Bangladesh favours mungbean production almost throughout the year. In general, however, it is grown on marginal lands of poor fertility with low moisture status and under poor management conditions. In spite of many advantages of producing mungbean, the area covered by it and its total yield are declining (BBS, 1995). This is mainly because the pulses in general, cannot compete with HYV cereals in terms of productivity and economic returns and are thus being pushed to marginal lands where nutrient limitations are severe.

The average yield of mungbean is 0.69 t ha^{-1} (BBS, 2005) which is very poor in comparison to mungbean growing countries in the world. There are many reasons of lower yield of mungbean. The management of fertilizer is the important one that greatly affects the growth, development and yield of this crop. Pulses although fix nitrogen from the atmosphere, there is evidence that application of nitrogenous fertilizers become helpful in increasing the yield (Patel *et al.*, 1984 and Ardeshana *et al.*, 1993). Nitrogen is most useful for pulse crops because it is the component of protein (BARC, 1997). Moreover, phosphorous contributes to the formation of nodule and as well as grain. Likewise, potassium helps in many biochemical processes.

Nitrogen is an essential element and important determinant in growth and development of crop plants (Tanaka *et al.*, 1984). Its deficiency constrains leaf area expansion, enhances leaf senescence, alters canopy structure and subsequently reduces crop yields (Wolf *et al.*, 1988). Phosphorus plays a key role in plant's physiological processes. It is an essential constituent of nucleoprotein, phospholipids, enzymes and other plant substances.

Phosphorus influences nutrient uptake by promoting root growth, nodulation and specific nodule activity. Mungbean responds favorably to P fertilization (Ali and Bhuiya, 1979; Arya and Kalra, 1988; Patel and Patel, 1991; Singh and Singh, 1993; Ali, 1993; Chowdhury, 1996).

The productivity of a crop depends on the photosynthetic efficiency and partitioning of the photoassimilate to the economic sink (Gifford *et al.*, 1984). The production and utilization of photosynthates occur in a dynamic balance within a plant. This balance is achieved by adjusting either the capacity of source or the capacity of sink. This phenomenon is known as source-sink relationship (Evans, 1975). For higher productivity of crop, an appropriate relationship between source and sink and their capacity is required (Rajgopal, 1976). This appropriate relationship can be achieved by source –sink manipulation.

Mobilization of nutrient elements (i.e., translocation and re translocation) takes place within the plant during its life cycle. The extent of remobilization of the elements (e.g., N, P and K), however, depends on the availability of these elements in the plant and demand for photosynthesis. Fertilizers (N and P) may increase significantly mungbean yield (Patel and Parmer, 1986) by increasing root growth, nodulation, leaf area, and total dry matter. But optimum requirements for fertilizers depend on soil fertility levels and methods of application. Information on nutrient requirement of mungbean under Bangladesh soil condition is measuer (Islam, 1991).

A number of studies have been reported on the effect of source-sink manipulations on the productivity of different crops. Selective defoliation improved light interception in fababean resulting in a greater photosynthetic efficiency. On the contrary, (Pommer *et al.*, 1984) observed that defoliation reduced dry matter accumulation in maize (Hamid and Hashem, 1991). A complete defoliation at reproductive stage reduced yield in mungbean (Rao and

Ghildyal, 1985), Hintz and Fehr, 1990), pigeonpea (Pandey and Singh, 1981), maize (Singh and Nair, 1975; Hicks *et al.*, 1977), cowpea (Panday, 1983) and sesame (Roshid, 1998). Flower removal increased dry matter accumulation in remaining reproductive sink in groundnut (Talwar *et al.*, 1992) and seed yield in soybean (Olpenshaw *et al.*, 1978).

Inadequate leaf production in the vegetative phase indicates that during the post-flowering phase, when the sink activity was high, most photosynthates required for the growth and development of pods come from the current photosynthesis (Kuo *et al.*, 1978). It is therefore imperative that for high yield formation in mungbean, 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.*, 1990).

However, the optimum leaf area index for maximizing yield or biomass production has not been elaborately reported. Excessive leaf development during the later growth stages was found to be detrimental to seed yield (Patel *et al.*, 1992). Production of leaves, particularly in the lower part of the plant often causes mutual shading resulting in yield reduction. Total dry matter production is positively correlated with the amount of foliage displayed in upper 50% of the canopy (Hamid *et al.*, 1990). It seems likely that the foliage developed in the lower part of the canopy has little or negative contribution to dry matter production. Thus manipulation of source may provide opportunity for increasing yield in plants with excessive leaf development habit.

Sink in mungbean is determined by the number of pods per plant (Mackenzie *et al.*, 1975), number of seeds per pod and weight of an individual seed (AVRDC, 1976). Removal of apical shoot above node 5 or removal of inflorescence or axillary bud at nodes 1-4 together with the apical shoot greatly increased pod number and seed weight of mungbean (Clifford, 1979). The leaves at flowering nodes are the major contributors to seed filling and development (AVRDC, 1974). Several verities have recently been released in Bangladesh. Such investigation is necessary in these varieties.

Hence, the present study was undertaken to maximize the seed yield of mungbean by manipulating source through removal of selective leaves using optimum fertilizers (N, P and K) with following objectives:

- To evaluate the effect of removal of different leaves (source manipulation) on yield and yield attributes of mungbean under different levels of fertilization.

- To determine the effect of nitrogen, phosphors and potassium fertilizer on the productivity of mungbean in terms of dry matter and yield.

CHAPTER 2
REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

2.1 Effect of fertilizers on various plant characters including yield and yield attributes of mungbean

2.1.1 Plant height

An experiment was conducted by Sardana and Verma (1987) in New Delhi, India, in 1983-84. They stated that application of nitrogen, phosphorus and potassium fertilizers resulted in significant increases in plant height of mungbean. Suhartatik (1991) also reported that NPK fertilizers significantly increased the plant height of mungbean.

In a field experiment, Yein *et al*. (1981) applied nitrogen in combination with phosphorus fertilizer to mungbean which resulted in increased the plant height. Yein (1982) carried out 2- year field trials in Assam, India on mungbean and reported that application of various levels of nitrogen plus phosphorus significantly increased the plant height.

A field experiment was carried out by Rao *et al*. (1993) to find out the response of four mungbean cultivars (Pusa Baishakhi, LGG 407, LGG 410 and MS 267) to 3 levels of phosphorus (0, 25 and 50 kg P_2O_5/ha) in sandy loam soil of Bapalta. The soil was low in available P_2O_5 (9 kg/ha). A uniform dose of 20 kg N/ha was applied as a basal for all the treatments. Experimental results showed that plant height significantly increased with the increase in P levels from 0 to 50 kg P_2O_5/ha.

Trung and Yoshida (1983) conducted a field trial on mungbean testing 0 - 100 ppm N in the form of ammonium nitrate or 10 or 100 ppm N as urea, sodium nitrate, ammonium nitrate or ammonium sulphate. They observed that maximum plant height was obtained by 25 ppm N at all the stages of development.

Hamid (1988) conducted a field experiment to investigate the effect of nitrogen and carbon on the growth and yield performance of mungbean (*Vigna radiata* L. wilczek). He found that the plant height of mungbean cv. Mubarik was found to be increased with nitrogen at 40 kg / ha.

Quah and Jaafar (1994) found that plant height of mungbean was significantly increased by the application of nitrogen fertilizer at 50 kg / ha rate.

Ahmed *et al.* (1986) carried out an experiment with various levels of phosphorus on the growth and yield of mungbean. They noted that phosphorus application up to 60 kg/ha progressively and significantly enhanced the plant height.

In a field experiment, Patel and Patel (1991) observed that plant height of mungbean showed superiority at 60 kg P_2O_2/ha followed by 40 kg P_2O_5/ha application rate, grown on the soil which was sandy in texture, low in total N (0.04%), higher in available P (77.33 kg/ha) and rich in available K (388.15 kg/ha) with the P^H 7.5. Thus plant height was found to be increased with increasing level of phosphorus from 0 to 60 kg/ha.

Bayan and Saharia (1996) carried out an experiment to study the effect of phosphorus on mungbean during the *Kharif* seasons of 1994-95 in Biswas Chariali, Assam, India. The results indicated that plant height was unaffected by phosphorus application.

Sharma and Singh (1997) carried out a field experiment during 1989 and 1990 to study the effect of various levels of phosphorus (0, 25, 50 and 75 kg/ha) on the growth, yield and yield attributes of mungbean. Results of their study revealed that application of phosphorus at 50 kg/ha enhanced the plant height significantly.

An experiment was conducted by Singh *et al*. (1999) on mungbean cv. NDM1 grown at Faisalabad, Uttar Pradesh, India in summer 1996 and the crop was given 0 - 26.4 kg P/ha. They reported that plant height in general was increased with the use of P up to 26.4 kg/ha.

2.1.2 Leaf area index (LAI)

Leaf area index (LAI) is the ratio of leaf area. Its ground area and it is the functional size of the standing crop on unit land area (Hunt, 1978). It depends on the leaf growth, number of leaves per plant, population density and leaf senescence (Khan, 1981). The higher productivity of a crop depends on the persistence of high LAI over a greater part of its vegetative phase. The rate of photosynthesis depends on the LAI. After germination LAI increases and reaches the peak and thereafter it declines due to increased senescence of older leaves (Katiya, 1980).

Sardana and Verma (1987) conducted an experiment in New Delhi, India, in 1983-84 and pointed out that application of nitrogen, phosphorus and potassium fertilizers resulted in significant increases in leaf area index (LAI) of mungbean. Suhartatik (1991) also reported that residue of lime with NPK fertilizers significantly increased the leaf area index (LAI) of mungbean. In a field trial, conducted by Bali *et al*. (1991) on mungbean in the *Kharif* seasons on silty clay loam soil and reported that LAI increased with increasing nutrient up to 40 kg N and 60 kg P_2O_5/ha.

Application of P increased nodulation in mungbean owing to better root growth by which N uptake in plant was increased. Due to increase in N uptake there was an increase in nucleic acid, amides and amino acids. This caused cell multiplication which in turn increased LAI (Borde *et al*., 1983). Agbenin *et al.*

(1991) found that applied N significantly increased the LAI of mungbean over the control.

2.1.3 Total dry matter

The total dry matter production is the integration of crop growth rate over the entire growth period. The pattern of assimilate distribution is determined by that of photosynthesis and environmental conditions (Evans, 1975). Total dry matter production of a crop is dependent on the source and its activities as well as the length of its growth period, during which photosynthesis continues. It is the actual assimilates of seed (or any other sink) after maintaining the total cost of respiration. The process of photosynthesis, mineral uptake, respiration and senescence of leaves usually determine the dry weight of a plant.

Yein (1982) carried out a 2-year field experiment in Assam, India, on mungbean (*V. radiata*) and reported that combined application of nitrogen and phosphorus significantly increased the dry weight of plants. Agbenin *et al.* (1991) found that applied N significantly increased the dry matter yield of mungbean over the control. Leelavathi *et al.* (1991) also reported that different levels of nitrogen showed significant difference in dry matter yield of mungbean up to a certain level (60 kg N/ha).

Reddy *et al.* (1990) set up an experiment with three cultivars of mungbean in 1987, applying 0 or 50 kg P_2O_5/ha as a basal dressing or 50 kg P_2O_5/ha in two equal split dressings at the sowing and flowering. They found that application of phosphorus increased the dry matter accumulation in mungbean.

A field trial carried out by Mitra *et al.* (1999) during the *Kharif* (rainy) seasons of 1996 and 1997 to study the effect rock phosphate on the growth and yield of mungbean in acid soils of Tripura, India. Results revealed that mungbean cv. GM- 9002 had greater dry matter accumulation at harvest than cv. UPM-12 or MH-309. Maximum dry matter at harvest was recorded with the application of

Mussoorie rock phosphate (50 kg P_2O_5/ha). Raundal *et al.* (1999) also reported that application of phosphorus 60 kg/ha to mungbean grown in *Kharif* (monsoon) season significantly increased the dry matter yield.

Chowdhury and Rosario (1992) studied the effect of 0, 30, 60, or 90 kg N/ha levels on the rate of growth and yield performance of mungbean at Banos, Philippines in 1988. They observed that N above the rate of 30 kg/ha reduced the dry matter yield.

Santos *et al.* (1993) carried out an experiment on mungbean cv. Berken which was grown in pots in podzolic soil with 7 levels of N (0, 25, 100, 200, 400, or 500 kg/ha) applied as NH_4NO_3 and noted that application of N up to 200 kg/ha incresed the total dry matter at both harvest higher rates decreased it.

Yakadri *et al.* (2002) studied the effect of nitrogen (20, 40 and 60 kg/ha) on crop growth and yield of greengram (cv. ML - 267). Application of nitrogen at 20 kg/ha resulted in the significant increase in leaf area ratios indicating better partitioning of leaf dry matter.

2.1.4 Straw yield

Mahmoud *et al.* (1988) observed that nitrogen application increased the straw production up to a certain level with different row spacing in mungbean. Sarkar and Banik (1991) conducted a field experiment. Results showed that straw yield of mungbean increased significantly using N up to 10 kg N/ha. On an average straw yield was increased by 24 percent due to 10 kg N/ha over no nitrogen. They also reported that increasing levels of P_2O_5 up to 60 kg/ha resulted in correspondingly higher straw yield of mungbean. Increased straw yield was attributed to higher synthesis of carbohydrates and protein. Sharma and Sing (1997) stated that applications of phosphorus @ 50 kg/ha enhanced the straw yield of mungbean significantly.

2.1.5 Pod length

In a field trial, carried out by Sardana and Verma (1987) in Delhi, India, during 1983-84, it was found that application of nitrogen, phosphorus and potassium fertilizers resulted in significant increases in pod length of mungbean. Suhartatik (1991) noted that residue of lime with NPK fertilizer significantly increased the pod length of mungbean.

Tank *et al.* (1992) reported that mungbean fertilized with 20 kg N/ha could be assigned to significantly increase pod length over the rest of the higher (40 kg N/ha) and lower (unfertilized control) levels of N. They also observed that pod length significantly increased up to the levels of 40 kg P_2O_5/ha. In a field trial, carried out by Sarkar and Banik (1991), it was observed that application of 10 kg N/ha to mungbean resulted in appreciable improvement in pod length over the control.

Results of a field experiment conducted by Patel and Patel (1991) revealed that pod length of mungbean varieties showed superiority at 60 kg P_2O_5/ha followed by 40 kg/ha P_2O_5 application rate. Thus pod length was found to be increased with increasing levels of phosphorus from 0 to 60 kg/ha. They also noted that *Rhizobium* culture did not show any effect on pod length.

Srinivas *et al.* (2002) studied the effect of nitrogen (0, 20, 40 and 60 kg/ ha) and phosphorus (0, 25, 50 and 75 kg/ha) on the growth and yield components of mungbean. They observed that pod length was increased with the increasing rates of N up to 40 kg/ha which was then followed by a decrease with further increase of N.

Malik *et al.* (2003) studied the effect of varying levels of nitrogen and phosphorus on mungbean cv. NM-98. It was reported that pod length was significantly affected by both nitrogen and phosphorus application.

2.1.6 Number of pods/plant

A field trial was carried out by Sardana and Verma (1987) in New Delhi, India, in 1983-84 and observed that application of nitrogen, phosphorus and potassium fertilizers resulted in significant increases in number of pods/plant of mungbean.

Samiullah *et al.* (1987) reported that number of pods/plant was highest with the application of 10 kg N +75 kg P_2O_5 + 60 kg K_2O in summer mungbean. Suhartatik (1991) observed that NPK fertilizers significantly increased the number of pods/plant of mungbean.

In an experiment, Yein *et al.* (1981) applied nitrogen and phosphorus fertilizers to mungbean and reported that combined application of nitrogen and phosphorus fertilizers increased the number of pods/plant. In trials, on clayey soils during the summer seasons of 1979-80, Patel *et al.* (1984) studied the effects of 0, 10, 20 and 30 kg N/ha and 0, 20, 40, 60 and 80 kg P_2O_5/ha on the growth and seed yield of mungbean. Results of their studies revealed that Patel *et al.* (1984) observed that the application of 40 kg P_2O_5/ha along with up to 20 kg N/ha significantly increased the number of pods/ plant of mungbean and a further increase in phosphorus rates was not economical.

Tank *et al.* (1992) stated that mungbean fertilized with 20 kg N along with up to the level of 40 kg P_2O_5/ha could be considered to significantly higher number of pods/plant over the unfertilized control.

Kalita *et al.* (1989) conducted an experiment in 1986-88, applying 30 kg P_2O_5/ha to mungbean and suggested that application of phosphorus increased the number of pods/plant. In another trial, Reddy *et al.* (1990) found that application of phosphorus increased the number of pods/plant in mungbean.

Bayan and Saharia (1996) reported that application of phosphorus to mungbean (*V. radiata* L.) did not affect the number of pods/plant. Results of a field experiment carried out by Shukla and Dixit (1996) revealed that application of phosphorus to mungbean significantly increased the number of pods/plant up to 40 kg P_2O_5/ha.

Sharma and Singh (1997) carried out a field experiment during 1989 and 1990 to study the effects of various levels of phosphorus (0, 25, 50 and 75 kg/ha) on the growth, yield and yield attributes of mungbean. They observed that application of phosphorus at 50 kg/ha significantly enhanced the number of pods/ plant.

Masthan *et al*. (1999) stated that number of pods/ plant of summer mungbean cv. LGG 127 was increased with increasing P rates. Mitra *et al*.(1999) expected that mungbean grown in acid soils of Tripura, the maximum number of pods/plant were recorded with application of 50 kg P_2O_5/ha. Singh *et al*. (1999) reported that number of pods/ plant of mungbean cv. NDM-1 grown at Faisalabad, Uttar Pradesh, India in summer 1996 was increased with using P up to 26.4 kg ha.

Sarkar and Banik (1991) reported that application of 10 kg N/ha to mungbean resulted in appreciable improvement in the number of pods per plant compared with using no nitrogen. Suhartatik (1991) observed that N, P and K fertilizers in combination significantly increased the number of pods per plant.

Srinivas *et al.* (2002) examined the effect of nitrogen (0, 20, 40 and 60 kg/ha) and phosphorus (0, 25, 50 and 75 kg/ha) on the growth and yield of mungbean. They observed that the number of pods per plant was increased with the increasing rates of N up to 40 kg/ha followed by a decrease with further increase in N.

2.1.7 Number of seeds/pod

Samiullah *et al.* (1987) conducted a field experiment and observed that number of seeds/pod were the highest with 10 kg N + 75 kg P_2O_5 + 60 kg K_2O in summer mungbean.

Kalita *et al.* (1989) conducted field trials during 1986 to 1988 applying 30 kg P_2O_5/ha to mungbean and noted that phosphorus application increased the number of seeds/pod over the control. Reddy *et al.* (1990) carried out an experiment with three cultivars of mungbean in 1987, applying 0 or 50 kg P_2O_5/ha in two equal split dressings at the sowing and flowering time, Results showed that application of phosphorus increased the number of seeds/pod in mungbean.

Bayan and Saharia (1996) reported that application of phosphorus to mungbean did not affect the number of seeds/pod. Shukla and Dixit (1996) conducted a field experiment with mungbean and reported that application of phosphorus significantly increased the number of seeds/pod up to 40 kg P_2O_5/ha. Sharma and Sing (1997) carried out a field experiment and reported that number of seeds/ pod of mungbean was highest with the application of 50 kg P_2O_5/ha

Malik *et al.* (2003) investigated the effect of varying levels of nitrogen (0, 25 and 50 kg/ha) and phophorus (0, 50, 75 and 1000 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98 during 2001. It was found that number of seeds per pod was significantly affected by varying levels of nitrogen and phosphorus.

Gopala Rao *et al.* (1993) conducted a field trial on four mungbean cultivars (Pusa Baishakhi, LGG 407 410 and MS 267) with three levels of P (0, 25 and 50 kg P_2O_5/ha) in sandy loam soil, which contained low available P_2O_5 (9 kg/ha). They reported that number of seeds/ pod significantly increased with the increase in P levels from 0 to 50 kg P_2O_5/ha where a uniform dose of 20 kg N/ha was applied as basal for all the treatments.

2.1.8 1000 seed weight

Sardana and Verna (1987) carried out an experiment in Delhi, India in 1983-84 and stated that application of nitrogen, phosphorus and potassium fertilizers resulted in significant increases in 1000-seed weight of mungbean.

Patel *et al.* (1984) studied the effects of 0, 10, 20 and 30 kg N/ha and 0, 20, 40, 60 and 80 kg P_2O_5/ha on the growth and seed yield of mungbean on clayey soil during summer seasons of 1979-80. They observed that application of 40 kg P_2O_5/ha with up to 20 kg N/ha significantly increased the 1000-seed weight of mungbean; further increase in phosphorus rates was not economical. Bali *et al.* (1991) carried out a field trial during the *Kharif* season on silty clay loam soil and found that 1000-seed weight of mungbean increased with up to 40 kg N and 60 kg P_2O_5/ha.

A field experiment was conducted by Sarkar and Banik (1991). Results revealed that application of 10 kg N/ha to mungbean resulted in appreciable improvement in yield attributes like 1000-seed weight over the control (no nitrogen). Quah and Jaffar (1994) noted that 1000 seed-weight of mungbean increased significantly due to the application of nitrogen at 50 kg/ha.

An experiment carried out in 1980-82 by Patel *et al.* (1988) on a loamy sand soil and observed that application of 20 kg P_2O_5/ha to mungbean increased 1000 seed weight.

Mitra *et al.* (1999) reported that 1000 seed weight of summer mungbean might be maximized with the application of rock phosphate (50 kg P_2O_5)/ha when grown in acid soils of Tripura in India.

Sangakkara (1990) carried out a field experiment on mungbean cv. M15 and Type 61 where 0 - 120 kg K_2O/ha which were applied with basal dressings or split applications of 60 – 40 kg KCl at planting and flowering time. Results revealed that potassium application significantly increased 1000 seed weight.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different nitrogen levels on the yield and yield components of mungbean at the Agronomic Research Station, Farooqabad in Pakistan during the year of 2000 and 2001. They revealed that various yield components like 1000 grain weight were affected significantly by the fertilizer combinations of 50-50-0 NPK kg/ ha application.

Srinivas *et al.* (2002) conducted an experiment on the performance of mungbean at different levels of nitrogen and phosphorus. Different rates of N (0, 25, and 60 kg/ha) and P (0, 25, 50 and 75 kg/ha) were tested. They observed that 1000 seed weight was generally increased with increasing rates of P along with increasing rates of N up to 40 kg ha^{-1} which was then followed by a decrease with further increase in N.

2.1.9 Seed yield

An experiment was conducted by Sardana and Verma (1987) in Delhi, India, in 1983-84. Results revealed that application of nitrogen, phosphorus and potassium fertilizers resulted in significant increases in seed yield of mungbean. Khanam *et al.* (1996) reported that the full NPK plus compost treatment increased the seed yield of mungbean by 83-87%.

A field trial was conducted by Dhingra *et al.* (1998) in 1992 - 94 at Ludhiana, Punjab, India on loamy sand soil, low in organic carbon and medium in P and K, to study the combined effects of NPK and other manipulations on the productivity of mungbean *(V. radiata)* - Indian mustard *(Brassica juncea)* cropping system under irrigated conditions. The highest productivity of mungbean grown in the system was obtained with 30 kg N, 40 kg P and 20 kg K/ha applied to the crop under the normal plant density.

Yein *et al.* (1981) applied nitrogen and phosphorus fertilizers to study their relative contributions towards increasing the seed yield of mungbean. Their studies showed that nitrogen along with phosphorus fertilizer increased the seed yield. Yein (1982) conducted another 2-year field trials in Assam, India, on mungbean and found out that 10 kg nitrogen in combination with 20 kg phosphorus/ha resulted in significant increases in seed yield.

In trials on clayey soil during the summer seasons of 1979-80, Patel *et al.* (1984) studied the effects of 0, 10, 20 and 30 kg N/ha and 0, 20, 40, 60 and 80 kg P_2O_5/ha on the growth and seed yield of mungbean. A significant increase in seed yield was observed with the application of nitrogen up to 20 kg/ha and 40 kg P_2O_5/ha; further increase in phosphorus rates was not economical.

Arya and Kalra (1988) reported that with the phosphorus (50 kg/ha) and nitrogen (50 kg/ha) increased the soil N content and mungbean yield. Bali *et al.* (1991) conducted a field trial in the *Kharif* seasons on silty clay loam soil and found that seed yield of mungbean increased with up to 40 kg N and 60 kg P_2O_5/ha.

A field experiment was carried out by Sarkar and Banik (1991) who showed that application of N and P improved plant productivity and significantly enhanced the seed yield of mungbean. Response to N and P_2O_5 was recorded up to 10 and 60 kg/ha, respectively. The maximum seed yield was obtained with the combination of 20 kg N and 60 kg P_2O_5/ha which was statistically at par with 10 kg N supplied along with 60 kg P_2O_5/ha. Both 10 and 20 kg N/ha gave significantly higher seed yield over the control at each P level.

In a field experiment on a clay soil during the *Kharif* season of 1990, Badole and Umale (1994) observed that seed yield of mungbean cv. TAP was increased by N and P application. In the fertilizer treatments, application of 50% of the recommended N and P rate gave the highest yield of 1.17 t/ha.

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

Yadav *et al.* (1994) conducted a field trial on sandy loam soil during the *Kharif* (monsoon) season of 1986 at Hisar, Haryana, India, with mungbean cv. K 851 and the crops were given 0, 50 or 100% of the recommended N and P fertilizers (20 kg N as urea and 40 kg P_2O_5/ha as single super phosphate). They found that mungbean receiving the recommended fertilizer rate gave the highest seed yield.

Huesca and Oria (1981) noted that N fertilizer had no effect on the seed yield of mungbean. Mungbean was grown by Trung and Yoshida (1983) in soil, containing) 0-100 ppm N in the form of ammonium nitrate or 10 or 100 ppm N as urea, sodium nitrate, ammonium nitrate or ammonium sulphate. They found that seed yield of mungbean increased with the increase in N up to 50 ppm.

Hamid (1988) reported that N application increased the seed yield of mungbean cv. Mubarik grown in a polyethylene pot house. Mahmoud *et al.* (1988) also observed that applied nitrogen increased the seed yield up to a certain level with different row spacing in mungbean. However, Patel *et al.* (1988)

conducted a field experiment on a loamy sand soil in 1980-82 and noted that application of 0 - 20 kg N/ha to mungbean had no significant effect on the seed yield.

Pongkao and Inthong (1988) reported that application of 15 kg N/ha to mungbean was superior to nil in the entire characteristics measured, especially producing increased seed yield up to 23 percent which was statistically significant. Though the four rates of N applied at the flowering did not cause the difference in yield to be statistically significant, however 60 kg N/ha tended to produce the highest yield.

Leelavathi *et al.* (1991) reported that different levels of nitrogen showed significant difference in seed yield of mungbean up to a certain level (60 kg N/ha). Sarkar and Banik (1991) reported that seed yield of mungbean increased significantly up to 10 kg N/ha. On an average, seed yield was increased by 24 percent due to 10 kg N/ha over no nitrogen.

Chowdhury and Rosario (1992) undertook a study to point out the effects of 0, 30, 60 or 90 kg N/ha on the growth and yield performance of mungbean at Los Banos, Philippines in 1988. They noted that applied N at the levels above 30 kg/ha reduced the seed yield.

Tank *et al.* (1992) observed that mungbean fertilized with 20 kg N/ha out yielded the rest of the higher (40 kg N/ha) and lower (unfertilized control) levels of N by recording significantly higher seed yield. Ardeshna *et al.* (1993) stated that application of nitrogen @ 20 kg/ha to mungbean out-yielded (7.5 q/ha) and as well as showed significantly higher yield than that of 10 kg/ha (6.74q/ha).

Quah and Jaffar (1994) noted that seed yield of mungbean was increased significantly by the application of nitrogen fertilizer at 50 kg/ha. Kaneria and

Patel (1995) conducted a field experiment on a vertisol soil in 1989-91 in Gujarat, India using mungbean cv. K 581 which was given 0 or 20 kg N/ha. The application of 20 kg N/ha significantly increased the seed yield from 1.08 (no nitrogen) to 1.14 t/ha.

In a field experiment conducted by Satyanarayanamma *et al.* (1996) in 1992-93 at Lam, Guntur, Andhra Pradesh, India, 5 mungbean cultivars were sprayed with 2% urea at pre-flowering, flowering, pod development or at all the combinations or two of three growth stages. They reported that spraying urea at flowering and pod development stages produced the highest seed yield of 1.59 t/ha.

Ahmed *et al.* (1986) conducted a field experiment to investigate the effect of various levels of phosphorus on the growth and yield performance of mungbean. They found that phosphorus application up to 60 kg/ha progressively and significantly enhanced the seed yield.

Patel *et al.* (1988) reported that application of 20 kg P_2O_5/ha to mungbean gave average seed yield of 0.75 t/ha compared with 0.57 t/ha without phosphorus. Yield was not further increased with 40 - 60 kg P_2O_5/ha. In 1986-88, Kalita *et al.* (1989) applied 30 kg P_2O_5/ha to mungbean that produced the seed yields of 0.900 - 0.960 t/ha compared with 0.590 - 0.680 t/ha with no phosphorus. Further increase in yield with 45 kg P_2O_5/ha was not significant.

In an experiment, carried out by Reddy *et al.* (1990) with three cultivars of mungbean in 1987, applying 0 or 50 kg P_2O_5/ha as a basal dressing or 50 kg P_2O_5/ha in two equal split dressings at the time of sowing and flowering, gave the average seed yield of 65.09, 99.56 and 108.61 g/m^2, respectively.

Thakuria and Saharia (1990) noted that Phosphorus levels significantly influenced the seed yield. The highest seed yield of 7.20 q/ha was recorded with the application of 20 kg P_2O_5/ha, which was at par with 40 and 60 kg P_2O_5/ha. In a field trial, Sarkar and Banik (1991) studied that increase in levels of P_2O_5 up to 60 kg/ha resulted in higher seed yield. They also found that increase in seed yield of mungbean due to 30 and 60 kg P_2O_5/ha was 51 and 93 percent over the control, respectively.

In a field experiment, during the summer seasons in 1987-88 at Baruipur Farm of Calcutta University, Sarkar (1992) studied that yield response of mungbean to phosphorus application (0, 40 or 80 kg P_2O_5/ha) was linear.

Tank *et al.* (1992) carried out a field experiment and reported that seed yield of mungbean were increased significantly up to the level of 40 kg P_2O_5/ha over the control. This was evidently attributed to higher number of pods/plant, pod length and test weight. Relative consistency in seed yield with an increase in P level from 40 to 80 kg/ha indicated that P level greater than 40 kg P_2O_5/ha may not be helpful for harvesting potential yield of summer mungbean.

Ardeshna *et al.* (1993) observed that significantly higher seed yields of mungbean (7.7 and 7.71 q/ha) were recorded at 40 and 60 kg P_2O_5/ha, respectively compared with 20 kg P_2O_5/ha (6.46 q/ha). Chovati *et al.* (1993) described that application of 40 kg P_2O_5/ha was at par with 60 kg P_2O_5/ha and resulted in significantly higher growth and seed yield of summer mungbean than 0 and 20 kg P_2O_5/ha. The response to Phosphorus fertilization could be ascribed to low P status of these soils.

In a field trial conducted by Borah (1994) at Shillongani, Assam, India, in the 1990-91 rainy seasons and applied 0 or 50 kg diammonium phosphate/ha on mungbean cv. ML-131. Results revealed that applied phosphorus did not affect the crop yield.

Kalita *et al*. (1989) conducted an experiment during the winter season of 1988 - 89 in India. Results reported that application of phosphorus significantly increased the seed yield of mungbean.

Bayan and Saharia (1996) carried out an experiment to study the effect of phosphorus on mungbean during the *Kharif* seasons of 1994 - 95 in Biswanath Chariali, Assam, India. The results indicated that seed yield was unaffected by phosphorus application.

Sharma and Sing (1997) conducted a field experiment in 1989 and 1990 in Uttar Pradesh, India, Mungbean cv. Pant Moong 2 was given 0,25, 50 or 75 kg P_2O_5/ha. It was found that seed yield increased with up to 50 kg P_2O_5 (1.22 t/ha).

Sharma and Sing (1997) carried out a field experiment during 1989 and 1990 to study the effects of various levels of phosphorus (0, 25, 50 and 75 kg/ha) on the growth, yield attributes and yield of mungbean. They found that application of phosphorus @ 50 kg/ha enhanced the seed yield significantly during both the years.

Karam *et al.* (1998) performed a field trial in 1986-88 at Kanpur, Uttar Pradesh, India. Mungbean cv. T 44 was intercropped with pigeonpea (*Cajanus cajan*) cv. T 21 with application of 0, 30, 60, or 90 kg P/ha. The best-combined yield was obtained by the application of 60 kg P/ha.

Singh and Ahlawat (1998) carried out 2-year experiment at the Indian Agricultural Research Institute, New Delhi, India, during 1986-87 on a sandy loam soil, low in organic carbon and N, and Medium in P and K and with a pH of 7.8. Results of their study indicated that P application to mungbean cv. PS 16 increased the seed yield up to 12.9 kg /ha.

Masthan *et al.* (1999) conducted a field experiment in 1991-93 at Hyderabad, Andhra Pradesh, India, and reported that yield of summer mungbean cv. LGG 127 increased with the increased phosphorus rate.

Raundal *et al.* (1999) carried out a field trial in *Kharif* (monsoon) season at Pune, Maharashtra, India, in 1997-98. Results of their experiment suggested that application of 60 kg P_2O_5/ha to mungbean significantly increased the seed yield (18.23 q/ha).

An experiment was conducted by Singh *et al.* (1999) on mungbean cv. NDM-1 at Faisabad, Uttar Pradesh, India in summer 1996. The crop was given 0 - 26.4 kg P/ha. Results of their study showed that seed yield of mungbean increased with up to 26.4 kg P/ha.

Ram and Dixit (2000) conducted a field experiment during summer 1987at Faisabad, Uttar Pradesh, India. Mungbean cv. K-851 was sown on 20 or 30 March or 9 April and given 0, 20, 40 or 60 kg P/ha. They reported that seed yield of mungbean was increased with increasing P rate.

Sadasivam *et al.* (1990) reported that mungbean cv. CO3 gave 809, 833, 870 and 890 kg seed/ha with no K, 25 kg K_2O/ha and 1% K_2SO_4 spray at the flowering, respectively. The greatest responses came from the application as foliar sprays.

In a field trail, conducted by Sangakkara (1990), 0 - 120 kg K_2O/ ha was applied as basal dressings or split applications (60: 40 at the planting and flowering time) and the growth and yield parameters of mungbean cv. MI 5 and Type 61 were studied. Potassium application did not affect the germination of seeds and seedling establishment but it increased the seed yield /plant.

Dinata *et al*. (1992) studied the response of mungbean varieties cv. MLG 944 and MLG 648 to potassium fertilizer from April to June 1989 in Kuta, Badung (Bali). The potassium content in the soil was low. The potassium doses were 0, 12.5, 25, 37.5 50 and 75 kg K_2O/ha, respectively, There was no significant effect of potassium on the seed yield of MLG 944 and MLG 648 (1.9 and 1.5 t/ha, respectively).

Raju and Varma (1984) reported that application of 15 - 60 kg N/ha significantly increased seed yields of mungbean.

Results of an experiment, conducted by Sardana and Verma (1987) in Delhi, India, revealed that the application of nitrogen, phosphorus and potassium fertilizers in combination resulted in the significant increase in seed yield of mungbean.

Patel *et al*. (1992) conducted a field trial to evaluate the response of mungbean to sulphur fertilization under different levels of nitrogen and phosphorus. Greengram cv. Gujrat 2 K 851 were given 10 kg N + 20 kg P/ha, 20 kg N + 40 kg P/ha and 0, 10, 20 or 30 kg S/ha as gypsum. Seed yield was 1.2 and 1.24 t /ha in Gujrat 2 and K 851, respectively with 20 kg N + 40 kg P/ha.

Phimsirkul (1992) conducted a field trial on mungbean variety with U-Thong 1 grown in different soils under varying N levels. Results revealed that there was no effect of N fertilizer when mungbean was grown in Mab Bon soil. However, seed yield of mungbean was increased when the crop received N at 30 kg/ha.

Sing and Singh (1993) examined the effects of varying levels of N on mungbean cv. MH-85-61. They found that nitrogen application at the rate of 30 kg N resulted in the highest seed yield in mungbean.

Bachchhav *et al.* (1994) conducted a field experiment during the summer season with greengram cv. Phule-M. They observed that among nitrogen fertilizers rates seed yield increased with 30 kg N/ha.

Kaneria and Patel (1995) conducted a field experiment on a Vartisol soil in Gujarat, India with mungbean cv. K 581 using 0 or 20 kg N/ha levels. They found that application of 20 kg N/ha significantly increased the seed yield (1.14 t/ha) when compared with that of control (1.08 t/ha).

In a field experiment conducted by Satyanarayanamma *et al.* (1996), five mungbean cultivars were sprayed with 2% urea at pre-flowering, flowering, pod development or at all the combinations or at combination of two of three growth stages. They reported that spraying urea at flowering and pod development stages produced the highest seed yield.

Karle and Pawar (1998) examined the effect of varying level of N and P fertilizers on summer mungbean. They reported that mungbean produced higher seed yield with the application of 15 kg N/ha and 40 kg P_2O_5/ha.

A field experiment was carried out by Sharma and Sharma (1999) during summer seasons at Golaghat, Assam, India. Mungbean was grown using farmers practices (no fertilizer) or using a combinations of fertilizer application (30 kg N + 35 kg P_2O_5/ha). Seed yield was 0.400 t/ha with farmer's practices, while the highest yield was obtained by the fertilizer application (0.770 t/ha).

Mandal and Sikder (1999) conducted a greenhouse pot experiment on mungbean cv. BARI Mung-5 under different N rates (0, 20 and 30 kg/ha). They noted that the seed yield increased (700, 800 and 900 kg/ha) significantly with increased N application.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different nitrogen levels on mungbean at the Agronomic Research Station, Farooqabad in Pakistan. They revealed that seed inoculation + 50-50-0 NPK kg/ha exhibited superior performance in respect of seed yield (955 kg/ha).

Malik *et al*. (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25 and 50 kg/ha) and phosphorus (0, 50,75 and 100 kg/ ha) on the yield and quality of mungbean cv. NM-98. Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 P_2O_5 kg/ha resulted in maximum seed yield (1112.96 kg/ha).

Mozumder *et al*. (2003) conducted an experiment to study the effect of different nitrogen levels viz. 0, 20, 40, 60 and 80 kg N/ha on Binamoog-2 and they observed that increase of nitrogen fertilizer increased seed yield up to 40 kg N ha-1 and that was 1607 kg/ha.

Rajender *et al*. (2003) investigated the effects of N (0, 10, 20 and 30 kg/ha) and P (0, 20, 40 and 60 kg/ha) fertilizer rates on mungbean genotypes MH 85-111 and T44. Grain yield increased with increasing N rates up to 20 kg ha^{-1}. Further increase in N did not affect yield.

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

Ivanov *et al*. (1987) studied the influence of nitrogen, phosphorus and potassium on spacing and soil moisture content on commercial green bean production. Increasing nitrogen rates increased pod yields. A higher pod yield (fresh) of 22840 kg/ha was obtained with N: P_2O_5: K_2O at the ratio of 150: 100: 100 kg/ha with 150 cm^2 of growing space per plant and at 75% of Soil Moisture Capacity (SMS).

Lixandru *et al.* (1984) stated that application of 60 kg N + 60 kg P_2O_5/ha before sowing to *Phaseolus vulgaris* increased yield by 550 kg/ha compared with the unfertilized or nitrogen treated control. The soil contained 150 - 200 ppm potassium and with further potassium application had a negative effect on plant growth. Application of 60 kg P_2O_5/ha increased grain crude protein content to 10%, compared with 13% by 90 kg nitrogen and 30 kg P_2O_5. In drought years, grain yields were reduced, but grain crude protein content was increased. Optimum fertilizer rates were 103 - 127 kg nitrogen, 10.5 kg P_20_5 and 75 - 95 kg K_2O/ha.

Mauro and Vieira (1975) reported that in the rainy season an increase in NPK rates from 20:60:10 to 40: 120: 20 kg/ha had a beneficial effect on bean yield.

Souza *et al.* (1973) studied the effect of nitrogen, phosphorus and potassium on the production and nutritive value of beans (*Phaseolus valgaris* L.) and found the highest yield with 40 kg nitrogen and 60 kg or 120 kg P_2O_5/ha. Potassium alone or in combination had no effect on yield. Crude protein content was increased from 18.5 to 23.8%.

Naik (1989) carried out an experiment with garden pea (*Pisum sativum* L.) applying nitrogen @ 25-75, P_2O_5 @ 25-100 and K_2O @ 25-50 kg/ha. The highest rates of nitrogen and phosphorus application resulted in the highest yields but no appreciable response to potassium was observed.

Pachuri *et al.* (1998) conducted an experiment in 2 year trials with the garden pea cultivar Lincoln. He applied N at 0, 37.5 or 75 kg /ha; P_2O_5 at 0, 75 or 175 kg/ha and K_2O at 0, 50 and 100 kg/ha. The highest seed yield was obtained in plants receiving N: P_2O_5: K_2O at 75: 150: 50 kg/ha

Michaloje (1997) studied the effect of N (0, 20 or 40 kg/ha) and K (0, 150 or 300 kg K_20/ha) on the yield and chemical composition of broad bean. The highest seed yield and best quality was obtained by applying 40 kg N and 150 kg K_2O/ha.

2.1.10 Harvest index

Harvest index is the ratio of economic yield to the biological yield as reflected by the translocation of assimilates to the grain.

Mozumdar *et al.* (2003) conducted a field experiment at the Bangladesh Agricultural University, Mymensingh. They tested five levels of nitrogen (0, 20, 40, 60 and 80 kg/ha) and two varieties of summer mungbean viz., Binamoog-2 and Kanti. Results revealed that nitrogen application had negative affect on the harvest index in both the varieties.

2.2 Source - sink relations: manipulations through leaf clipping

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

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

Studies of Chawdhury *et al*, (1982) indicated seasonal variations in leaf photosynthetic rates in mungbean. Net photosynthetic rate during the post flowering phase was higher which might be related with the sink demand. Rao and Ghildyal (1993) showed that the leaf photosynthetic rate in mungbean was the maximum after 28 days of sowing and decreased subsequently.

Genotypic differences in leaf area development in mungbean have been reported (Hamid *et al*., 1990). However, the optimum leaf area index for maximizing yield or biomass production has not been reported. Patel *et al*., (1982) 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.

There seems to be limited studies on the alteration of source sink relations of mungbean either in Bangladesh or elsewhere. Clifford (1979) suggested that removal of apical shoot above node 5 or removal of inflorescence or axillary buds at nodes 1-4 together with the apical shoot greatly increased pod number and seed weight of mungbean. Hamid (1989) showed that defoliation at the reproductive stage reduced pod set and grain yield, and the reduction was proportional to the degree of defoliation.

Defoliation affected leaf photosynthetic rates in a number of crop species. Mariko and Hogetsu (1987) reported that defoliated sunflower plants showed higher rates of photosynthesis than those of undefoliated plants. Defoliation tends to influence the ageing of the remaining or new leaves. 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 for mungbean also the partioning of dry matter seemed to be more favorable for increasing harvest index. Genotypes of a number of crop species with profuse branching often show poor harvest index in spite of high dry matter yield. In such genotypes, retention of dry matter in vegetative organs is high and is reflected by its poor harvest index. Hamid (1994) demonstrated that the development of tertiary branches and much of the secondary branches in mungbean is counter productive. Therefore, mungbean plant types with a maximum of two to three erect branches having shorter and thicker internodes and basal podding might be desirable for high yield potential. The hypothesis is subject to be tested by regulating source sink capacity.

Partioning of assimilate is generally dependent on the sinks closest to the source. For example, upper leaves export photosynthesis to the shoot apex, lower leaves to roots and middle leaves to both (Wardlaw, 1968).

However since phloem sieve connections are on one side of the stem, the leaves on one side may be more efficient at exporting assimilate to sinks on the same side. This has been shown in many crops (Wardlaw, 1968).

According to the mass flow hypothesis, anything increasing photosynthesis, increase hydrostatic pressure and translocation rate. However, this is trce only if sinks have the ability to utilize the increased production. Otherwise, there would be a steady build up of sugars in the system, causing a feed back inhibition resulting in reduced photosynthesis (Mondal *et al.*, 1978).

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

Some meristems are in more favorable positions to intercept assimilate. For example the intercalary meristems of leaves are in a better position to intercept translocated assimilate than are the peripheral root and shoot meristems (Evans and Wardlaw, 1976).

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 (Labanauskas and Dungan, 1956).

Partitioning has been extensively studied in small grain crops. Work in wheat and barley has shown that photosynthesis of the flag leaf, stem and head which are the closest sources to the grain is the primary contributor to the grain. Lower leaves supply the needs of lower stem and roots (Lubton, 1966; Wardlaw, 1968).

The strength of the grain as a sink and the relative availability and strength of sources affect the assimilate partitioning. If the top leaves are removed, the lower leaves will supply assimilate to the grain; if the lower leaves are removed the flag leaf will transport assimilate to roots (Marshall and Wardlaw, 1973).

In soybean, in which almost every node provides seed growth and development. The pattern of translocation from each leaf is similar. The greatest amount of assimilate remains with the pods at the node of the applied leaf, with the rest transported to upper nodes and lower nodes. Lower light levels reducing the amount of assimilate produced (Shibles *et. al*, 1975).

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

In two separate experiments, Williams *et al.* (1976) and Mercer (1976) found reduced pod growth rate, pod yield, pod and seed number following the defoliation in groundnut (*Arachis hypogea L.*).

Hamid *et al.* (1991) stated that removal of leaves after anthesis did not result in yield reduction in rapeseed (*Brassica campestris L.*). They found that there were significant reduction in siliqua number per plant due to defoliation and as branches where usually formed during the pre-anthesis stage, therefore it was expected that the number of branches per plant would be unaltered due to defoliation.

Bardhan *et al.* (1988) also reported that leaf cutting in rice at different growth stages did not affect the grain yield. Grain yields in single cut and uncut crops were similar. Yields in double cut crop were higher. It was also found that first cut produced 3.8 t green leaves/ha and the second cut 20 days after the first cut produced 3.4 t green leaves/ha. Grain yield/plant and grain to straw ratio also increase. But, Plant height, total grains/panicle and length of panicle were reduced due to leaf clipping.

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

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

Dann (1968) reported that clipping at vegetative stage decreased the straw and grain yields in wheat. 1000-grain weight was the major yield component which was reduced by clipping. However, highly significant correlations were obtained between dry matter removed by clipping, 1000-grain weight and grain yield.

Stoy (1966) stated that in wheat, defoliation of the flag leaf and two upper leaves at ear emergence significantly reduced both straw and grain yield.

CHAPTER 3
MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

The details of methodology followed to find out the effect of leaf clipping and different fertilizers doses on growth and yield of mungbean seed have been presented in this chapter.

3.1 Site description

3.1.1 Geographical location

The experimental area was situated at $23^{0}77$'N latitude and $90^{0}33$'E longitude at an altitude of 8.6 meter above the sea level.

3.1.2 Agro-Ecological zone

The experimental field belonged to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur tract leaving small hillocks of red soils as islands surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Soil

Initial soil samples from 0 -15 cm depth were collected from experimental field. The collected samples were analyzed at Soil Resources Development Institute (SRDI), Dhaka, Bangladesh. The physio-chemical properties of the soil are presented in Appendix II.

3.1.4 Weather condition of the experimental area

Details of the meteorological data related to the temperature, relative humidity, rainfall and sunshine during the period of the experiment was collected from Bangladesh meteorological Department, Dhaka and presented in Appendix III.

3.2 Source of seed

The seeds of mungbean variety BARI mung-6 were collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

3.3 Fertilizer application

Fertilizer was applied in the experiment as per treatment where N, P_2O_5, and K_2O were applied (in the form of urea, TSP and MP respectively) as basal dose during final preparation.

3.4 Experimental design and lay out

The experiment a factorial one and was laid out in a randomized complete block design (RCBD). Each treatment was replicated three times The size of each plot was 3m × 2m. The distance between two adjacent replications (block) was 1.0 meter and plot-to plot distance was 0.75 meter. The intra block and plot spaces were used as irrigation and drainage channels. A layout of the experiment has been shown in Appendix IV.

3.5 Treatments of the experiment

Leaf clipping treatments:

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

Fertilizer treatments:

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

As such there were twelve treatment combinations as follows:

C_0F_1= No removal + (10 Kg N +20 kg P_2O_5+15 kg K_2O/ha)

C_0F_2= No removal + (20 kg N+ 40 kg P_2O_5 +30 kg K_2O/ha)

C_0F_3= No removal + (30 kg N+ 60 Kg P_2O5+ 45 kg K_2O/ha)

C_1F_1= Removal of new leaves developed- after first flowering + (10 Kg N + 20 kg P_2O_5+15 kg K_2O/ha)

C_1F_2= Removal of new leaves developed- after first flowering + (20 kg N+ 40 kg P_2O_5 +30 kg K_2O/ha)

C_1F_3= Removal of new leaves developed- after first flowering + (30 kg N+ 60 Kg P_2O5+ 45 kg K_2O/ha)

C_2F_1= Removal of subtending leaves + (10 Kg N +20 kg P_2O_5+15 kg K_2O/ha)

C_2F_2= Removal of subtending leaves + (20 kg N+ 40 kg P_2O_5 +30 kg K_2O/ha)

C_2F_3= Removal of subtending leaves + (30 kg N+ 60 Kg P_2O5+ 45 kg K_2O/ha)

C_3F_1= Removal of empty leaves + (10 Kg N +20 kg P_2O_5+15 kg K_2O/ha)

C_3F_2= Removal of empty leaves + ((20 kg N+ 40 kg P_2O_5 +30 kg K_2O/ha)

C_3F_3= Removal of empty leaves + (30 kg N+ 60 Kg P_2O5+ 45 kg K_2O/ha)

3.6 Leaf clipping

Leaf clipping of subtending and empty leaves was done after first flowering by removal the whole leaf with the help of a knife. New leaves above the first flowering inflorescence were removed continuously when ever those were opened.

3.7 Sowing of seeds

Seeds were sown on 29 March, 2007 by hand. Mungbean seeds were sown in line maintaining line to line distance of 30 cm.

3.8 Thinning

The thinning was done 15 days after sowing maintaining plant to plant distance of 10 cm.

3.9 Intercultural operations

3.9.1 Weeding

The experimental crop was found to be infested with weeds of different kinds which were controlled manually by nirani. Weeding was done two times; 15 and 25 days after sowing.

3.9.2 Application of insecticides

The mungbean plants were infested at seedling stage by cutworm and at vegetative stage by hairy caterpillars. They were controlled by spraying Nogos and Savin-85 SP respectively, as per recommendation. Irrigation was given as per necessity of the crop.

3.10 Harvesting

Mungbean pods were harvested on 9 June, 2007. Ten plants from each plot were selected at random before harvesting and were uprooted for data recording. The harvested pods were dried in sun for consecutive three days.

3.11 Threshing

The pods were threshed by a bamboo stick and seeds were separated from the plants.

3.12 Drying

The separated seeds were dried in sun for consecutive three days.

3.13 Cleaning and weighing

The threshed and dried seeds were cleaned by using a winnower.

3.14 General observations

The crop was frequently monitored to note any change in plant characters. The crop looked promising since the initial stage and it maintained a satisfactory growth till harvest.

3.15 Determination of maturity

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

3.16 Recording of data

Different growth and yield data were recorded from the experiment.

Data were recorded on the following parameters:

i. Plant height
ii. Leaf area
iii. Number of seeds per pod
iv. 1000- seed weight
v. Grain weight per hectare
vi. Harvest index
vii. Dry weight of leaflets
viii. Dry weight of inflorescence
ix. Dry weight of steam
x. Dry weight of roots

3.17 Procedure of data collection

3.17.1 Plant height

The heights of ten plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm at 20, 30, 40, 50 and 60 days after sowing.

3.17.2 Number of seeds per pods

The number of seeds in each pod was also recorded from ten randomly selected pods at the harvest

3.17.3 Weight of 1000-seed

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

3.17.4 Grain yield/ha

The seeds collected from 1 m^2 of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}.

3.17.5 Stover yield

The sum of the plant parts (leaves dry weight, stem dry weight and pod shell dry weight) constituted the Stover dry weight. The plants collected from 1 m^2 of each plot were oven at 72 C for 72 hours dried properly. The weight (in gram) of these plants was taken at the harvest which was then converted into t/ha.

3.17.6 Harvest index (%)

The harvest index was calculated by using the following formula

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Analysis of data

The data collected on different parameters were statistically analyzed using the MSTAT- computer package program. The means were compared following least significance deference (LSD) test at 0.05 levels of significance.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER 4
RESULTS AND DISCUSSION

As mentioned in the pervious chapter, the effect of four levels of leaf clipping and three levels of fertilizer dose on the productivity of mungbean were studied in this part of the experiment. The results on morphological characters, yield contributing characters and yield are presented and discussed in this chapter.

4.1 Plant height (cm)

Leaf clipping had a significant effect on plant height (Table 1). It was observed that C_3 showed that the highest plant height at 20, 30 and 40 DAS. C_1 at 20 and 50 DAS gave same results, but C_0 at 20 DAS, C_0 and C_1 at 30 and 40 DAS also gave the statistically similar results. At 60 DAS at all treatments showed statistically similar results. Removal of subtending levels at the post flowering stage (C_2) reduced plant height at 20, 30, 40 and 50 DAS.

The plant height varied significantly among the fertilizer doses (Table 1). At all the growth stages, the highest plant height was shown by F_2 treatment and the shortest plant height was obtained by F_1 treatment. At 20 and 40 DAS, F_3 showed the statistically similar result with F_2. But in 40, 50 and 60 DAS it was observed that F_1 and F_2 gave the same results. At 60 DAS, the treatment 20 kg N + 40 kg P_2O_5 + 30 kg K_2O (F_2) produced the tallest plant (56.96 cm) which significantly differed with the rest. The plot applied with 10 kg N + 20 kg P_2O_5 + 15 kg K_2O/ha (F_1) produced significantly the shortest plant (55.29 cm) which was statistically similar with F_3 treatment.

The interaction effect of leaf clipping and fertilizer dose on plant height was statistically significant and shown in Table 2. At 20 DAS, C_3F_2 showed the maximum height (17.92 cm) which was not significantly different than C_1F_3. The shortest plant height (11.08 cm) was obtained with C_2F_1 which was similar with C_2F_3 treatment. At 30 DAS, C_3F_2 showed the highest plant height (39.42 cm) and the lowest plant height (23.34 cm) was obtained by C_2F_1 treatments. At 40 DAS, the highest plant height (51.30 cm) obtained by C_3F_2 and the lowest plant height (42.64 cm) was obtained from C_2F_1 which, however, was similar with C_2F_2 and C_2F_3 treatments. At 50 DAS, the tallest plant height (56.31 cm) was showed by C_3F_2 treatment and the lowest plant height (47.38 cm) was obtained by C_2F_1 treatment. At 60 DAS, the tallest height (58.55 cm) was showed by C_3F_2 which was similar with C_1F_2 treatment and the shortest plant height (50.70 cm) was obtained by C_2F_1.

Table-1: Plant height (cm) of mungbean cv.BARI mung-6 at different days after sowing as influenced by leaf clipping and fertilizer doses

Treatments	Days after sowing (DAS)				
	20	30	40	50	60
Leaf clipping (C)					
C_0	13.93	30.68	45.79	51.49	55.51
C_1	14.26	30.17	47.60	53.50	55.55
C_2	13.59	29.48	44.72	50.63	55.50
C_3	14.66	33.48	48.74	53.52	56.74
$LSD_{0.05}$	0.657	2.841	3.302	1.397	NS
Fertilizer (F)					
F_1	13.88	29.84	45.52	51.64	55.22
F_2	14.39	32.52	48.77	53.00	56.96
F_3	14.06	30.50	45.84	52.22	55.29
$LSD_{0.05}$	0.435	2.326	2.860	1.210	1.355

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

Table-2: Plant height (cm) of mungbean cv. BARI mung-6 at different days after sowing as influenced by the interaction of leaf clipping and fertilizer doses

Interaction (CxF)	Days after sowing (DAS)				
	20	**30**	**40**	**50**	**60**
C_0F_1	12.57	29.16	44.47	51.08	54.90
C_0F_2	13.47	30.12	46.15	52.03	56.22
C_0F_3	13.56	30.08	45.47	53.42	55.22
C_1F_1	15.62	32.86	50.63	55.24	57.55
C_1F_2	17.20	33.45	50.15	53.65	58.55
C_1F_3	14.95	31.65	50.11	53.29	57.16
C_2F_1	11.08	23.34	42.64	47.38	50.78
C_2F_2	12.50	28.20	43.42	49.65	53.89
C_2F_3	11.30	27.58	43.00	48.53	52.66
C_3F_1	13.60	32.82	46.69	53.06	56.83
C_3F_2	17.92	39.42	51.30	56.31	58.94
C3F3	15.57	32.76	46.50	53.80	57.17
$LSD_{0.05}$	2.869	6.652	5.720	2.419	4.709
CV (%)	8.13	7.31	9.42	6.58	10.28

C_0 = No removal
C_1 = Removal of new leaves developed after first flowering
C_2 = Removal of subtending leaves (at the base of each inflorescence)
C_3 = Removal of empty leaves (from the nodes having no inflorescence)
F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha
F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha
F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/h

✓4.2 Leaf area (cm^2)

Leaf area was affected significantly due to the leaf clipping (Table 3). It was observed that Co showed the highest leaf area at 20, 30, 40, 50 and 60 DAS and the lowest leaf area was obtained by C_3 treatment at all the stages. At 30 DAS, C_2 gave same leaf area. At 20 and 60 DAS, C_1 and C_2 gave statistically similar results and at 40 and 50 DAS C_1 and C_3 also gave similar results.

The effect of various fertilizer treatments were significant in respect of leaf area at 30, 40, 50, 60 DAS and at harvest (Table 3). Significantly the highest leaf area (1297.0 cm) was observed with F_2 at 60 DAS but at the same DAS, the lowest leaf area (834.4 cm) was obtained with F_1. The highest leaf area with F_2 might be attributed due to increased growth which was probably favored by the balanced fertilization. At 20, 30 and 50 DAS, F_2 and F_3 gave similar leaf area but F_1 showed the lowest leaf area at 20, 30, 40, 50 and 60 DAS.

The interaction effect of fertilizer dose and leaf clipping on leaf area was statistically significant (Table 4). At 20 DAS, C_0F_2 showed the highest leaf area (137.30 cm^2) which was similar with C_0F_1 and C_oF_3 treatments and the lowest leaf area (51.00 cm^2) which obtained by C_3F_1 treatment. At 30 DAS, C_0F_2 showed the highest leaf area (477.0 cm^2) which was statistically similar with C_oF_3, the lowest value (286.2 cm^2) was obtained by C_3F_1.

At 40, and 50 DAS, the highest leaf area (1246.0 cm^2 and 913.7 cm^2 respectively) was obtained by C_0F_2 and the lowest values (311.2 cm^2 and 254.6 cm^2 respectively) were obtained by C_3F_1 which was statistically similar with C_3F_3. At 60 DAS, C_0F_2 showed the highest leaf area (1826.0 cm^2) and the lowest leaf area (586.10 cm^2) was shown by C_3F_1 which was statistically similar with C_1F_1, and C_3F_3.

Table 3: Leaf area (cm^2) of mungbean cv. BARI mung-6 at different days after sowing as influenced by leaf clipping and different fertilizer doses

Treatments	Days after sowing (DAS)				
	20	30	40	50	60
Leaf clipping (C)					
C_0	122.1	400.2	977.4	746.9	1350.0
C_1	104.2	345.9	449.0	382.1	931.60
C_2	101.5	394.1	812.1	685.5	998.90
C_3	84.33	307.9	443.9	344.1	849.00
$LSD_{0.05}$	12.13	19.69	55.93	55.67	89.26
Fertilizer (F)					
F_1	91.94	324.6	637.4	481.30	834.4
F_2	109.0	383.0	717.4	587.10	1297.0
F_3	108.1	378.6	657.4	550.50	965.5
$LSD_{0.05}$	10.51	17.06	48.44	48.21	77.30

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

Table 4: Leaf area (cm^2) of mungbean cv. BARI mung-6 at different growth stages as influenced by the interaction of leaf clipping and fertilize doses

Interaction (CxF)	Days after sowing (DAS)				
	20	30	40	50	60
C_0F_1	129.80	419.3	855.4	735.8	1562.0
C_0F_2	137.30	477.0	1246. 0	913.7	1826.0
C_0F_3	131.00	455.3	893.6	831.2	1709.0
C_1F_1	98.77	312.3	487.9	415.4	661.8
C_1F_2	99.08	331.4	539.2	458.1	898.6
C_1F_3	98.10	331.7	494.4	433.5	820.2
C_2F_1	103.6	374.7	817.7	495.8	942.0
C_2F_2	117.9	376.8	830.7	700.9	1076.0
C_2F_3	103.2	368.5	725.0	619.8	1019.0
C_3F_1	51.00	286.2	311.2	240.9	586.1
C_3F_2	87.36	308.2	481.3	376.1	657.9
C_3F_3	79.07	303.3	364.8	254.9	629.5
$LSD_{0.05}$	21.01	34.11	96.88	96.42	154.6
CV (%)	12.14	9.25	10.16	13.69	9.78

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

4.3 Leaf dry weight/plant

Leaf dry weight/plant was affected significantly due to leaf clipping (Table 5). It was observed that Co gave the highest leaf dry weight / plant. At 20 DAS, the treatments C_o, C_2 and C_3 gave statistically similar results. At 40 DAS, C_1 gave same result as was found with C_o. The lowest value (3.324 g/plant) obtained by C_2. At 60 DAS, C_1 and C_3 gave similar result but the lowest leaf dry weight (5.143 g/plant) was obtained by C_2.

The effect of various fertilizer treatments were significant in respect of leaf dry weight/plant at 30, 40, 50, 60 DAS (Table 5). It was observed that F_2 gave the highest leaf dry weight g/plant at 20, 40, 50 and 60 DAS. But at 20 DAS, there were no significant differences among F_1, F_2 and F_3. At 40 DAS, F_3 (4.192 g/plant) gave statistically similar result with F_2 (5.059 g/ plant) and the lowest value (3.317g/plant) was obtained by F_1. At 50 and 60 DAS similar results were shown by F_1 and F_3. The highest dry matter of F_2 might be attributed due to increased celluar activity favoured by balanced nutrition which also increased the accumulation of higher dry matter in leaf.

The interaction effect of fertilizer dose and leaf clipping on leaf dry weight/plant was statistically significant (Table 6). At 20 DAS, C_oF_2 showed the highest leaf dry weight/plant (5.057 g). The lowest dry weight /plant (1.673 g) was statistically similar with C_2F_2, C_2F_3, C_3F_1 and C_3F_3. At 40 DAS, C_oF_2 showed the highest leaf dry weight/plant (6.017g) which was similar with C_1F_2. The lowest value (2.407 g/plant) was obtained by C_2F_1 which was similar with C_2F_3. At 50 DAS, C_oF_2 gave the highest value (6.370 g/plant) which was statistically similar with C_1F_2. The lowest value (2.357 g/plant) was obtained by C_2F_1. At 60 DAS C_oF_2 gave the highest dry leaf weight/plant (8.787g) and the lowest value (5.633 g/plant) was obtained by C_2F_1.

✓Table 5: Dry weight of leaflets (g/plant) of mungbean BARI mung-6 at different days after sowing as influenced by leaf clipping and fertilizer doses

Treatments	Days after sowing (DAS)			
	20	40	50	60
Leaf clipping (C)				
C_0	4.489	4.923	5.316	7.764
C_1	2.772	4.628	5.227	7.156
C_2	2.207	3.470	3.324	5.143
C_3	2.396	3.736	3.970	6.952
$LSD_{0.05}$	0.8923	0.381	0.3697	0.4533
Fertilizer (F)				
F_1	2.605	3.317	4.134	6.515
F_2	3.400	5.059	4.863	7.099
F_3	2.892	4.192	4.381	6.648
$LSD_{0.05}$	NS	1.196	0.3202	0.3926

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

✓**Table 6:** Dry weight of leaflets (g/plant) of mungbean BARI mung-6 at different days after sowing as influenced by the interaction of leaf clipping and fertilizer doses

Interaction (CxF)	Days after showing (DAS)			
	20	40	50	60
C_0F_1	3.333	4.877	4.397	7.867
C_0F_2	5.067	6.017	6.370	8.787
C_0F_3	3.420	4.683	5.383	7.997
C_1F_1	4.980	5.123	5.407	7.227
C_1F_2	4.053	5.553	6.093	8.077
C_1F_3	2.793	4.053	4.203	7.067
C_2F_1	1.673	2.407	2.357	5.633
C_2F_2	1.780	3.320	3.767	5.813
C_2F_3	1.693	2.707	3.220	3.767
C_3F_1	2.073	3.377	3.767	5.850
C_3F_2	2.570	4.277	4.377	6.430
C_3F_3	2.153	3.877	4.170	6.533
$LSD_{0.05}$	1.545	2.392	0.6403	0.7852
CV (%)	5.32	6.14	8.92	7.59

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1= 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2= 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3= 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

4.4 Stem dry weight/plant

Stem dry weight/plant was affected significantly due to leaf clipping (Table 7). It was observed that C_3 showed the highest stem dry weight/plant at 20, 40, 50 and 60 DAS. At 20 DAS, C_0 and C_2 gave the similar result as was obtained by C_3. The lowest value (2.283 g/plant) was obtained by C_1. At 40 DAS, C_0, C_1 and C_3 gave statistically similar results. At 50 DAS, the highest value (4.588g/plant) was obtained by C_3 which was also similar with C_1. The lowest dry weight/plant (3.812 g) was obtained by C_2. At 60 DAS, the highest value (8.319g/plant) was obtained by C_3 which was similar with C_0 and C_1. The lowest value (5.357g/plant) was obtained by C_2.

The effect of various fertilizer treatment was significant in respect of stem dry weight/plant at 30, 40, 50, 60 DAS (Table 7). At 20 DAS, there were no significant differences with F_1, F_2 and F_3. At 40 DAS, highest stem dry weight/plant (4.441g) was obtained by F_2 and the lowest (3.258 g) was obtained by F_1 and it was statistically similar with F_3. At 50 DAS, the highest value (4.606 g) was obtained by F_2 and the lowest value (3.948 g) was obtained by F_3 which was similar with F_1. Significantly the highest stem dry weight/plant (7.666 g) was observed at 60 DAS with F_2 but at the same DAS, the lowest leaf dry weight/plant (6.977 g) was obtained with F_1. The highest dry matter in the stem at F_2 might be attributed due to lack of subtended leaves which increase which would have used the benefit of balanced nutrition.

The interaction effect of fertilizer dose and leaf clipping on stem dry weight/plant was statistically significant (Table 8). At 20 DAS, the highest stem dry weight/plant (3.910g) was obtained by C_3 F_2 which was statistically similar with C_1F_1 and C_1F_2. At 40 DAS, the highest value (4.783 g/plant) was observed by C_3F_2 which was similar to C_1F_2. The lowest value (2.517 g/plant) was obtained by C_2F_1 which was similar with C_2F_2. At 50 DAS, the highest dry weight/plant (5.450g) was obtained by C_3F_2 and the lowest (3.070g/plant) by C_2F_1. At 60 DAS, the highest stem dry weight/plant (10.69 g) was obtained from C_3F_2 and the lowest (5.900 g) from C_2F_1.

Table 7: Dry weight of stem (g/plant) of mungbean BARI mung-6 at different days after sowing as influenced by leaf clipping and fertilizer doses

Treatments	Days after sowing (DAS)			
	20	40	50	60
Leaf clipping (C)				
C_0	2.660	3.306	4.068	7.568
C_1	2.283	3.612	4.499	7.872
C_2	2.608	3.302	3.812	5.357
C_3	3.122	4.417	4.588	8.319
$LSD_{0.05}$	0.542	0.7381	0.4596	0.604
Fertilizer (F)				
F_1	2.474	3.258	4.171	6.977
F_2	2.816	4.441	4.606	7.666
F_3	2.715	3.278	3.948	7.193
$LSD_{0.05}$	NS	0.6392	0.3980	0.5389

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

Table 8: Dry weight of stem (g/plant) of mungbean BARI mung-6 at different days after sowing as influenced by the interaction of leaf clipping and fertilizer doses

Interaction (CxF)	Days after sowing (DAS)			
	20	40	50	60
C_0F_1	2.570	2.960	4.017	6.843
C_0F_2	2.487	3.527	4.357	7.040
C_0F_3	2.283	3.113	4.180	6.477
C_1F_1	3.157	4.030	4.350	7.230
C_1F_2	3.390	4.573	4.840	9.687
C_1F_3	2.383	3.833	4.213	7.087
C_2F_1	1.737	2.517	3.070	5.693
C_2F_2	2.047	2.527	3.957	6.390
C_2F_3	2.067	2.827	3.470	5.900
C_3F_1	3.067	4.647	4.443	8.143
C_3F_2	3.910	4.783	5.450	10.69
C_3F_3	2.923	4.573	4.553	8.170
$LSD_{0.05}$	1.805	1.278	0.7960	2.778
CV (%)	8.71	9.41	6.59	10.12

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

4.5 Root dry weight/plant

Root dry weight/plant was not so affected due to leaf clipping (Table 9). At 20, 40 and 50 DAS there were no significant effect by leaf clipping but at 60 DAS it was shown that the highest dry weight of roots/plant (2.213g) was obtained by C_3 which was similar with C_0 and C_1. The lowest dry weight /plant (1.940g) was obtained by C_2.

The effect of various fertilizer treatments were not so significant effect (Table 9). At 20, 40, 50 and 60 DAS was effect on root dry weight not significant.

The interaction effect of fertilizer dose and leaf clipping on root dry weight/plant was significant (Table 10). At 20, 40 and 50 DAS, root dry weight was shown on significant effects. At 60 DAS, the highest dry weight/plant (2.49g) was obtained by C_3F_2 which was similar with C_3F_1. The lowest value (1.79 g/plant) obtained by C_2F_1.

Table 9: Dry weight of roots (g/plant) of mungbean BARI mung-6 at different days after sowing as influenced by leaf clipping and fertilizer doses

Treatments	Days after sowing (DAS)			
	20	**40**	**50**	**60**
Leaf clipping (C)				
C_0	0.5933	0.6967	0.8289	2.180
C_1	0.7244	0.7000	0.8411	2.201
C_2	0.5900	0.6778	0.8222	1.940
C_3	0.7311	0.9044	1.196	2.213
$LSD_{0.05}$	NS	NS	NS	0.5009
Fertilizer (F)				
F_1	0.6408	0.7675	0.8700	2.077
F_2	0.7183	0.8242	0.9592	2.267
F_3	0.6200	0.7258	0.8533	2.057
$LSD_{0.05}$	NS	NS	NS	NS

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

Table 10: Dry weight of roots (g/plant) of mungbean cv. BARI mung-6 at different days after sowing as influenced by the interaction of leaf clipping and fertilizer doses

Interaction (CxF)	Days after showing (DAS)			
	20	40	50	60
C_0F_1	0.63	0.67	0.81	2.02
C_0F_2	0.67	0.70	0.84	2.15
C_0F_3	0.62	0.67	0.82	1.98
C_1F_1	0.70	0.77	0.93	2.24
C_1F_2	0.80	0.83	0.96	2.39
C_1F_3	0.66	0.70	0.87	2.17
C_2F_1	0.46	0.64	0.81	1.79
C_2F_2	0.47	0.62	0.75	1.97
C_2F_3	0.49	0.66	0.79	1.82
C_3F_1	0.79	0.83	0.96	2.36
C_3F_2	0.84	0.87	1.89	2.49
C_3F_3	0.71	0.79	0.87	2.21
$LSD_{0.05}$	NS	NS	NS	0.998
CV (%)	8.33	7.45	9.10	10.25

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

4.6 Inflorescence dry weight/plant

Inflorescence dry weight/plant was affected significantly due to leaf clipping (Table 11). At 20 DAS, the highest dry weight /plant (1.617g) was obtained by C_3 and C_0. The lowest value (0.4867g/plant) was obtained by C_2. At 40 and 50 DAS the highest value was obtained by C_3 and the lowest value by C_2. At 60 DAS, the highest inflorescence dry weight/plant was obtained from C_3 (2.136 g/plant) and the lowest by C_2 (1.247 g/plant).

The effect of various fertilizer treatments was significant on inflorescence dry weight/plant. At 40 and 60 DAS, there was no significant difference. But at 20 DAS, the highest inflorescence dry weight /plant (1.408 g) was obtained by F_2 which was statistically similar with F_3 and the lowest value (0.8717 g/plant) obtained by F_1. At 50 DAS, the highest value (6.514 g) was obtained by F_2 and the lowest value (4.260g/plant) was obtained by F_1. Significantly the highest inflorescence dry weight/plant (1.787 g) was observed at 60 DAS with F_2, but at the same DAS, the lowest inflorescence dry weight/plant (1.739 g) was obtained by F_1. The highest dry matter at F_2 might be attributed due to increased weight in different structure of the inflorescence which was favored by balanced nutrition.

The interaction effect of leaf clipping and fertilizer dose on inflorescence dry weight/plant was statistically significant (Table 12). At 20 DAS, the highest value (2.847g/plant) was obtained by C_3F_2 and the lowest value (0.2167g/plant) was obtained by C_2F_3 which was similar with C_2F_2. At 40 DAS, the highest value (8.323 g/plant) was obtained by C_1F_2 which was similar with C_1F_1. The lowest value (2.930g/plant) was obtained by C_1F_3. At 50 DAS, the highest dry weight/plant (7.560g) was obtained by C_3F_1 and the lowest dry weight/plant (3.297g) obtained by C_2F_3. At 60 DAS, the highest inflorescence dry weight/plant (2.750 g) was obtained from C_3F_2 and the lowest (1.000 g) from C_2F_1.

Table 11: Dry weight of inflorescence (g/plant) of mungbean BARI mung-6 at different days after sowing as influenced by leaf clipping and fertilizer doses

Treatments	Days after sowing (DAS)			
	20	**40**	**50**	**60**
Leaf clipping (C)				
C_0	1.140	5.476	5.503	1.811
C_1	1.602	5.856	6.068	1.836
C_2	0.4867	5.393	4.358	1.247
C_3	1.617	6.431	6.421	2.136
$LSD_{0.05}$	0.9082	0.821	1.674	0.5220
Fertilizer (F)				
F_1	0.8717	5.686	4.260	1.739
F_2	1.408	6.213	6.514	1.787
F_3	1.354	5.468	5.988	1.746
$LSD_{0.05}$	0.5741	NS	1.450	NS

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

Table 12: Dry weight of inflorescence (g/plant) of mungbean cv. BARI mung-6 at different days after sowing as influenced by the interaction of leaf clipping and fertilizer doses

Interaction (CxF)	Days after sowing (DAS)			
	20	40	50	60
C_0F_1	0.8467	5.753	6.647	2.133
C_0F_2	0.9000	5.527	5.807	1.553
C_0F_3	0.8533	6.287	5.750	1.747
C_1F_1	1.567	8.040	7.127	1.283
C_1F_2	2.383	8.323	4.577	1.823
C_1F_3	1.107	2.930	3.360	1.833
C_2F_1	0.5967	5.010	4.603	1.000
C_2F_2	0.3967	4.890	5.173	2.297
C_2F_3	0.2167	6.527	3.297	1.947
C_3F_1	1.333	6.047	7.680	1.263
C_3F_2	2.847	4.003	7.560	2.750
C_3F_3	1.490	6.130	5.470	1.457
$LSD_{0.05}$	1.573	3.154	2.900	1.424
CV (%)	8.85	6.51	7.24	8.26

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

4.7 Stover yield (t/ha)

Leaf clipping exerted significant effect on stover yield and shown in Table 13. Removal of empty leaves (C_3) obtained stover yield of 2.018 t/ha and removal of new leaves (C_1) of 1.993 t/ha. Removal of subtending leaves (C_2) had stover yield of 1.800 t/ha. Such happened because the subtending leaves were major source of assimilates for the reproductive sink.

Stover yield was significantly influenced by the fertilizer dose in mungbean (Table 13). The differences among the fertilizer dose treatments were statistically significant. The highest Stover yield (t/ha) was obtained from F_2 (1.977 t/ha) whereas, the lowest from F_1 (1.893 t/ha) which was similar with F_3 (1.908 t/ha).

The interaction effect of leaf clipping and fertilizer dose and on stover yield (t/ha) was statistically significant (Table 14). The treatment combination of F_2 and removal of empty leaves (i.e, C_3F_2) gave the highest stover yield (2.10 t/ha) and the lowest straw yield (1.78 t/ha) was recorded from the treatment combination of C_2F_1.

Table 13: Stover yield (t/ha) of mungbean BARI mung-6 as influenced by leaf clipping and fertilizer doses

Treatments	Stover yield (t/ha)
Leaf clipping (C)	
C_0	1.893
C_1	1.993
C_2	1.800
C_3	2.018
$LSD_{0.05}$	0.06913
Fertilizer (F)	
F_1	1.893
F_2	1.977
F_3	1.908
$LSD_{0.05}$	0.05987

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

Table 14: Stover yield (t/ha) of mungbean BARI mung-6 as influenced by the interaction of leaf clipping and fertilizer doses

Interaction (CxF)	**Stover yield (t/ha)**
C_0F_1	1.87
C_0F_2	1.93
C_0F_3	1.88
C_1F_1	1.94
C_1F_2	2.06
C_1F_3	1.98
C_2F_1	1.78
C_2F_2	1.82
C_2F_3	1.80
C_3F_1	1.98
C_3F_2	2.10
C_3F_3	1.97
$LSD_{0.05}$	0.1197
CV (%)	7.22

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

4.8 Pod length (cm)

Leaf clipping had significant effect on pod length (Table 15). The tallest pod (11.53 cm) was obtained from C_3 which was similar to C_0 (10.22 cm) and C_1 (10.35 cm) and the shortest pod (9.12 cm) from C_2.

Fertilizer treatments had significant effect on pod length (Table 15). The tallest pod (11.26 cm) was obtained from F_2 treatment and the shortest (10.25 cm) from F_1 treatment. The results corroborates with the findings noted by Suharatatik (1991) who stated that residue of lime with N, P and K fertilizers significantly increased the pod length of mungbean.

The interaction effect of fertilizer dose and leaf clipping had also significant on pod length (Table 16). The tallest pod (12.98 cm) was obtained from C_3F_2 whereas, the shortest (9.09 cm) from C_2F_1 which was similar with C_0F_1, C_0F_3, C_2F_2 and C_2F_3.

Table 15: Pod length (cm) and number of seeds pod^{-1} of mungbean BARI mung-6 as influenced by leaf clipping and fertilizer doses

Treatments	Pod length (cm)	Number of seeds pod^{-1}
Leaf clipping (C)		
C_0	10.22	11.22
C_1	10.35	11.10
C_2	9.12	9.05
C_3	11.53	13.18
LSD $_{0.05}$	0.3632	1.5478
Fertilizer (F)		
F_1	10.25	12.00
F_2	11.26	13.22
F_3	10.41	12.20
LSD $_{0.05}$	0.3145	0.4819

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

Table 16: Pod length (cm) and Number of seeds pod^{-1} of mungbean BARI mung-6 as influenced by the interaction of leaf clipping and fertilizer doses

Interaction (CxF)	Pod length (cm)	Number of seeds pod^{-1}
C_0F_1	10.26	10.17
C_0F_2	10.28	10.30
C_0F_3	10.21	9.98
C_1F_1	10.37	10.85
C_1F_2	11.41	11.90
C_1F_3	10.29	10.73
C_2F_1	9.09	9.35
C_2F_2	9.15	9.58
C_2F_3	8.950	9.52
C_3F_1	10.40	11.18
C_3F_2	12.98	12.31
C_3F_3	10.29	11.05
$LSD_{0.05}$	0.629	0.9489
CV (%)	8.56	7.19

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

4.9 Number of seeds pod^{-1}

Leaf clipping significantly influenced the number of seeds per pod (Table 15). Of the leaf clipping treatments, the removal of empty leaves produced the highest number of seeds per pod (13.18) which was statistically similar to control (11.22) and new leaves removal treatments C_1 (11.10), while the lowest (9.05) was recorded from subtending leaf removal treatment of C_2. This observation agreed with those of Pandey (1983) who worked in cowpea and Hintz and Fehr (1990) who worked in soybean.

Number of seeds per pod varied significantly with the variation in fertilizer dose (Table 15). The highest number of seeds per pod was recorded from F_2 (13.22) while the lowest from the F_1 (12.00) which was similar with F_3.

There was a significant effect of interaction between leaf clipping and fertilizer dose (Table 16). The highest number of seeds per pods (12.31) was recorded from the treatment combination of the removal of empty leaves (C_3) and F_2. This might be attributed to the less competition for assimilates during seed development due to the removal of vegetative sink organ under heath. The lowest number of seeds per pod (9.35) was recorded in C_2F_1 treatment.

4.10 Thousand seeds weight (g)

Leaf clipping also exerted significant effect on thousand seed weight and shown in Table 17. The removal of new leaves (C_1) and the removal of lower empty leaves (C_3) significantly increased the 1000 seed weight (38.57g and 39.32g) respectively. While the removal of subtending leaves (C_2) significantly reduced the 1000 seed weight. The new leaves and the lower empty leaves might have played the role of relative sink as new leaves consume energy for their development and lower shaded leaves require energy for their existence. During seed development, there might have existed a competition for assimilates among the developing seeds and the relative sinks (new leaves and lower shaded empty leaves). The removal of these relative sinks probably reduced this competition resulting in significant increase in 1000 seed weight. Similarly Clifford (1979) found increased grain weight after the removal of axillary buds. An opposite opinion is also available. Removal of subtending leaves and removal of branches caused reduction in assimilatory surface. As a result, supply of photo assimilates to developing seeds was reduced. This might have resulted in decreased 1000 seed weight.

Thousand seed weight of mungbean was significantly influenced by fertilizer doses (Table 17). The highest thousand seed weight (39.40g) was recorded from the F_2 while the lowest from the F_1 which was statistically similar with F_3

In respect of the interaction effect of leaf removal and fertilizer doses (Table 18), the highest 1000-seeds weight (40.67 g) was found with C_3F_2 which was also similar with C_1F_2 (40.12 g) while the lowest (34.91 g) was found with C_2F_1

Table 17: Thousand seeds weight (g), grain yield (t/ha) and harvest index (%) of mungbean cv. BARI mung-6 as influenced by leaf clipping and fertilizer doses

Treatments	1000 seed weight (g)	Grain yield (t/ha)	Harvest index (%)
Leaf clipping (C)			
C_0	36.66	0.9233	32.82
C_1	38.57	0.9933	33.28
C_2	35.31	0.8167	31.20
C_3	39.32	1.044	34.08
$LSD_{0.05}$	1.833	0.06183	1.441
Fertilizer (F)			
F_1	36.76	0.9125	32.49
F_2	39.40	0.9850	34.15
F_3	37.54	0.9358	32.89
$LSD_{0.05}$	1.587	0.05355	1.248

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

Table 18: Thousand seeds weight, grain yield (t/ha) and harvest index (%) of mungbean cv.BARI mung-6 as influenced by the interaction of leaf clipping and fertilizer doses

Interaction (CxF)	1000 seed weight (g)	Grain yield (t/ha)	Harvest index (%)
C_0F_1	35.95	0.91	32.73
C_0F_2	36.07	0.92	32.28
C_0F_3	37.97	0.94	33.45
C_1F_1	37.27	0.95	32.98
C_1F_2	40.12	1.06	33.97
C_1F_3	38.33	0.97	32.88
C_2F_1	34.91	0.78	30.47
C_2F_2	35.54	0.84	31.58
C_2F_3	35.48	0.83	31.56
C_3F_1	38.91	1.01	33.78
C_3F_2	40.67	1.12	34.78
C_3F_3	38.38	1.03	33.67
$LSD_{0.05}$	3.175	0.1071	2.497
CV (%)	8.15	6.47	7.37

C_0 = No removal

C_1 = Removal of new leaves developed after first flowering

C_2 = Removal of subtending leaves (at the base of each inflorescence)

C_3 = Removal of empty leaves (from the nodes having no inflorescence)

F_1 = 10 Kg N +20 kg P_2O_5+15 kg K_2O/ha

F_2 = 20 kg N +40 kg P_2O_5 + 30 kg K_2O /ha

F_3 = 30 kg N + 60 kg P_2O_5 + 45 Kg K_2O/ha

4.11 Grain yield (t/ha)

Leaf clipping exerted significant effect on grain yield shown in Table 17. Removal of empty leaves increased grain yield 1.044 t/ha. Removal of new leaves also increased yield (0.9933 t/ha). However, due to the removal of subtending leaves a decreased grain yield (0.8167 t/ha) was obtained. This was expected as the subtending leaves were the major source of assimilates for the reproductive sink. The decrease in grain yield in this treatment might be due to limitation of source for proper development and formation of seeds during pod development stage. As a result of this source removal, probably the number of pods per plant, number of seeds per pod and the individual seed size were reduced which in tern leaded to decreased seed yield. Similar observations also reported earlier in mungbean (Clifford, 1979).

In the previous study, it was observed that removal of empty leaves and new leaves reduced the competition for assimilates for the development of seeds in pod, which might had helped to increase the seed size as well as seed yield. Clifford (1979) reported an increased seed weight by removing axillary buds in mungbean. Talwar *et al* (1992) also reported higher yield by removing flowers and gynophores in groundnut. In cereals, reduction of sink size contributed to higher spikelet filling and grain yield in rice (Rao 1991).

Grain yield was significantly influenced by fertilizer doses in mungbean (Table 17). The differences among the fertilizer dose treatments were statistically significant. The highest grain yield (0.9850 t/ha) was obtained from F_2 whereas, the lowest from F_1 (0.9125 t/ha).

The interaction effect of leaf clipping and fertilizer dose on grain yield was statistically significant (Table 18). The treatment combination of C_3 and F_2 gave the highest grain yield (1.12 t/ha) and the lowest seed yield (0.78 t/ha) was recorded from the treatment combination of C_2 and F_1

4.12 Harvest index

Harvest index (HI) is the ratio of economic yield to biological yield. Any management practices which would lead to higher HI keeping the biological yield unaltered might be beneficial in obtaining higher economic yield. Higher HI describes the greater partitioning of accumulated dry matter into the economic sink i. e, seed. The HI in mungbean was significantly influenced by both leaf clipping and fertilizer dose treatments.

Harvest index was significantly influenced by leaf clipping treatments (Table 17). The highest HI (34.08) was obtained with the removal of empty leaves (C_3), while the lowest (31.20) with the removal of subtending leaves (C_2). Removal of subtending leaves had detrimental effect on HI, whereas the removal of empty leaves exerted positive effects on HI. Higher HI due to the removal of flowers and gynophores in groundnut was reported by Talwar *et al.* (1992).

Harvest index was also significantly influenced by fertilizer doses (Table 17). Results showed that the highest Harvest index (34.15) was obtained from F_2 and the lowest (32.49) from F_1 which was similar with F_3.

Harvest index was significant due to leaf clipping, fertilizers and also their interactions (Table 18) indicating the highest value from C_3F_2 (34.78) and the lowest value C_2F_1 (30.47).

CHAPTER 5

SUMMARY AND CONCLUSION

CHAPTER 5

SUMMARY AND CONCLUSION

An experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of leaf clipping and fertilizers on different growth and yield parameters of mungbean during the period from March 2007 to June 2007. The trial comprised four treatments of leaf clipping (C_0 = No removal, C_1 = Removal of new leaves develop after first flowering, C_2 = Removal of subtending leaves and C_3 = Removal of subtending leaves) and three treatments of fertilization (F_1 = 10 kg N + 20 kg P_2O_5 + 15 kg K_2O/ha, F_2 = 20 kg N+ 40 kg P_2O_5 +30 kg K_2O/ha and F_3 = 30 kg N+ 60 Kg P_2O5+ 45 kg K_2O/ha).

The experiment was set up in a factorial randomized complete block design (RCBD) with three replications. Seeds of cv. BARI mung - 6 were sown on 29 March 2007 and harvested on 15 June, 2007. Data on different growth and yield attributes were recorded and analyzed statistically. The treatment means were compared by the LSD test at 5% level of probability.

Results showed that the plant height was the highest (56.74 cm) with the treatment of removal of empty leaves (C_3) whereas, the shortest (55.50 cm) with removal of subtending leaves (C_2). Likewise, the highest plant (56.96 cm) was observed with the treatments of 20 kg N+ 40 kg P_2O_5 + 30 kg K_2O/ha, whereas, the shortest (55.22 cm) with 10 kg N + 20 kg P_2O_5 + 15 kg K_2O/ha. The tallest plant (58.55 cm) was found with the interaction treatment of C_3F_2.

Significantly the highest leaf area was obtained from the fertilizer treatment F_3 as well as with the interaction treatment of C_0F_2 (1826.0 cm) whereas, the lowest from C_3F_1 (586.10 cm). The higher dry weight of leaflets was obtained from no clipping treatment and F_3 fertilizer treatment. The interaction treatment of C_0F_2 (8.787 g/plant), while, the lowest was shown by C_2F_1 (3.767 g/plant). Unlike with leaf dry weight, the highest dry weight of stem was shown by the leaf clipping treatment C_3 as well as by the fertilizer treatment F_2. The interaction treatment of C_3F_2 showed the highest value of stem dry matter (10.69 g/plant) and the lowest by C_2F_1 (5.900 g/plant).

The highest dry weight of roots was obtained from the removal of new as well as subtending leaves, but the highest value of the same parameter was shown by C_3F_2 (2.49 g/plant) and the lowest by C_2F_1 (1.97 g/plant). The highest dry weight of inflorescence was exhibited when empty leaves were removed (C_3) and also by the interaction treatment of C_3F_2 (2.750 g/plant) whereas, the lowest by C_2F_1 (1.000 g/plant). Stover yields were significantly due to leaf clipping, fertilizer and their interaction showing the highest value by C_3F_2 (2.10 t/ha) and the lowest by C_2F_1 (1.78 t/ha).Pod length was significantly higher due to clipping of empty leaves (C_3), and F_2 fertilizers treatment. Their interaction also showed significant effect on the parameter showing the highest value with C_3F_2 (12.98 cm) and the lowest with C_2F_1 (9.09 cm).

Similar effect was seen on number of seeds pods^{-1} showing the higher values with C_3 (13.18), F_2 (13.22) and C_3F_1 (12.31) and the lowest with C_2F_1 (9.35). Thousand seeds weight varied highly due to the leaf clipping and fertilizers and interaction. The higher values of 1000-seeds weight was obtained with removal of empty leaves (C_3) and also the fertilizer treatment 20 N+ 40 kg P_2O_5 +30 kg K_2O/ha. Among the interaction treatment, the highest 1000-seeds weight (40.67 g) was found with C_3F_2.

Total grain yield (t/ha) was significant due to leaf clipping, fertilizers and their interaction showing the highest value by C_3F_1 (1.12 t/ha) and the lowest by C_2F_1 (0.78 t/ha).Harvest index was significant due to leaf clipping, fertilizers and their interaction giving the highest value by C_3F_2 (34.78) and the lowest by C_2F_1 (30.47).

On the basis of the results as was obtained from the experiment, the following conclusions may be drawn:

- Subtending leaves were the most important source for pod filling in mungbean because, on removal of which, the yield reduced drastically.

- For high seed yield in mungbean, the formation and development of new leaves after the attainment of reproductive phase were not found to be desirable.

- Seed yield of mungbean could be increased to some extent by removing the lower empty leaves (the relative sink) before pod development.

- For optimum growth and productivity of mungbean, fertilizers at the rate of 20 kg N + 40 kg P_2O_5 + 30 kg K_2O/ha might be the optimum.

However, the experiment was conducted in one season with only one variety. So, the findings should be considered as tentative. On this context, the trial could be repeated for a couple of years in different agro ecological zones of Bangladesh involving some more genotypes of mungbean for the precise conclusion and recommendation along with its economics.

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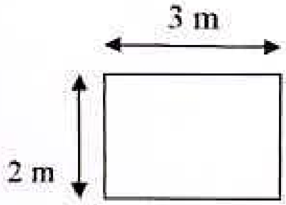
APPENDICES

APPENDIX –IV. Experimental layout



Plot size: 3 m×2 m
Between Plot: 0.75m
Between replication: 1 m