GROWTH AND YIELD RESPONSE OF MUSTARD TO LEAF CLIPPING

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CERTIFICATE

This is to certify that the thesis entitled ***"GROWTH AND YIELD RESPONSE OF MUSTARD TO LEAF CLIPPING"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE IN AGRONOMY,*** *embodies the result of a piece of bonafide research work carried out by* ***SAMIA JASMIN, Registration No.: 12-05029,*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that any help or sources of information, as has been availed of received during the course of this investigation have duly been acknowledged.

Dated:

Dhaka, Bangladesh

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Dedicated to

My Beloved Parents

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GROWTH AND YIELD RESPONSE OF MUSTARD TO LEAF CLIPPING

ABSTRACT

The experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka during the period from October 2017 to February 2018 to study the growth and yield response of mustard to leaf clipping. The treatment consisted of three variety *viz*. V_1=BARI Sarisha-14,V_2=BARI Sarisha-15 and V_3=BARI Sarisha-17 and five leaf clipping *viz.* C_0 = No leaf clipping, C_1= Clipping of 1^{st} and 2^{nd} leaf at main stem, C_2= Clipping of 2^{nd} and 3^{rd} leaf at main stem, C_3 =Clipping of 3^{rd} and 4^{th} leaf at main stem, C_4 = Clipping of 4^{th} and 5^{th} leaf at main stem. The experiment was laid out in split plot design with three replications. Significant effect was observe on the basis of plant height (cm), branches plant^{-1}, avobe ground dry matter plant^{-1}, length of siliqua(cm) siliquae plant^{-1}, seeds siliqua^{-1}, 1000 seed weight (g), yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t/ha) and harvest index. Results revealed that the highest length of siliqua (5.07 cm), siliqua plant^{-1} (102.4), seeds siliqua^{-1} (26.67), thousand seed weight (3.82 g)), total yield (1.86 t ha^{-1}),Biological yield(5.78 t ha^{-1}) and harvest index (64.62%) was obtained from BARI Sarisha-17 with clipping of 2^{nd} and 3^{rd} leaf on main stem at flower initiation stage while the lowest (1.007 t ha^{-1}) from BARI Sarisha-14 with clipping of 4^{th} and 5^{th} leaf on main stem at flower initiation stage.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
CV%	=	Percentage of coefficient of variance
DAS	=	Days after sowing
g	=	gram (s)
ha^{-1}	=	Per hectare
HI	=	Harvest Index
Hr	=	Hour
kg	=	Kilogram
LAI	=	Leaf area index
LSD	=	Least Significant Difference
Max	=	Maximum
Min	=	Minimum
MoP	=	Muriate of Potash
N	=	Nitrogen
NAA	=	Naphthalene acetic acid
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
NS	=	Not significant
SAU	=	Sher-e-Bangla Agricultural University
T	=	Ton
TSP	=	Triple Super Phosphate

Chapter 1

Introduction

Chapter 1

INTRODUCTION

Mustard belongs to the family Brassicaceae is most important oilseed crops, source of vegetable oil, widely grown oilseed crops of Bangladesh occupying 0.532 million ha of land and the production was 0.596 million MT (metric ton) with an average yield of 1.12 MT (metric ton)/ ha in 2013-14 (AIS, 2015). It is now ranked first among oilseed crops in Bangladesh as well as the second largest oilseed crop in the world after soybean (FAO, 2007). Domestic production of edible oil in Bangladesh mainly comes from mustard and sesame. Bangladesh has been facing acute shortage of edible oil for the last several decades. Our internal production can meet only about 21% of our consumption. The rest requirement is met through import (Begum *et al*.2012). The country has to import annually more or less 1.9 million tons of edible oil and on average 31,685 MT mustard seeds for oil production from 2006 to 2010 (FAO, 2011). Mustard seeds contain 40-45% oil and 20-25% protein (Mondal and Wahhab, 2001). Using local oil-extraction machine average 33% oil may be extracted. Oil cake is a nutritious food item for cattle and fish, which is also used as a good organic fertilizer. Dry mustard plants may be used as fuel. Mustard is grown more or less all over Bangladesh, but more particularly in the districts of Comilla, Tangail, Jessore, Faridpur, Pabna, Rajshahi, Dinajpur, Kushtia, Kishoregonj, Rangpur, Dhaka (BBS, 2012).Mustard is a cold loving crop and grows well during Rabi season (October-February) usually under dry and low input condition in this country. Its low yield can be attributed to several factors, the nutritional deficiency, among others is highly important .Mustard has been shifted to marginal lands due to access of high valued crops like boro, wheat, maize etc. Besides this fact other cultivation managements are responsible for poor productivity also.

Cultivation of HYV instead of local variety is a way of improving productivity. Mustard plant produces many leaves which become overlapping each other reducing the photosynthetic efficiency which reduce the productivity. Leaf clipping may change this backdrop as some specialists claimed important of this management while working with different crops

With increasing population growth, the demand of edible oil is increasing day by day. It is therefore, the production of edible oil should be increased considerably to fulfill the demand of the country.

Mustard is characterized by a large number of oblong-shaped leaves in the lower layers of the plant axis (Weiss, 1983). Such leaves contribute to the development of supra-optimal leaf area indices with accompanying self-shading and shading by other leaves within the plant axis (Anten et al., 1995). These shaded leaves have reduced effective solar irradiation and photosynthetic rate reflected in lower seed yield. It was postulated that removal of such shaded leaves may affect growth of new leaves, their photosynthetic capacity and yield of the crop. It is reported that, only upper new leaves (32 per cent) and inflorescence and pod wall (68 per cent) have more photosynthetic efficiency and translocation towards sink (Pandya, 1975). Ear leaf defoliation retransmitted accumulated matter from stem to grain (Egile, 2000). Applying below ear leaf defoliation at stress condition can prohibit yield quantity and quality reduction compared to normal condition (Lauer, 2004). So leaf clipping on mustard may increase mustard yield in Bangladesh. Total dry matter production is positively correlated with the amount of foliage displayed in upper 50% of the canopy (Hamid *et al.*, 1990). It seems like that the foliage developed in the lower part of the canopy has little or negative contribution to dry matter production. Thus manipulation of source may provide opportunity for increasing yield in plants having habit of excessive leaf development. In some situations, physical leaf is adequate and even more than required, but the functional efficiency is far lower due to utilizing resources as a respiratory burden of excessive leaves (Venkateswarlu and Visperas, 1987; Mondal, 2007). The leaves at flowering nodes are the major contributors to seed filling and development (AVRDC, 1974). It is therefore imperative that for high yield formation in mustard, plants should have adequate foliage development prior to pod development stage.

Mustard is cultivated for different purposes In Bangladesh. Mainly it is grown for grains as an oilseed crop. A substantial area is also used to grow mustard with the aim of using its leaf as green vegetable. Another use of mustard, although not frequent, is to use its flowers/inflorescence as a recipe for making a special fried diet diving it with thoroughly broken eggs indicating that there is an economic importance of its flowers using them as edible item. The crops, which are produced for edible flowers, may also be used as a grain producing one if instead of using the complete inflorescence some portion of it is removed. This aspect needs to be evaluated.

Understanding the above facts the only way designed to improve mustard yield with following objectives.

Objectives:

1. To study the varietal differences of mustard to leaf clipping
2. To determine the leaf position which is to be clipped down for yield improvement of mustard
3. To study the combined effect of variety and leaf clipping on the growth and yield of mustard

Chapter 2

Review of literature

Chapter 2

REVIEW OF LITERATURE

A number of research works on different aspects of mustard production have been done by research workers in and outside of the country. Recently Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have started research on varietal development and improvement of this crop. Research works related to the study of have been reviewed in this chapter

2.1 Effect of variety on mustard performance

Ali and Rahman (1998) found significant variation on plant height of different varieties of rape and mustard. Jahan and Zakaria (1997) demonstrated that Dhali was the tallest plant (142.5cm), which was similar with sonali (139.5cm), and Japari (138.6cm). The shortest plant was observed in Tori-7 (90.97cm) which was significantly shorter than other varieties.

Hussain *et al.* (1996) found that the highest plant was in Narenda (175cm), which was identical with AGA-95-21 (166cm). The shortest variety was Tori-7. Mondal *et al.* (1992) stated that variety had significant effect on plant height. They found the highest plant height (134.4cm) in the variety J-5004, which was identical with SS-75 and was significantly taller than JS-72 and Tori-7.

Paul *et al*. (1978) investigated eleven yields related characters in six *Brassica juncea* parents and all their F1s, excluding reciprocals and observed that seed yield /plant was significantly correlated with siliqua number/plant and with primary and secondary branch numbers, and that these three characters all had a high positive direct effect on seed yield. A discriminate function using siliqua number per plant, primary branch numbers and seed yield appeared the most effective for selection, giving expected genetic gains of 43.06 and 48.94% in the parental and F1 generations, respectively.

Campbell and Kondra (1978) found that number of branches/plant played a significant role in the seed production. Shamsuddin and Rahman (1977) and Mondal *et al.* (1992) identified the differences in branch number/plant were identical to be due to varietals behavior.

BARI (2000) investigated that the number of primary branches/plant was higher (4.02) in the variety SS-75 and lower (2.1) in the variety BARI Sharisa-5 under poor management under medium management, the higher number of primary branches/plant was found in BARI Sarisha-6 (5.5) and lower in BARI Sharisa-8 under higher management. The highest number of primary branches /plant was with BARI Sarisha-6 (5.9) and lower (3.0) with Nap-248.

Jahan and Zakaria (1997) reported that the local varieties Tori-7 and Sampad produce the highest number of primary branches / plant (4.07) which were at par with BLN-900. The minimum primary branches/plant (2.90) was found in Jatarai which was identical to those found in Hyola-40 and BARI sharisa-8.

Hossen (2005) carried out an experiment on mustard in Sher-e-Bangla Agricultural University farm, October 2004 to February 2005 to test the performance of different varieties viz. BARI Sarisha-8, BARI Sarisha-9 and Tori-7. He reported that BARI Sarisha-8 produced higher siliqua than BARI Sarisha-9 and Tori-7.

Mondal *et al.* (1992) reported that maximum number of siliqua per plant was in the variety J-5004 which was identical with the variety Tori-7. The lowest number of siliqua per plant (45.9) was found in the variety SS-75.

Masood *et al.* (1999) demonstrated that significant genetic variation in pod length among seven genotypes of *B. campestris* and a cultivar of *B. napus*. Similar result for pod length was observed by Lebowitz (1989) and Olsson (1990).

Singh *et al.* (2002) stated that 1000-seed weight ranged between 2.36 and 4.20gm in F_1; 2.36 and 4.20 in F_2 population. Significant genetic variations were observed among a large number of strains of *B. campestris* , *B. napus* and *B. juncea*

Karim *et al.* (2000) stated that varieties showed significant variation in the weight of 1000-seeds. They found higher weight of 1000-seed in J-3023 (3.43 gm), J-3018 (3.42 gm) and J-4008 (3.50 gm).

BARI (2001) investigated significant variation in 1000-seed weight of rapeseed and mustard in different variety and the highest weight of 1000-seed was observed in variety Jamalpur-1 and lowest on BARI Sharisa-10.

Rahman (2002) reported that yield variation existed among the varieties whereas the highest yield was observed in BARI Sarisha-7, BARI Sarisha-8 and BARI Sarisha-11 (2.00-2.50 t ha^{-1}) and the yield was in variety Torio-7 (0.95-1.10 t ha^{-1}).

Mondal (1995) reported that after continuous efforts plant breeders of Oilseed Research Centre, BARI have developed several short duration genotypes of *B. Napus* with high yield potential. The genotype, Nap-3 is one of these genotypes (Biswas and Zaman (1990) which is under active consideration for recommendation as a variety. It is likely to be a good variety for Bangladesh, but it has a problem of high shattering habit.

Mendham *et al.* (1990) showed that seed yield was dissimilar due to varietals difference in species of *B. Napus*.

Uddin *et al*. (1987) stated that there was a significant yield difference among the varieties of rapes and mustard with the same species. Shamsuddin and Rahman (1977) found that yields were different among the varieties within the same species.

Rahman and Das (1991) found that several mutants of *B. juncea,* gave 8-13% higher seed yield than the mother and 39-43% higher seed yield than the recommended variety, Rai-5.

Halva *et al.* (1986) stated that seed yield of mustard varied widely among the species but the variation was little within the species. They observed that seven varieties of *Sinapis alba*, eight varieties *B. juncea* and one variety of *B. nigra* produced an average yield of 2.2, 1.6 and 0.70 t ha^{-1} respectively. Similar result was obtained by Malik (1989) with *B. carinata* which produced 49% higher yield than each of *B. juncea* and *B. campestris*.

BARI (2000) reported that in case of poor management Isd-local gave the highest stover yield (3779 kg ha^{-1}) and lowest yield (1295 kg ha^{-1}) was found in Nap-248. In case of medium management highest weight (6223.3 kg ha^{-1}) was in the same variety and lowest (3702.3 kg ha^{-1}) from pt-303 under high management conditions. The highest stover yield,6400 kg ha^{-1} was obtained from the variety Rai-5 and lowest stover yield 4413.3 kg ha^{-1} was obtained from Tori-7.

Mendham *et al.* (1990) found that vernalization and photoperiod appear to affect the rate of development to flowering in a quantitative and additive fashion in all cultivars, which helped to biological yield.

2.1 Effect leaf clipping on growth and yield of different crops

Khan (2002 and 2003) and Khan and Lone (2005) reported that mustard leaves on lower layers con-tribute to the development of supra-optimal leaf area indices with accompanying self-shading and shading by other leaves within the plant axis. These shaded leave receive reduced irradiation and thus are less photo synthetically active.

Earlier research has shown that removal of shaded leaves of mustard improves assimilate balance, growth and photosynthetic potential of the rest of the leaves (Khan et al. 2002).

Bouchart et al. (1998) stated that modifications in source/sink relations are considered as prominent factors in N accumulation. The reported study was conducted with the assumption that N assimilation in leaves of mustard is enhanced after defoliation and the N assimilation is linked with the ethylene biosynthesis as ethylene has vital influence in providing physiological adaptive signals (Abeles et al. 1992 and Khan 2006).

Earlier, it has been reported that defoliation at 40 DAS enhanced emer-gence of new leaves on the upper axis with higher pho-tosynthetic capacity. De-foliation increased the rates of leaf emergence and the development of young leaves to maturity (Khan et al. 2002 and Khan & Lone 2005).

Eagles (1976), Alderfer and and Caemmere and Farquhar (1984) and Marriott and Haystead (1990) stated that the emergence of new leaves has been shown to have greater efficiency for co_2 assimilation

Defoliation did not significantly affect remobilization of Grain yield and 1000-grain weight in weight. (Ahmadi et al., 2009)

An optimum rate of maize leaf defoliation without affecting the grain, stover yield components and dry matter yield of undersown forage crops was harvested at the rate of 25-50% of defoliation of maize leaf (Hassen and Chauhan, 2003).

Grain stored photosynthates are obtained via three main resources including current photosynthesis in the leaves; photosynthesis in green parts of plants excluding the leaves and transferring from the storing parts. But interfere amount of the resources depends on species and environmental conditions (Hashemi and Maraashi, 1993).

Distance of leaves to the ear and their photosynthetic efficiency are important in a slight defoliation (Andrew and Peterson 1984). They showed that leaves on top of the ear transfer about 23 to 91 percent of photosynthates to the cob and the greatest amount of transferred materials belongs to the nearest leaf on top of the ear.

Abbaspour *et al*. (2001) demonstrated that 100 percent defoliation was lead to minimum yield of seeds compared to control because of decrease in grain weight and filled grain percent .

Remison (1978) reported that complete defoliation was the most effective on the ear diameter, dry grain weight, one hundred grain weight and grain yield. There was no significant difference between removing of the whole leaves on the top of ear and the whole leaves under ear.

Tilahun (1993) demonstrated that removing of above three leaves has considerable effect on total dry weight of grains.

Hashemi *et al.* (1995) stated that below leaves of maize transferred a greater part of their photosynthates to the roots, but above leaves transferred their production to the upper plant organ.

Barzegari (1996) reported that photosynthetic products of above leaves of the ear and below five leaves move to the grains.

Kabiri (1996) reported that removing of above leaves of ear could decrease the number of grain in row; since this type of defoliation causes to produce immature grains in the tip of ear.

(Dungan *et al*. (1965) found that -in developmental stages of maize, the stem is a temporary storing site of carbohydrates and soluble solid. This accumulation continues until the ear changes to the main sink to store.

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

Alexander and Thomson (1982) found the effect of clipping frequency on competition between *Lolium perenne* and *Agrostis tenuiswas*. The yield of clippings of both species increased and then declined during the 12-week pter than that of *Agrostis*. *Lolium* was clearly the better competitor in unclipped controlseriod of the experiment, but the clip yield of *Lolium* was always significantly great. The proportion of the biomass contributed to the mixture by *Agrostis* increased as the interval between clips decreased. Tiller production was unaffected by increased clipping frequency in *Lolium* but was increased in *Agrostis*. Total yield was much more drastically reduced by frequent clipping in *Lolium* than in *Agrostis*, where yield was practically unaffected by wide variations in clipping frequency. The results were in agreement with the field distributions of the two species. They also suggested that the differences in height and response to clipping are likely to confound any attempt to monitor the progress of competition experiments by measuring the yield of clippings.

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

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

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

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

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

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

Hamid *et al*. (1994) investigated that the development of· tertiary branches and much of the secondary branches in mungbean is counterproductive. Therefore, mungbean plant types with a maximum of two to three erect branches having shorter and thicker internodes and basal podding might be desirable for high yield potential. The hypothesis is subject to be tested by regulating source sink capacity.

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

Khalifa *et al.* (2008) impemented several field experiments during two summer seasons of 2003 and 2004 to study the effect of leaf cutting on physiological traits and yield of two rice cultivars hybrid (H5) (IR 70368 A /G 178) and inbred rice. The leaf cutting was followed from flag leaf as follows: 1.) L; Control = without leaf cutting, 2.) L1; flag leaf cut, 3.) L2; second leaf cut, 4.) L3; third leaf cut, 5.) L4; both flag leaf and second leaf cut. 6.) L5; flag leaf, second leaf and third leaf cut together. A split plot design with four replications was used; the main plots were devoted to the cutting of leaves, while the sub-plots were assigned to the two rice cultivars. Chlorophyll, sugar, starch and grain yield parameters were severely affected by L5, followed by L4, L1, L3 and L2 in sequence. However, as a single component affecting maximum to these parameters is the removal of flag leaf. The flag leaf contributed maximum to the yield of rice grains. L5, L4, L1, L2 and L3 treatments grain yield (relative % of control) by 59.87, 94.92, 44.89, 29.58 and 19.98 % respectively. Flag leaf contributed to 45% of grain yield and is the single most component for yield loss. The contribution of removal of leaf in hybrid rice was minimum, suggesting the probability of maximum translocation of photosynthesis from stem to the grain during grain feeling stage of hybrid rice after leaf removal.

Kumar *et al*. (2016) demonstrated the virulence of *R. solanacearum* on adult host plants, infection studies of this pathogen on the seedling stages of hosts are less common. In a preliminary observation, inoculation of *R. solanacearum* F1C1 on 6- to 7-day-old tomato seedlings by a simple leaf-clip strategy resulted in a lethal pathogenic condition in seedlings that eventually killed these seedlings within a week post-inoculation. This prompted testing of the effect of this inoculation technique in seedlings from different cultivars of tomato and similar results were obtained. Colonization and spread of the bacteria throughout the infected seedlings was demonstrated using *gus*-tagged *R. solanacearum* F1C1. The same method of inoculating tomato seedlings was used with *R. solanacearum* GMI 1000 and independent mutants of *R. solanacearum* GMI 1000, deficient in the virulence genes *hrpB*, *hrpG*, *phcA* and *gspD*. Wildtype *R. solanacearum* GMI 1000 was found to be virulent on tomato seedlings, whereas the mutants were found to be non-virulent. This leaf-clip technique, for inoculation of tomato seedlings, has the potential to be a valuable approach, saving time, space, labour and costs.

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

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

Li *et al*. (2004) carried out an experiment to examine how the interactions of nutrient availability and partial ramet clipping affect growth, reproduction and biomass allocation of *Cyperus esculentus*, an invasive sedge. The plants sprouting from tubers were grown at low and high nutrient levels, and were subject either to no clipping, one, two or three clippings, with each clipping cutting half of the existing ramets at soil level. Results showed that nutrient availability and clipping frequency tended to independently affect most of growth, reproduction and biomass allocation parameters of *Cyperus esculentus* examined in that study. Increased supply of nutrients led to an increase in plant productivity and its associated traits. All of the traits, except for the number of ramets, displayed a decreasing pattern with increasing clipping frequency, indicating that *Cyperus esculentus* had under compensatory responses to ramet clipping. It is likely that the patterns of plants' response to clipping are species specific, and depend on morphological characters of species. Its susceptibility to ramet clipping can offer opportunities for controlling this invasive species through mechanical methods such as mowing. Clipping had little effects on biomass allocation; however, root weight fraction increased with increasing clipping frequency. While nutrient availability and clipping frequency had no influence on leaf carbon concentration at harvest, both of them increased leaf nitrogen concentration, and hence reduced leaf C/N ratio.

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

Mahmood and Chowdhury (1997) conducted some studies to investigate the impact of the removal of green photosynthetic structures including flag leaf, 3rd nodal leaf and awns, on yield and some yield related parameters in two local wheat cultivars (Pasban 90 and Inqalab 91). The experiment was conducted in a triplicated randomized complete block design in split-plot fashion. The two varieties differed significantly for flag leaf area, 3rd nodal leaf area, seed set percentage, grains per spike and grain weight per spike. Effect of removing flag leaf (T2), 3rd nodal leaf (T3) and awns (T4) was displayed as reduction in yield attributes. Removal of flag leaf resulted 16.4, 14.8, 34.5 and 20.0% reduction in seed set percentage, grains/spike, grain weight/spike and 100 grain weight, respectively. Reduction in these traits as a consequence of the removal of 3rd nodal leaf and awns was also significant. However the rate of the reduction was less than that of removal of flag leaf. Interaction of varieties and treatments was significant for seed set, grains/spike and 100-grain weight. Both of the varieties exhibits a marked reduction in the four traits studied when the flag leaf was removed. However, Inqalab 91 was found superior to Pasban 90. The result signified the contribution of flag leaf on yield related traits studied. In ranked order maximum contribution occurred from flag leaf followed by 3rd nodal leaf and awns at the last.

Mapfumo *et al.* (2007) were found the viability of intensifying pearl millet and sorghum production through use of nurseries and transplanting to address the problem of poor stand establishment. The experiments were conducted over two seasons, the 1999/2000 and 2000/2001 seasons in the south eastern lowveld of Zimbabwe where the mean rainfall is less than 500 mm per annum. Treatments included two pearl millet cultivars (PMV2 and PMV3) and two sorghum cultivars (*Mutode* and *Macia*).

These crops were transplanted with and without leaf clipping at three seedling ages (30, 40 and 50 days for pearl millet; 29, 39 and 49 days for sorghum). Transplants were raised in nursery seedbeds. In the 1999/2000 season, there were significant effects of cultivar ($P<0.05$) and leaf clipping ($P<0.01$) on pearl millet grain yield. Clipped seedlings yielded 932 kg ha^{-1} compared to 797 kg ha^{-1} for non-clipped seedlings while PMV3 yielded 902 kg ha^{-1} compared to 820 kg ha^{-1} for non-clipped seedlings. However, leaf clipping tended to increase yields for both cultivars. An increase in seedling age from 29 days also tended to reduce yields. It was concluded that leaf clipping of 30-day old seedlings at transplanting may enhance sorghum and pearl millet yields in the semi-arid tropics.

Mariko and Hogetsu (1987) stated that defoliated sunflower plants showed higher rates of photosynthesis than those of under foliated plants. Defoliation tends to influence the ageing of the remaining or new leaves. Old Leaves can be allowed to rejuvenate, matter ones to maintain their vigor and young ones to develop their photosynthesis rapidly. Physiological approaches in breeding for higher yield in mungbean are often directed to increase the total dry matter production and better redistribution of photosynthesis. Plant with high dry matter production capacity does not mean high seed yield potential. Increase in yields over the past decade has been possible mainly through favorable partitioning into grains. It may be shown tor mungbean also the 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.

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

Moriondo *et al.* (2003) carried out experiment on defoliation of sunflower and no significant difference was observed in terms of plant height. Defoliation affected seed number per head, so that 34.5% reduction in seed number occurred by removal of 6 leaves from lower part of the plant .

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

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

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

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

Rockwood (1973) stated that increased foliage losses lead to reduction in reproduction of plants. Six costa rican tree species were defoliated by hand twice during 1970. Subsequent collection of fruit crops during 1971 showed that control totals for fruit number and weight were much larger than totals of defoliated trees in all six species. Over 80% of the experimental defoliated plants produced no fruit what so ever. Individual controls out-produced occurred in either. It is concluded that heavy defoliation of wild trees will practically eliminate seed production for the year in which it takes place. These data and other work with crop plants have shown that both growth and reproduction are functions of leaf area. Consequently, eave defoliation drastically reduced the fitness of a plant. Herbivore consumption of plant parts has probably played an important role in the evolution of both the morphology and chemistry of plants. These data support the view that physical and chemical defenses evolved by plants have played an important role in plant— herbivore co—evolution.

Wallace *et al*. (1985) stated the *Kyllinga nervosa* and *Themeda triandra* plants were subjected to different clipping and nitrogen availability regimes. Following an extended period of growth under these conditions, total biomass, gas exchange and several morphological parameters were measured. *Kyllinga nervosa* showed compensatory growth to moderate levels of clipping whereas any clipping reduced the total biomass of *T. triandra.* Unclipped plants of either species were unable to respond to increased levels of nitrogen. Clipped plants responded in an ambiguous fashion, with increased allocation to offtake (material removed by clipping) in both species. Total biomass of *K. nervosa* was highest at 15 mM nitrogen levels which are equivalent to field levels. Both photosynthesis and respiration rates were unaffected by nitrogen treatments. Photosynthesis was significantly reduced by the most severe clipping regime of *K. nervosa*, but was unaffected by clipping of *T. triandra.*

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

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

Wang *et al.* (1997) stated that plants have a balanced and definite relationship among its organs to maintain and complete it life cycle and all the related physiological and biochemical processes that need to be complete the life cycle. This relationship can be manipulated for achieving higher yields. Yields of plants depend on the source-sink relationship. In source limited plants, the yield can be increased by increasing the supply of photosynthates in the sink either removing the extra sink or increasing the activity/capacity of source while in the sink limited plants, the yield can be increased by either removing the extra source or increasing the area of sink. All of these phenomena can be manipulated either by changing genetic makeup of the plants or by adopting proper agronomic means (Li *et al*. 2005).

Tadesse *et al.* (2012) stated that leaf removal in many plants increased yields through increasing reproductive buds and diverting photosynthates to the developing reproductive structure.

Hortensteiner and Felller (2002) and Khan *et al.* (2007) found that defoliation of older and senescing leaves allowed the growth of functional and efficient leaves. This increased the photosynthetic potential of remaining leaves and leads to enhance biomass accumulation and seed yield.

Hicks et al. (1977) investigated that reduction in corn yield has been shown to be directly proportional to the percentage leaf area destroyed. The degree of yield loss caused by defoliation is also dependent on the growth stage when defoliation occurs with yield losses greatest during the late vegetative and reproductive stages (Singh and Nair 1975 and Thomson and Nafziger, 2003). Defoliation may affect the "source-sink balance" and kernel weight of corn (Tollenaar and Danyard,1978).

Halbrecq and Ledent (2001) found that small limitations of assimilates supplied by the defoliation of the leaves subtending the inflorescences seemed not to be an important factor in the regulation of buckwheat seed setting.

Hong *et al.* (1987) reported that bud removal in soybean resulted in an increase in the number of branches but there was no difference in total area and dry weight of the leaves.

Thomison and Geyer, (2006) demonstrated that leaf destruction at or before the V4/V5 stages has been associated with delays in crop maturity and higher grain moisture at harvest. Defoliation at tasseling and during grain fill, especially during the early kernel development stages, can accelerate crop maturity and result in lower est weight. Severe leaf loss during grain fill affects the nutritional value of corn by changing the chemical composition of the kernels. In the sink limited plants, the yield can be increased by either removing the extra source or increasing the area of sink. All of these phenomena can be manipulated either by changing genetic makeup of the plants or by adopting proper agronomic means (Li et al., 2005).

Thomison and Geyer (2006) reported that defoliation of corn during vegetative development (approx. V12) by hail and wind. Although such defoliation often results in yield loss, effects of this injury on stalk and grain quality are usually negligible. Defoliation of corn during grain fill (approximately R3-R4) caused by hail and wind. In addition to reducing grain yields by 40% or more, such defoliation injury may predispose corn to stalk rots that result in greater stalk lodging. This injury may also reduce test weight, hasten maturity, and alter kernel chemical composition (e.g. increase protein and reduce oil content).

Excision of the inflorescence resulted in greater proportions of assimilate being sent to all other sinks. Loss of the vegetative apical shoot had a quite different effect in that greater proportions of assimilate were exported only to the inflorescence. The complexity ofsource-sink relationships in indeterminate plant types showed simultaneous vegetative and reproductive growth. It was suggested that inflorescence growth in monopodial orchids such as Aranda was primarily source-limited although significant sink limitations for assimilate gain by the inflorescence exist because of a modulating effect of the vegetative apical shoot on inflorescence sink strength and the ability of source leaves to respond positively to increased sink demand (Clifford *et al.*,1995).

Walker and Ho (1977) and Downton *et al.* (1987) found that decreasing sink demand by removing fruit generally reduced leaf photosynthetic rate in many species, such as tomato (*Lycopersicum esculentum* Mill.) kiwifruit (*Actinidia deliciosa* Liang et Ferguson) (Buwalda and Smith, 1990), and *Satsuma mandarin* (Citrus unshiu Marc.) (Iglesias *et al.,* 2002). Similarly, in peach trees, the photosynthetic rate was greater for leaves with a high crop load than a low crop load (Quilot *et al.*, 2004).

Alados *et al.* (1997) stated that an enlargement of the stem, increase in leaf and flower number, greater vegetative growth and inflorescence length in albaida (*Anthylis cylisoides* L.) after 10 % and 50 % of leaf removal by clipping.

Chapter 3

Materials and Methods

Chapter 3

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka during the period from October 2017 to February 2018 to study the "Growth and yield response of mustard to leaf clipping". The mpaterials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Description of the experimental site

3.1.1 Site and soil

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

3.1.2 Climate and weather

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

3.2 Planting materials

BARI Sarisha-14

Developed by Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh which is developed by crossing between Tori and Sonali Sarisha. The year of release was 2006. Main characteristics are short duration , plant height 75-85 cm, leaf light green, smooth, siliqua/plant 80-102, two chambers are present in pod but as like as four chambers. Seed/siliqua 22-26, seed color pink, 1000 seed weight 3.5-3.8 g, crop duration 75-80 days, after harvest aman and before transplant boro. It is easily cultivated because of short duration. Planting season and time is rabi season, mid October to Mid November.Yield is 1.4-1.6 t/ha.

BARI Sarisa-15

Developed by Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh. Method of development/origin was selection from local germplasm.year of release was 2006. Main characteristics is short durated variety, plant height 90-100 cm, siliqua/plant 70-80, two chambers are present in pod, seed/siliqua 20-22, pod is narrow and taller than BARI sarisa -14, seed color yellow, 1000 seed weight 3.25-3.50 g, crop duration 80-85 days, after harvest aman and before transplant boro, it is easily cultivated because of short duration.Planting season and time is rabi season, Mid October to Mid November Yield is1.55-1.65 t/ha

BARI Sharisa-17

Developed by Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh. Method of development/origin was hybridization between BARI Sarisa 15 and Sonali Sarisa. Year of release was 2013. Main characteristics is short duration crop (duration 82-86 days), plant height 95-97 cm, plant don’t lodge, pod/plant 60-65, seed/pod 28-30, flower and seed color yellow, because of yellow seed color comparatively 3-4% oil is greater than brown color seed usually. 1000 seed weight 3-3.4g. Yield is 1.7-1.8 t/ha, 5-10 % greater yield than BARI Sarisa-14. Resistance /Tolerant to drought and salt stress, Alternaria blight disease Orabancy parasite.

3.3 Treatments under investigation

There were two factors in the experiment as mentioned below:

Factor A: Variety (3)

V_1 = BARI sarisha-14

V_2 = BARI Sarisha-15

V_3 = BARI Sarisha-17

Factor-B: Leaf clipping at flower initiation stage (5)

C_0 = No leaf clipping

C_1 = Clipping of 1st and 2nd leaf on main stem

C_2= Clipping of 2nd and 3rd leaf on main stem

C_3 =Clipping of 3rd and 4th leaf on main stem

C_4 = Clipping of 4th and 5th leaf on main stem

3.3.1 Treatment combinations

There were 15 treatment combinations of different leaf clipping and different varieties used in the experiment under as following:

1. V_1C_0	9. V_2C_3
2. V_1C_1	10.V_2C_4
3. V_1C_2	11.V_3 C_0
4. V_1C_3	12. V_3C_1
5. V_1C_4	13. V_3C_2
6. V_2C_0	14. V_3C_3
7. V_2C_1	15. V_3C_4
8. V_2C_2	

3.4 Experimental design and layout

The experiment was laid out in a split plot design having three replications. Each replication had 15 unit plots to which the treatment combinations were assigned randomly. The unit plot size was 2.4 m^2 (2m ×1.2 m). The blocks and unit plots were separated by 1 m and 0.5m spacing, respectively.

3.5 Land Preparation

The land was prepared by disc plough and then country plough to fully loose the soil. It was then harrowed again to bring the soil in a good tilth condition . Weeds, stubbles and crop residues were cleaned from the land. The layout was done as per experimental design on October 31, 2017.

3.6 Fertilizer application

The fertilizers were applied at the rate of 25,22, 20 and 5 kg ha^{-1} of N, P_2O_5, K_2O and S respectively (Fertilizer Recommendation Guide-2005). Two-third urea and whole amount of other fertilizers were applied as basal dose during final land preparation and rest one-third urea was applied at flowering stage.

3.7 Seed collection and sowing

The seeds were collected from mustard research centre of Bangladesh Agricultural Research Institute (BARI), at Joydebpur, Seeds were treated with Vitavax 200 @ the rate of 3 g kg^{-1} of seeds and sown in line on October 31, 2017 as per experimental treatments. The recommended seed was 7 kg/ha. After sowing the seeds were covered with loose friable soil.

3.8 Intercultural operations

3.8.1 Weeding

Weeds were controlled through three weedings at 10, 15, 20 days after sowing (DAS). The weeds identified were kakpaya ghash, wild mustard, kanta notae, shetodron, bathua etc.

3.8.2 Thinning

Thinning was done two times; first thinning was done at 8 DAS and second thinning was done at 15 DAS to maintain optimum plant population. Row to row and plant to plant distance was maintained 30 cm and 5 cm respectively.

3.8.3 Irrigation and drainage

Germination of seeds was ensured by light irrigation. Two irrigations were given, first irrigation was given at vegetative stage and second irrigation was given at flowering stage. Excess water of the field was drained out.

3.8.4 Insect and pest control

Autistin 20g/10L of water was sprayed of 5 decimal lands for two times at 15 days interval after seedlings germination.. Before sowing seeds were treated with Vitavax 200 @ the rate of 3 g kg^{-1} to protect seed borne disease. Malathion 57 EC @ 1.5 L ha^{-1} was sprayed when required.

3.9 Leaf clipping

Leaf clipping was done at flowering initiation stage by removing the whole leaf from different position with the help of a knife as per treatment.

3.10 Determination of maturity

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

3.11 Harvesting and sampling

Harvesting was done when about 80% of the siliquae became brown color. The matured siliquae were collected by hand picking on 31 January, 2018.

3.12 Threshing

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

3.13 Drying, cleaning and winowing

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

3.14 Parameters studied

- Plant height (cm)
- Number of branches $plant^{-1}$ (no.)
- Above ground dry matter $plant^{-1}$ (g)
- Fodder yield (t ha^{-1})
- Length of siliqua (cm)
- Siliquae/plant

- Seeds/siliqua
- 1000 seed weight (g)
- Seed yield (t ha^{-1})
- Stover yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest index (%)

3.15 Procedures of Data Collection

3.15.1 Plant height (cm)

The height of the selected plants were measured from the ground level to the tip of the plants at 15, 30 , 45, 60, and 75 days after sowing and harvest

3.15.2 Number of branches plant^{-1}

Number of branches per plant was counted from each selected plant sample and then averaged 15, 30, 35, 45,60, 75 days after sowing and harvest.

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

Total dry mater of plant at harvest was calculated by aggregating the dry matter weight of leaves, stems, roots, siliquae cover, seed and other immature reproductive parts.

3.15.4.Fodder Yield t ha^{-1}

Fodder yield was recorded after clipping the leaf from 2.4 m^2 and was expressed in terms of yield (t/ha^{-1}).

3.15.5. Length of siliqua (cm)

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

3.15.6. Siliquae plant^{-1}

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

3.15.7. Seeds siliqua^{-1}

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

3.15.8.1000 seed weight (g)

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

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

Seed yield was recorded on the basis of total harvested seeds from 2.4 m^2 and was expressed in terms of yield (t/ha^{-1}). Seed yield was adjusted about 12% moisture content.

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

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

3.15.11 Biological yield

The biological yield was calculated with the following formula-
Biological yield= Grain yield + Stover yield

3.15.12 Harvest index (%)

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

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

3.16 Data analysis

The collected data on different parameters were compiled and statistically analyzed to find out the significant difference of different mustard variety and leaf clipping on growth and yield contributing characters of mustard with the help of a computer package program MSTAT-C and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of significance.

Chapter 4

Result and Discussion

Chapter 4

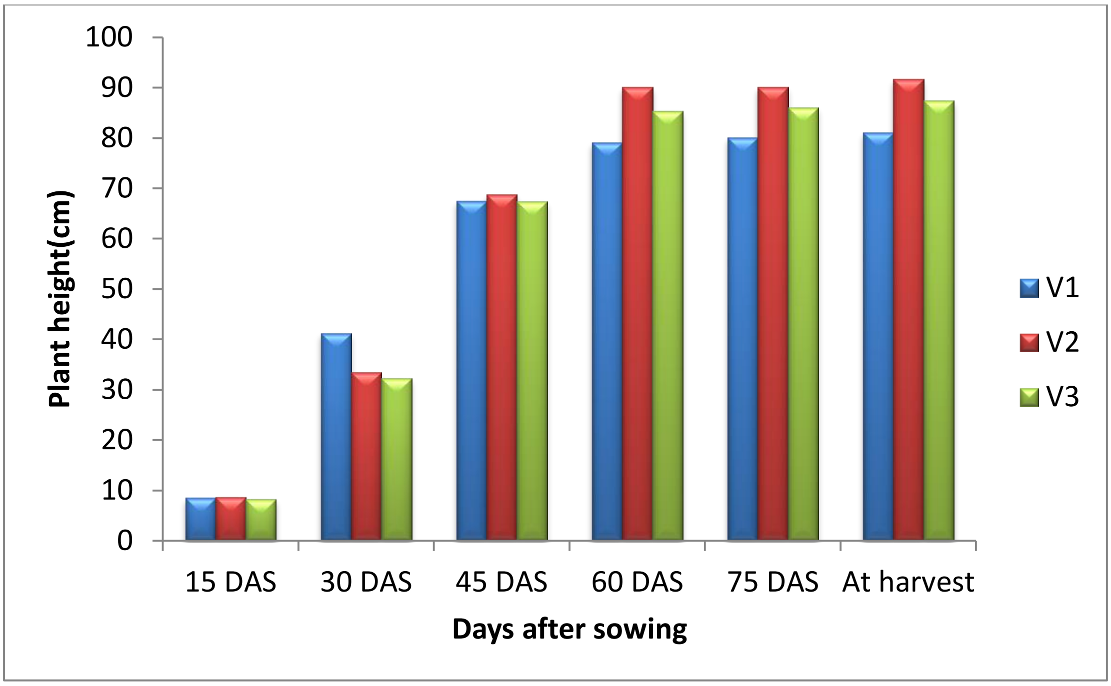
RESULTS AND DISCUSSION

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

4.1 Plant height

4.1.1 Effect of variety

The plant height was significantly varied with the different varieties at different DAS (Fig. 1). At 15 DAS, the tallest plant (8.67 cm) was obtained from V_2 which was statistically similar with $V_1$and V_3 variety. At 30DAS, highest plant height (41.25 cm) was obtained from V_1 and the lowest (32.24 cm) was obtained from V_3 variety which was statistically similar with V_2 variety. At 45 DAS, the tallest plant (68.78 cm) was obtained from V_2 which was statistically similar with V_1 and $V_{3.}$ At 60 DAS, the tallest plant (90.08 cm) was obtained from V_2 which was statistically similar withV_3 and the lowest (79.13 cm) was obtained from V_1 variety. At 75 DAS, the tallest plant (90.08 cm) was obtained from V_2 which was statistically similar with V_1 and $V_{3.}$ At harvest, the tallest plant (90.1 cm) was obtained from V_2 which was statistically similar with V_1 and $V_{3.}$

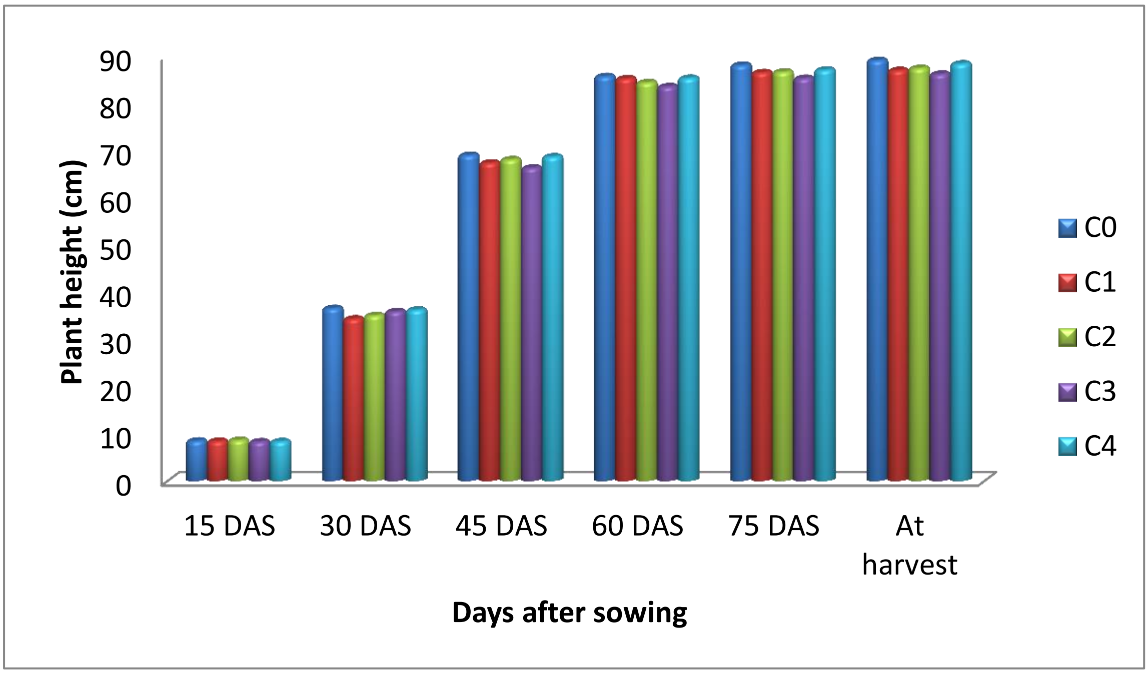


V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3=BARI Sarisha-17

Figure 1.Effect of varieties on the plant height of mustard at different DAS (LSD $_{(0.05)}$ = NS, NS, NS, 5.33, 5.35 and 5.37 at 30, 45, 60, 75 DAS and harvest respectively)

4.1.2 Effect of clipping

There was a significant variation in plant height at different DAS in different leaf clipping (Fig.2). At 15 DAS, the tallest plant (8.66 cm) was obtained from C_2 which was statistically similar with, $C_{0,}$ $C_{1,}$ C_3 and C_4 treatment. At 30DAS, the tallest plant (66.57cm) was obtained from C_1 which was statistically similar with, $C_{0,}$ $C_{2,}$ C_3 and C_4 treatment. At 45DAS, the tallest plant (69.02cm) was obtained from C_1 which was statistically similar with, C_0 $C_{2,}C_3$ and C_4 treatment. At 60DAS, the tallest plant (85.7cm) was obtained from C_1 which was statistically similar with, C_0 $C_{2,}$ C_3 and C_4 treatment. At 75DAS, the tallest plant (88.09cm) was obtained from C_1 which was statistically similar with, $C_{0,}$ $C_{2,}C_3$ and C_4 treatment. At harvest, the tallest plant (89.cm) was obtained from C_1 which was statistically similar with , $C_{0,}$ $C_{2,}C_3$ and C_4 treatment.



C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem.

Figure.2: Effect of leaf clipping on the plant height of mustard at different days after sowing. ($LSD_{0.05}$= NS, NS, NS, NS, NS at 15, 30, 45,60,75DAS and harvest respectively).

4.1.3 Combined effect of variety and leaf clipping on the plant height of mustard

Combined effect of variety and leaf clipping on the plant height of mustard are significant at plant height (Table 1). At 15 DAS, the tallest plant (9.33cm) was obtained fromV_2C_2 which was statistically similar with V_1C_0, V_1C_2, V_1C_3, V_1C_4, V_2C_0,V_2C_1, V_3C_1 and, V_3C_3 treatment. The lowest (7.94 cm) was obtained from V_1C_1 which was statistically similar with V_2C_3, V_2C_4, V_3C_0, V_3C_2, V_3C_4 treatment. At 30DAS the tallest plant (45.44 cm) was obtained from V_1C_0 which was statistically similar with, V_1C_3 and V_1C_4 treatment. The lowest (31.55 cm) was obtained from V_2C_3 which was statistically similar with V_2C_0,V_2C_1,V_2C_2,V_2C_4,V_3C_0 ,V_3C_2 V_3C_3, V_3C_4 treatment. At 45DAS, the tallest plant (72.72cm) was obtained from V_2C_1 which was statistically similar with V_1C_0,V_1C_2,V_1C_3,V_1C_4,V_2C_0,V_2C_2,V_2C_3,V_2C_4 V_3C_0,V_3C_1, V_3C_2,V_3C_3, V_3C_4 treatment. At 60DAS the tallest plant (92.54 cm) was obtained from V_2C_0 which was statistically similar with V_2C_1,V_2C_2,,V_2C_4,andV_3C_2 treatment. The lowest (75.09 cm) was obtained from V_1C_2 which was statistically similar with V_1C_0, V_1C_1, V_1C_3 treatment. At 75DAS, the tallest plant (93.80cm) was obtained from V_2C_0 which was statistically similar with V_2C_1, V_2C_2, V_2C_4, and V_3C_2 and treatment. The lowest (76.81 cm) was obtained fromV_1C_2 which was statistically similar with V_1C_2 and V_1C_3 treatment.

Table 1.Combined effect of variety and leaf clipping on the plant height of mustard at different days after sowing

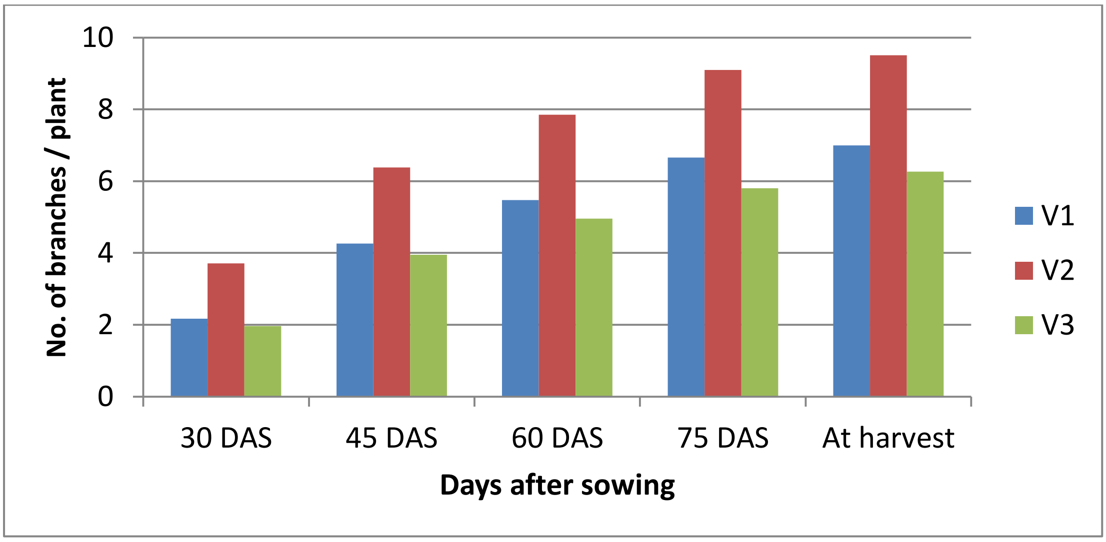
	Plant height (cm) at					
Treatment	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	Harvest
V_1C_0	8.38 ab	45.44 a	71.70 a	79.94 b-d	81.94 a-d	82.28 bc
V_1C_1	7.94 b	36.51 cd	60.90 b	79.39 cd	80.62 b-d	81.00 bc
V_1C_2	8.65 ab	39.47 bc	66.29 ab	75.09 d	76.81 d	77.31 c
V_1C_3	8.77 ab	43.01 ab	67.86 ab	78.11 cd	79.59 cd	80.21 bc
V_1C_4	8.84 ab	41.81 ab	71.10 a	83.11 a-d	84.30 a-d	84.74 a-c
V_2C_0	9.01 ab	32.24 de	65.93 ab	92.54 a	93.80 a	94.35 a
V_2C_1	8.84 ab	34.86 de	72.72 a	91.42 ab	91.00 a-c	91.36 ab
V_2C_2	9.32 a	33.57 de	72.44 a	89.91 a-c	91.81 ab	92.18 ab
V_2C_3	8.03 b	31.55 e	63.79 ab	86.83 a-d	88.15 a-d	88.57 a-c
V_2C_4	8.12 b	34.83 de	69.05 ab	89.69 a-c	91.52 a-c	91.90 ab
V_3C_0	8.14 b	32.02 de	69.44 ab	84.63 a-d	87.24 a-d	87.65 a-c
V_3C_1	8.59 ab	31.72 e	68.56 ab	84.90 a-d	86.71 a-d	87.22 a-c
V_3C_2	7.99 b	32.17 de	65.57 ab	88.23 a-c	90.04 a-c	90.49 ab
V_3C_3	8.22 ab	33.16 de	67.34 ab	85.69 a-d	86.82 a-d	87.16 a-c
V_3C_4	8.17 b	32.10 de	65.94 ab	83.22 a-d	84.41 a-d	84.61 a-c
$LSD_{(0.05)}$	1.13	4.53	9.5	11.91	12.00	12.04
CV(%)	7.92	7.54	8.3	8.33	8.25	8.24

C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem. V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3=BARI Sarisha-17 LSD=Least significance difference, CV=Coefficient of variation

4.2. Number branches/plant

4.2.1 Effect of variety

The number of branches plant^{-1}was also significantly influenced by variety (Fig. 3) At 30 DAS, the highest number of branches was obtained fromV_2 (3.71) variety. The lowest number of branches was obtained from V_1 (2.17) variety which was statistically similar with V_3 variety. At 45 DAS, the maximum number of branch was obtained from V_2 (6.38) variety. The minimum number of branches was obtained fromV_3 (3.95) which was statistically similar with V_1 variety. At 60 DAS, the highest number of branch (7.85) was obtained from V_2 variety. The lowest number of branches (4.96) was obtained from V_3 which was statistically similar with V_1 variety. At 75 DAS, the highest number of branch (9.1) was obtained from V_2 variety. The lowest number of branches (5.81) was obtained from V_3 which was statistically similar with V_1 variety. At harvest, the highest number of branches (9.51) was obtain in V_2 variety while the lowest number (6.27) from V_1 which was statistically similar with V_3 variety. The results are in agreement with those of Jahan and Zakaria (1997) who observed and reported that Tori-7 produce the highest number of primary branches / plant.

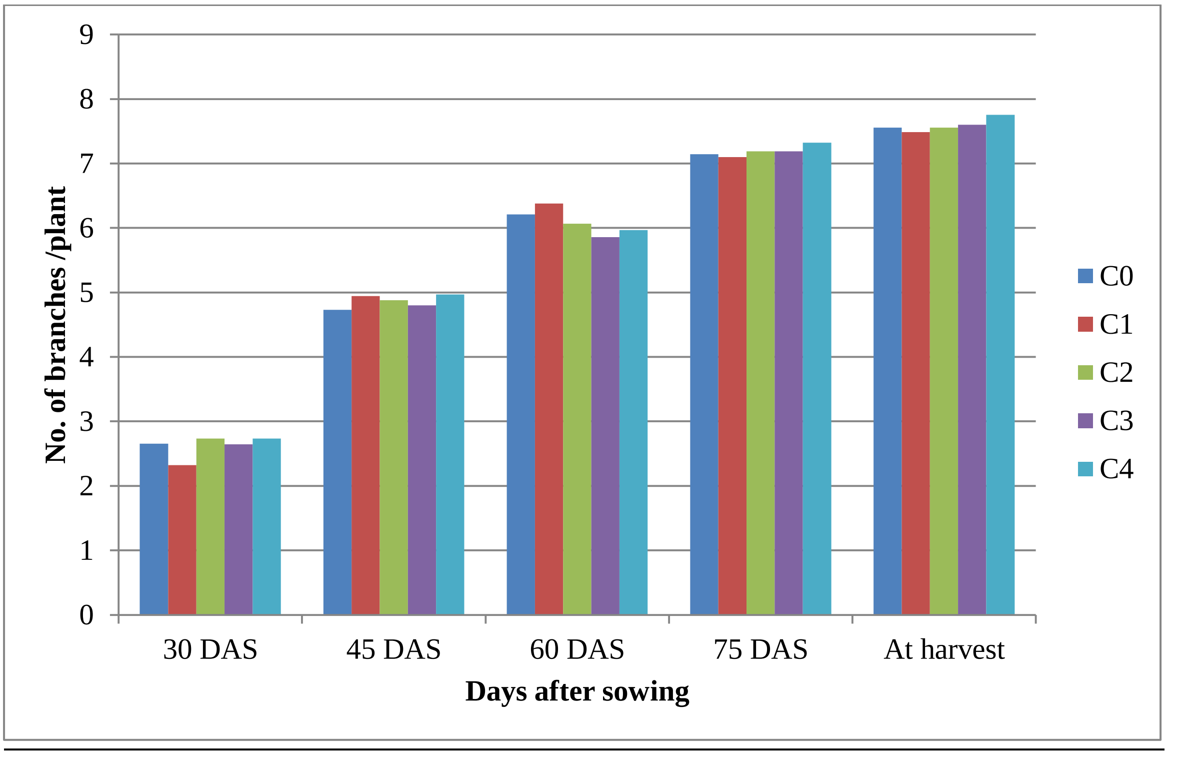


V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3= BARI Sarisha-17

Figure 3: Effect of varieties on the number of branches plant^{-1} of mustard at different DAS (LSD $_{(0.05)}$ = 0.77,0.74, 0.86, 0.76, and 0.74 0.19 at 30, 45, 60, 75 DAS and harvest respectively)

4.2.2 Effect of leaf clipping

Number of branches plant^{-1} was significantly varied with leaf clipping (Fig. 4). At 30 DAS, the highest number of branches was obtained from C_2 (2.73) treatment which was statistically similar with C_0, C_1, C_3, C_4 treatment. At 45 DAS, the maximum number of branches was obtained from C_4 (4.97) treatment which was statistically similar with C_0, C_1, C_2, C_3 treatment. At 60 DAS, the highest number of branches (6.38) was obtained from C_1 treatment which was statistically similar with C_0, C_2, C_3, C_4 treatment. At 75 DAS, the highest number of branches (7.32) was obtained from C_4 treatment which was statistically similar with C_0,C_1, C_2, C_3 treatment. At harvest, the highest number of branches (7.77) was obtained in C_4 treatment which was statistically similar with C_0, C_1, C_2 and C_3 treatment.



C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem.

Figure.4:Effect of leaf clipping on the number of branches plant^{-1} of mustard at different DAS (LSD $_{(0.05)}$ = NS, NS, NS, NS and NS at 15, 30, 45, 45, 60, 75 DAS and at harvest respectively)

4.2.3 Combined effect of variety and leaf clipping on the number of branches plant^{-1}of mustard

Interaction effect of variety and leaf clipping was significant on number of branches plant^{-1} (Table 2). At 30 DAS, the highest number of branches was obtained from V_2 C_2 (4.3) treatment combination which was statistically similar with V_2C_0,V_2C_3 and V_2C_4.The lowest number of branches was obtained from V_1C_2 (1.73) treatment combination which was statistically similar with V_1C_0, V_1C_3, V_1C_4, V_3C_0, V_3C_1, V_3C_2, V_3C_0, V_3C_4 treatment combination. At 45 DAS, the highest number of branches was obtained fromV_2C_2 (6.73) treatment combination which was statistically similar with V_2C_0, V_2C_1, V_2C_3, V_2C_4.The lowest number of branches was obtained from V_3C_0 (3.2) treatment combination which was statistically similar with V_1C_1, V_1C_2, V_1C_3, V_1C_4, V_3C_1, V_3C_2, V_3C_3, V_3C_4 treatment combination. At 60 DAS, the highest number of branches was obtained from V_2C_0 (8.53) treatment combination which was statistically similar with V_2C_0, V_2C_1, V_2C_1, V_2C_3, V_2C_4. The lowest number of branches was obtained from V_3C_2 (4.5) treatment combination which was statistically similar with V_1C_0, V_1C_1, V_1C_2, V_1C_3, V_1C_4, V_3C_0, V_3C_1, V_3C_2, V_3C_3, V_3C_4 treatment combination. At 75 DAS, the highest number of branches was obtained fromV_2 C_0 (9.73) treatment combination which was statistically similar with V_2C_0, V_2C_1, V_2C_2, V_2C_3, V_2C_4. The lowest number of branches was obtained from V_3C_0 (5.47) treatment combination which was statistically similar with V_1C_0, V_1C_1, V_1C_2, V_1C_3, V_1C_4, V_3C_1, V_3C_2, V_3C_3, V_3C_4 treatment combination.. At harvest, the highest number of branches was obtained fromV_2C_0 (9.8) treatment combination which was statistically similar with V_2C_1, V_2C_3, V_2C_2 ,V_2C_4.The lowest number of branches was obtained from V_3C_0 (5.47) which was statistically similar with V_1C_0, V_1C_1, V_1C_2, V_1C_3, V_1C_4, V_3C_0, V_3C_1, V_3C_2, V_3C_3, V_3C_4 treatment combination.

Table 2. Combined effect of leaf clipping and variety on the number of branches plant^{-1}of Mustard

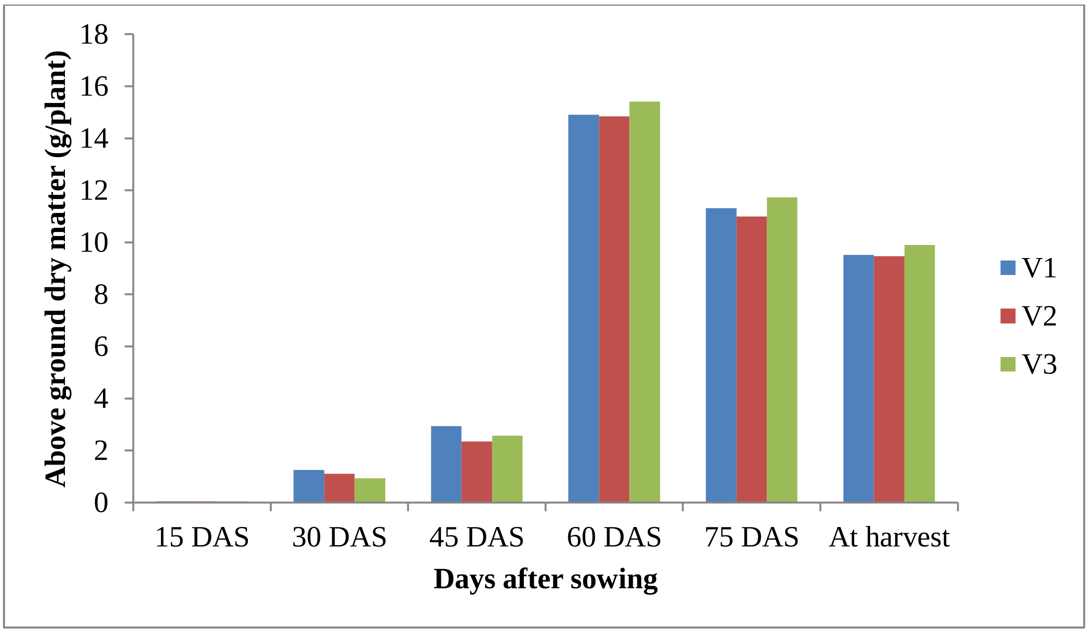
	Number of branches /plant at				
Treatment	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**Harvest**
V_1C_0	2.53 b-e	4.50 bc	5.70 cd	6.60 cd	7.00 b
V_1C_1	1.90 de	4.33 c	5.70 cd	6.73 cd	7.13 b
V_1C_2	1.73 e	4.16 c	5.90 b-d	6.77 cd	7.20 b
V_1C_3	2.26 c-e	3.70 c	4.53 d	6.00 cd	6.27 b
V_1C_4	2.43 b-e	4.63 bc	5.53 d	7.20 bc	7.40 b
V_2C_0	4.06 ab	6.50 a	8.33 a	9.37 a	9.80 a
V_2C_1	2.80 a-e	6.13 ab	7.87 a	8.80 ab	9.13 a
V_2C_2	4.300 a	6.73 a	7.80 ab	9.27 a	9.53 a
V_2C_3	3.53 a-d	6.43 a	7.80 ab	9.10 a	9.67 a
V_2C_4	3.86 ab	6.10 ab	7.46 a-c	8.96 a	9.40 a
V_3C_0	1.36 e	3.20 c	4.60 d	5.46 d	5.87 b
V_3C_1	2.26 c-e	4.36 c	5.57 cd	5.77 cd	6.20 b
V_3C_2	2.16 c-e	3.73 c	4.50 d	5.53 cd	5.93 b
V_3C_3	2.13 de	4.27 c	5.23 d	6.46 cd	6.87 b
V_3C_4	1.90 de	4.17 c	4.90 d	5.80 cd	6.47 b
LSD($_{0.05}$)	**1.73**	**1.645**	**1.912**	**1.714**	**1.652**
CV(%)	**39.23**	**20.07**	**18.61**	**14.15**	**12.91**

C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem. V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3=BARI Sarisha-17 LSD=Least significance difference, CV=Coefficient of variance

4.3 Above Ground Dry Matter Plant^{-1}

4.3.1 Effect of variety

Above Ground dry matter Plant^{-1} was also significantly influenced by variety (Fig. 5 and table 3). At 15 DAS, highest (0.04g) dry matter plant^{-1} was obtained from V_3 treatment which was statistically similar with V_1 and V_2. At 30 DAS, the highest dry matter plant^{-1} (1.25 g) was obtained from V_1 variety which was statistically similar with V_2 where the lowest dry matter plant^{-1} (0.94 g) was obtained from V_3 variety. At 45 DAS, the maximum dry matter plant^{-1} (2.94 g) was obtained from V_1 which was statistically similar with V_2 andV_3 variety. At 60 DAS, the maximum dry matter plant^{-1}(15.41g) was obtained from 3_1variety which was statistically similar with V_2 and V_3 variety. At 75 DAS, the maximum dry matter plant^{-1}(11.73g) was obtained from V_3 variety which was statistically similar with V_1 and V_2 variety. At harvest maximum dry matter plant^{-1} (9.90 g) was obtained from V_3 variety which was statistically similar with V_1 and V_2 variety.



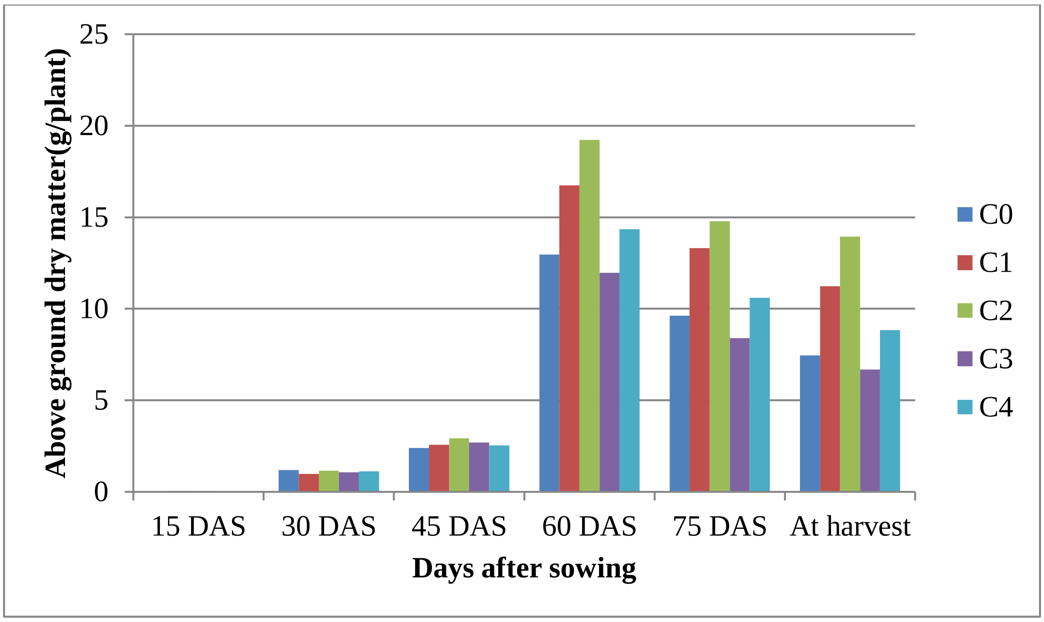
V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3= BARI Sarisha-17

Figure 5: Effect of varieties on the above ground dry matter plant^{-1} of mustard at different DAS (LSD $_{(0.05)}$ = NS, 0.15, 0.20,2.69,3.03, and 3.03 at 15.30, 45, 60, 75 DAS and harvest respectively)

4.3.2Effect of leaf clipping

Above Ground dry matter Plant^{-1} was also significantly influenced by leaf clipping (Fig. 6) At 15 DAS, the highest dry weight of was obtained from C_2 (0.05 g) treatment and the lowest dry weight was found from C_3 (0.04 g) treatment. At 30 DAS, the highest dry weight of was obtained from C_0 (1.18 g) treatment and the lowest dry weight was found from C_1 (0.98 g) treatment. At 45 DAS, the highest dry weight of was obtained from C_2 (2.91 g) and it was statistically similar with C_2 and C_3

treatment and the lowest dry weight was found from C_0 (2.39 g) and it was statistically similar with C_1 and C_4 treatment. At 60 DAS, the highest dry weight of was obtained from C_2 (19.24 g) and it was statistically similar with C_1 and the lowest dry matter obtained from C_3 (11.97g) which was statistically similar with C_2, C_3 and C_4 treatment. At 75 DAS, the highest dry weight of was obtained from C_2 (14.79g) and it was statistically similar with C_1 and the lowest dry weight was found from C_3 (8.39 g) and it was statistically similar with C_0, C_3, and C_4 treatment. At harvest, the highest dry weight of was obtained from C_2 (13.94 g) and it was statistically similar with C_1 and the lowest dry weight was found from C_3 (6.67g) and it was statistically similar with C_0 and C_4 treatment. There was evidence that removing even a vegetative part modified the growth of another vegetative organ. Although very few works have proved that removing whole or a portion of reproductive part have changed in the vegetative part. Bud removal in soybean resulted in an increase in the number of branches but there was no difference in total area and dry weight of the leaves (Hong *et al.* 1987).



C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem.

Figure.6: Effect of leaf clipping on the above ground dry matter plant^{-1} of mustard at different DAS (LSD $_{(0.05)}$ = NS,0. 199, 0.259, 3.22, 3.04 and 3.04 at 15, 30, 45, 45, 60, 75 DAS and at harvest respectively)

4.3.3 Combined effect of variety and leaf clipping

Above ground dry matter Plant^{-1} was also significantly influenced by combined effect of variety and leaf clipping (Table 3). At 15 DAS, the highest dry weight was obtained from V_1C_2 (0.06 g) and the lowest dry weight was found from V_2C_3 (0.03 g) treatment. At 30 DAS, the highest dry weight was obtained from V_1C_2 and V_1C_3 (1.35 g) and it was statistically similar with V_1C_0, V_1C_4 and V_2C_0 treatment and the lowest dry weight was found from V_3C_1 (0.85 g) and it was statistically similar with V_2C_1 ,V_2C_2, V_2C_3, V_2C_4, V_3C_0, V_3C_2, V_3C_3 and V_3C_4 treatment. At 45 DAS, the highest dry weight was obtained from V_1C_2 (3.22 g) and it was statistically similar with V_1C_3 and V_1C_4 treatment and the lowest dry weight was found from V_2C_0 (2.22 g) and it was statistically similar with V_1C_0, V_2C_1, V_2C_2, V_2C_3, V_2C_4, V_3C_0, V_3C_1, V_3C_4 treatment combination. At 60DAS, the highest dry weight was obtained from V_2C_3 (20.39 g) and it was statistically similar with V_1C_0,V_2C_0 and V_3C_1 treatment and the lowest dry weight was found from V_3C_3 (10.00 g) and it was statistically similar with V_1C_1, V_1C_3, V_1C_4, V_2C_2, V_2C_3, V_3C_0, V_3C_2 and V_3C_4 treatment combination. At 75DAS, the highest dry weight was obtained from V_3C_2 (16.22 g) and it was statistically similar with V_3C_0, V_1C_0, V_1C_1 treatment combination and the lowest dry weight was found from V_3C_3 (6.17g) and it was statistically similar with,V_1C_1, , V_1C_3, V_1C_4, V_2C_2 , V_2C_3, V_2C_4, V_3C_1 and V_3C_4 treatment combination. At harvest, the highest dry weight was obtained from V_3C_2 (14.87g) and it was statistically similar with V_1C_0, V_1C_2, V_2C_0, V_2C_1, V_3C_1 treatment and the lowest dry weight was found from V_3C_3 (4.48 g) and it was statistically similar with V_1C_1, V_1C_3, V_1C_4, V_2C_2, V_2C_3, V_2C_4 and V_3C_4 treatment combination.

Table 3. Combined effect of leaf clipping and variety on the above ground dry matter plant^{-1} of mustard.

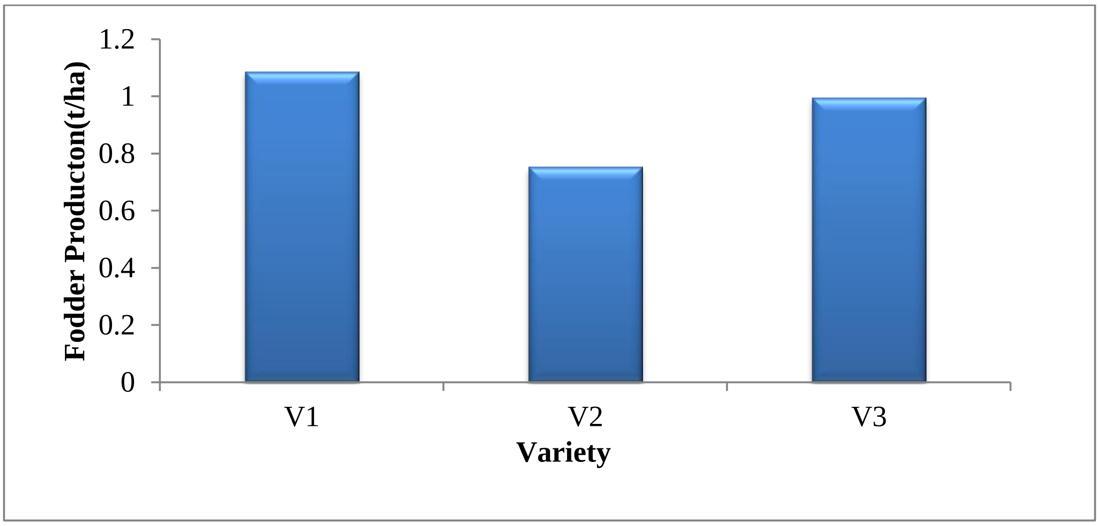
	Above ground dry matter (g plant^{-1}) at					
Treatment	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**Harvest**
V_1C_0	0.038	1.29 ab	2.54 d-g	17.27 a-c	13.28 a-c	12.42 ab
V_1C_1	0.047	0.99 b-d	2.79 a-e	13.84 c-e	10.71 b-e	8.317 b-d
V_1C_2	0.059	1.35 a	3.22 a	15.87 a-d	12.26 a-d	10.35 a-c
V_1C_3	0.034	1.35 a	3.12 ab	13.12 c-e	9.783 b-e	7.60 b-d
V_1C_4	0.031	1.28 ab	3.03 a-c	14.42 b-e	10.54 b-e	8.89 b-d
V_2C_0	0.041	1.20 a-c	2.22 g	20.05 a	14.89 ab	14.53 a
V_2C_1	0.045	1.09 a-d	2.37 e-g	16.66 a-c	13.04 a-c	11.14 a-c
V_2C_2	0.051	1.11 a-d	2.59 c-g	10.49 de	7.32 de	4.97 d
V_2C_3	0.03	0.97 a-d	2.25 fg	12.78 c-e	9.22 c-e	7.94 b-d
V_2C_4	0.037	1.15 a-d	2.28 fg	14.25 b-e	10.49 b-e	8.73 b-d
V_3C_0	0.039	1.05 a-d	2.41 e-g	12.55 c-e	16.20 a	7.03 cd
V_3C_1	0.05	0.85 d	2.53 d-g	19.75 ab	9.27 c-e	14.23 a
V_3C_2	0.047	0.99b-d	2.92 a-d	20.39 a	16.22 a	14.87 a
V_3C_3	0.043	0.88 cd	2.68 b-f	10.00 e	6.17 e	4.48 d
V_3C_4	0.041	0.92 cd	2.28 fg	14.39 b-e	10.77 b-e	8.87 b-d
LSD $_{(0.05)}$	**NS**	**0.3454**	**0.449**	**5.57**	**5.26**	**5.26**
CV(%)	**18.02**	**18.62**	**10.21**	**21.96**	**27.50**	**32.32**

C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem. V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3=BARI Sarisha-17 LSD=Least significance difference, CV=Coefficient of variation

4.4 Fodder production (t/ha)

4.4.1 Effect of variety

Variety had been significant variation in fodder production after clipping and it was also observed in studied varieties of mustard (Fig 7). The highest fodder (1.09 t/ha) was recorded in V_1which was statistically similar with V_3 while the lowest (0.75t/ha) was obtained from V_2 variety.

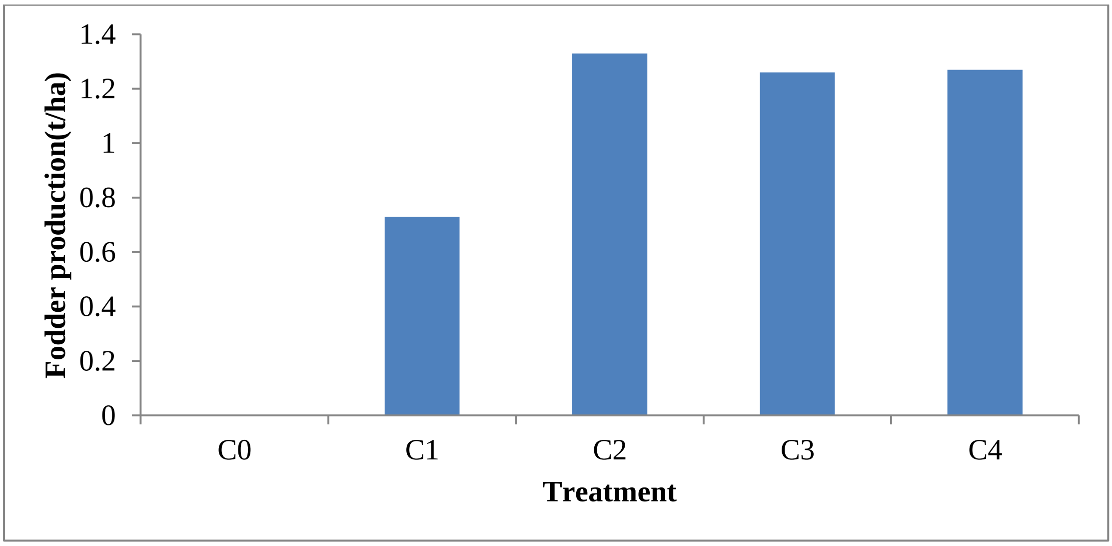


V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3= BARI Sarisha-17

Figure:7 Effect of varieties on in fodder production (t/ha) after clipping (LSD $_{(0.05)}$ =0.16

4.4.2.Effect of leaf clipping

There was significant variation in fodder production after clipping due to the leaf clipping (Fig.8). The maximum fodder (1.33 t/ha) was obtained from C_2 which was statistically similar with C_3, C_4 and while the lowest (0.00 t/ha) was obtained from C_0 (no clipping) treatment.



C_0 = No leaf clipping,C_1 = Clipping of 1^{st} and 2^{nd} leaf at main stem,C_2= Clipping of 2^{nd} and 3^{rd} leaf at main stem,C_3 =Clipping of 3^{rd} and 4^{th} leaf at main stem,C_4 = Clipping of 4^{th} and 5^{th} leaf at main stem.

Figure:8 Effect of leaf clipping on fodder production/ha after clipping (LSD $_{(0.05)}$ =0.20)

4.4.3 Combined effect of variety and leaf clipping fodder production after clipping

Interaction effect of different leaf clipping and varieties had a significant variation fodder production after clipping (Table 4).The highest fodder (1.59 t/ha) was obtained from V_1C_2 which was statistically similar with V_1C_4, V_1C_3, V_3C_2, V_3C_3 and V_3C_4 treatment combination whiles the lowest (0.00 t/ha) was obtained from V_1C_0, V_2C_0 and V_3C_0.

Table 4: Combined effect of variety and leaf clipping of mustard on fodder production after clipping

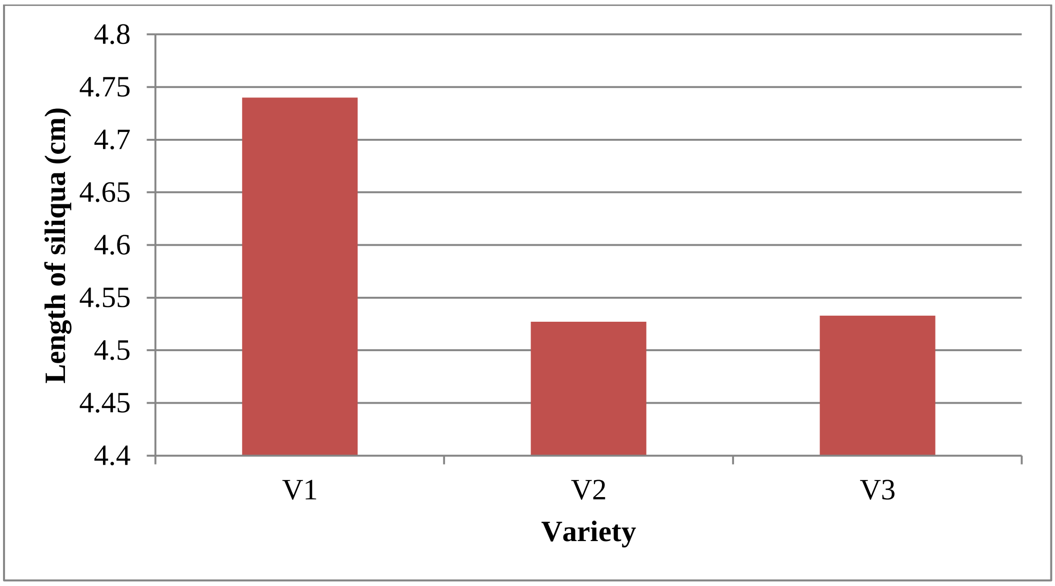
Treatment	Fodder production (t/ha)
V_1C_0	0.00 f
V_1C_1	0.80 de
V_1C_2	1.59 a
V_1C_3	1.51 ab
V_1C_4	1.52 ab
V_2C_0	0.00 f
V_2C_1	0.64 e
V_2C_2	1.19 bc
V_2C_3	0.79 de
V_2C_4	1.13 cd
V_3C_0	0.00 f
V_3C_1	0.75 e
V_3C_2	1.27 a-c
V_3C_3	1.46 a-c
V_3C_4	1.49 ab
$LSD_{(0.05)}$	0.35
CV (%)	21.94

C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem. V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3=BARI Sarisha-17 LSD=Least significance difference,

4.5 Length of siliqua

4.5.1 Effect of variety

Length of siliqua is one of the most important yield contributing characters of mustard. (Fig. 9).Varieties showed significant variation in siliqua length. The longest siliqua (4.74 cm) was recorded in V_1. The shortest siliqua (4.5 cm) was observed in V_2. The findings is in conformity with those of Jahan and Zakaria, (1997), Gangasaran *et al.* (1981) and Hussain *et al*. (1996) who observed a significant variation in siliqua length among the different varieties of mustard.

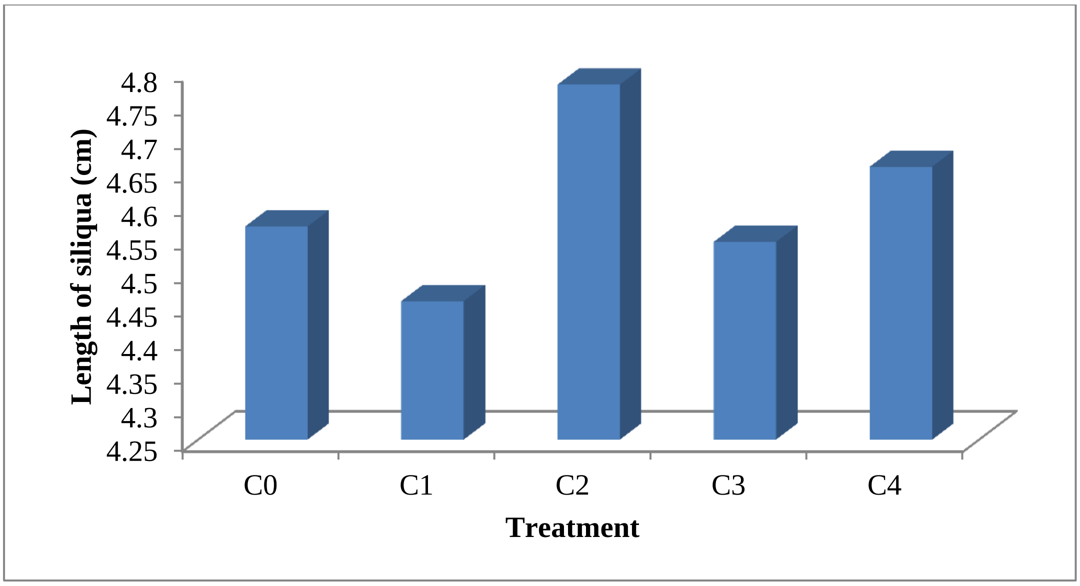


V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3=BARI Sarisha-17

Figure 9: Effect of varieties on length of siliqua ($LSD_{0.05}$=0.21)

4.5.2 Effect of leaf clipping

There was a significant variation with the siliqua length of mustard due to the leaf clipping. Leaf clipping showed significant variation in siliqua length (Fig.10). The longest siliqua (4.78 cm) was recorded in C_2. The shortest siliqua (4.46 cm) was observed in C_1 treatment.



C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem.

Figure 10: Effect of leaf clipping on the the length of siliqua $LSD_{0.05}$=(0.27)

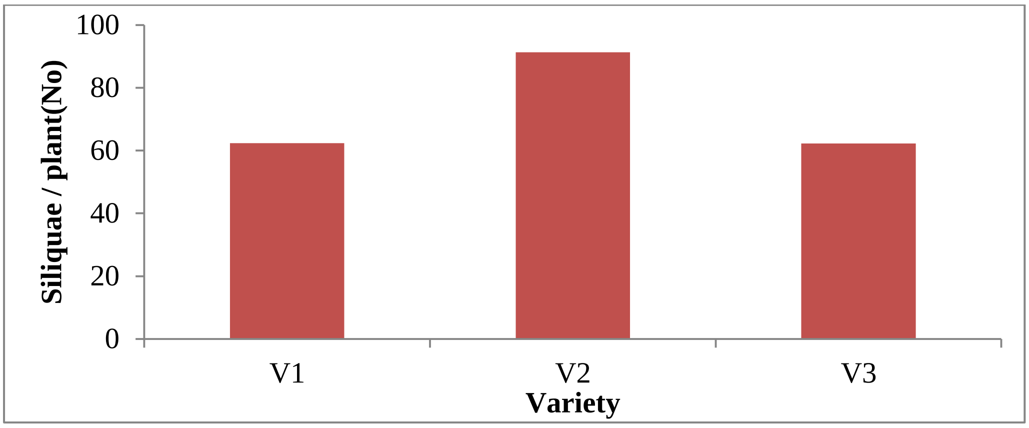
4.5.3 Combined effect of variety and leaf clipping

Interaction effect of leaf clipping and variety was significant on siliqua length of mustard (Table 5). The highest pod length (5.07 cm) was obtained from V_1C_2 treatment combination) which was statistically similar with V_1C_2 whiles the lowest (4.3cm) from V_2C_1 which was statistically similar with V_1C_0, V_1C_1, V_1C_3, V_2C_0, V_2C_2, V_2C_3, V_2C_4, V_3C_0, V_3C_1, V_3C_2, V_3C_3, V_3C_4 treatment combinations.

4.6 Siliqua/plant

4.6.1 Effect of variety

Siliquae plant^{-1} was affected significantly by different variety of mustard (Fig.11). The highest number of siliquae plant^{-1} of mustard (91.29) was obtained from V_2 variety. The lowest number of siliquae plant^{-1} of mustard (62.23) was obtained from V_3 variety which was statistically similar with V_2 variety. Mondal *et al*. (1992), Hussain *et al.* (1996), Jahan and Zakaria (1997) and Hossen (2005), reported that significant variation was found in number of siliqua per plant in different mustard varieties.

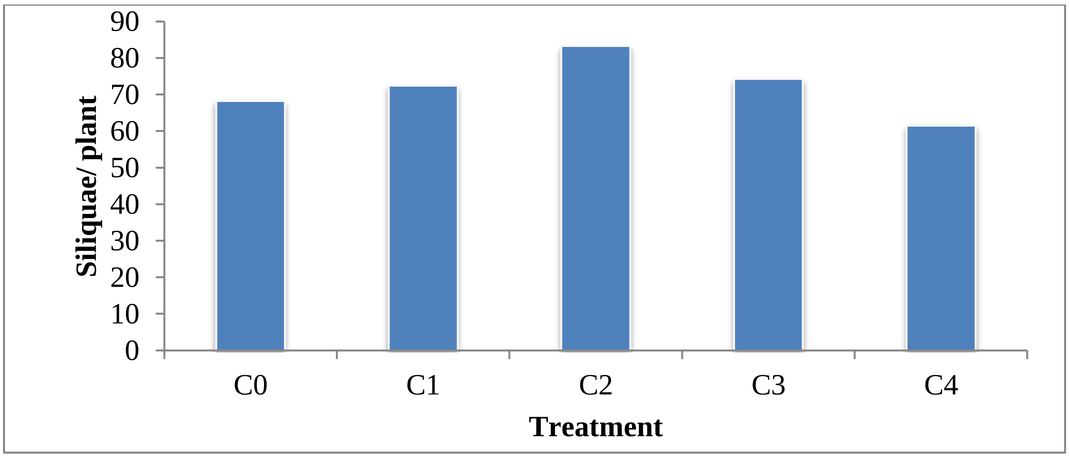


V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3= BARI Sarisha-17

Figure11. Effect of varieties on siliquae/plant (LSD $_{(0.05)}$ =7.91)

4.6.2 Effect of clipping

Siliquae plant^{-1} was affected significantly by different leaf clipping of mustard (Fig. 12). The highest number of siliquae plant^{-1} of mustard (91.29) was obtained from C_2 treatment was statistically similar with C_3 treatment. The lowest number of siliquae plant^{-1} of mustard (61.53) was obtained from C_4 treatment which was statistically similar with C_0 treatment.



C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem.

Figure 12. Effect of leaf clipping on siliquae plant^{-1} (LSD $_{(0.05)}$ =10.21)

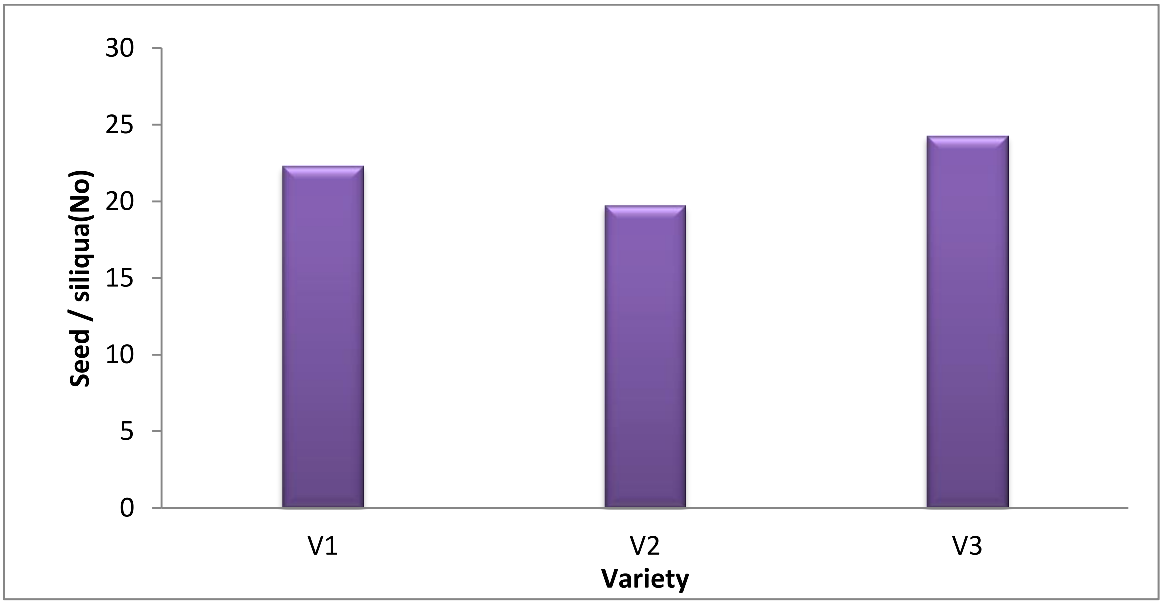
4.6.3 Combined effect of variety and leaf clipping

Siliquae plant^{-1} was affected significantly by Interaction effect of variety and leaf clipping of mustard (Table 5). The highest number of siliquae plant^{-1} of mustard (102.4) was obtained from V_2C_2 treatment combination which was statistically similar with V_2C_0,V_2C_1 & V_2C_3 treatment combination. The lowest number of siliquae plant^{-1} of mustard (51.13) was obtained from V_3C_4 treatment which was statistically similar with V_1C_0, V_1C_1, V_1C_3, V_1C_4, V_3C_0, V_3C_1 and V_3C_3 treatment combination.

4.7 Seeds / siliqua

4.7.1 Effect of variety

Seeds/siliqua was affected significantly by different variety of mustard (Fig.13) The highest number of seeds/siliqua of mustard (24.28) was obtained from V_3 variety. The lowest number of seeds/siliqua of mustard (19.75) was obtained from V_2 variety which was statistically similar with V_1 variety.

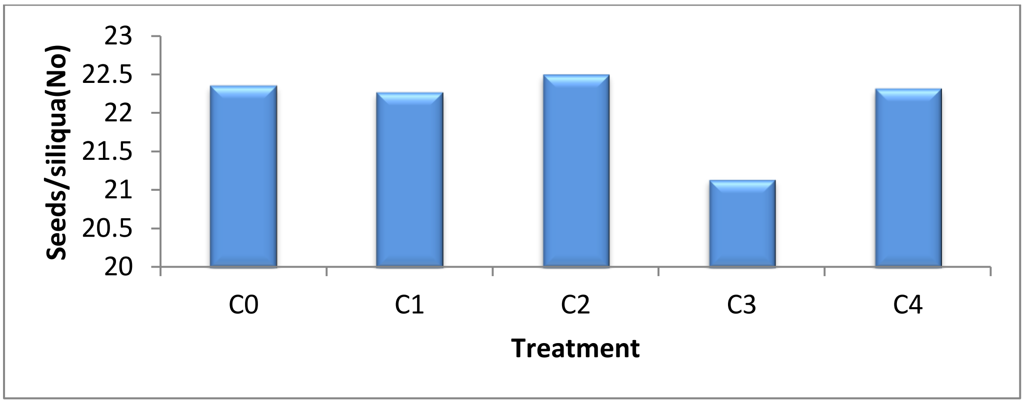


V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3= BARI Sarisha-17

Figure 13.Effect of varieties on seeds/siliqua (LSD $_{(0.05)}$ =0.609)

4.7.2 Effect of leaf clipping

Seeds/siliqua was affected significantly by different leaf clipping (fig.14). The highest number of seeds/siliqua (22.50) was obtained from C_2 treatment which was statistically similar with $C_{0,}$ C_1, C_4 treatment. The lowest number of seeds/siliqua of mustard (21.14) was obtained from C_3 treatment.



C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem

Figure 14. Effect ofleaf clipping on seeds/siliqua (LSD $_{(0.05)}$ =0.786)

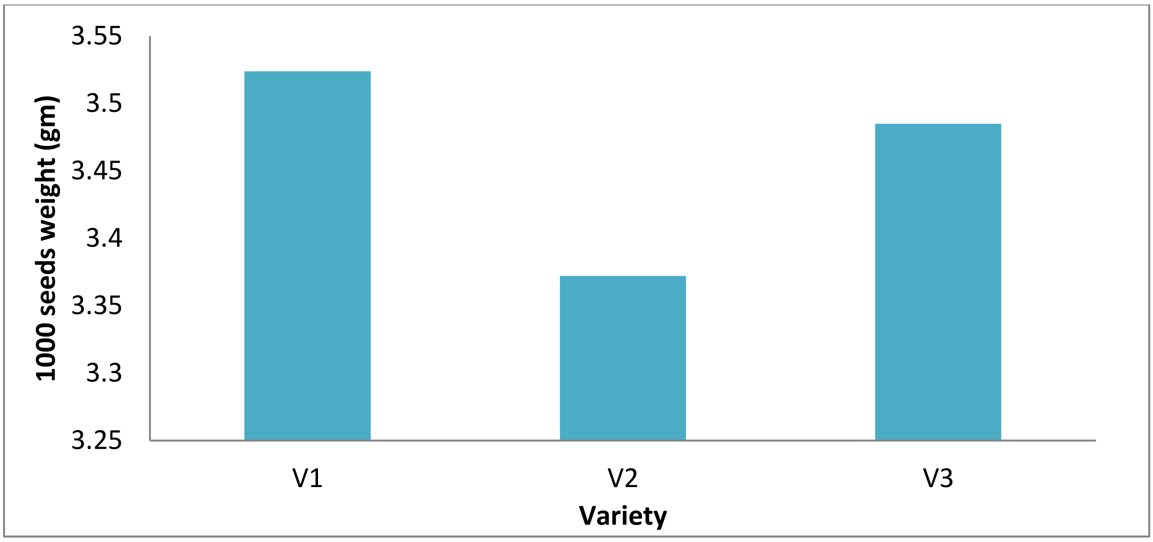
4.7.3 Combined effect of variety and leaf clipping

Seeds/siliqua was affected significantly by Interaction effect of variety and leaf clipping of mustard (Table 5). The highest number of seeds/siliqua of mustard (26.67) was obtained from V_3C_0 treatment combination. The lowest number of Seeds/siliqua of mustard (19.04) was obtained from V_2C_2 treatment combination which was statistically similar with $V_2C_{0,}$ V_2C_3 treatment combination.

4.8 1000 seed weight

4.8.1 Effect of variety

Variety had been significant variation in 1000-seed weight and it was also observed in studied varieties of mustard (Fig.15). The highest 1000-seed weight (3.37 g) was recorded in V_2 which was statistically similar with V_1 and V_3.

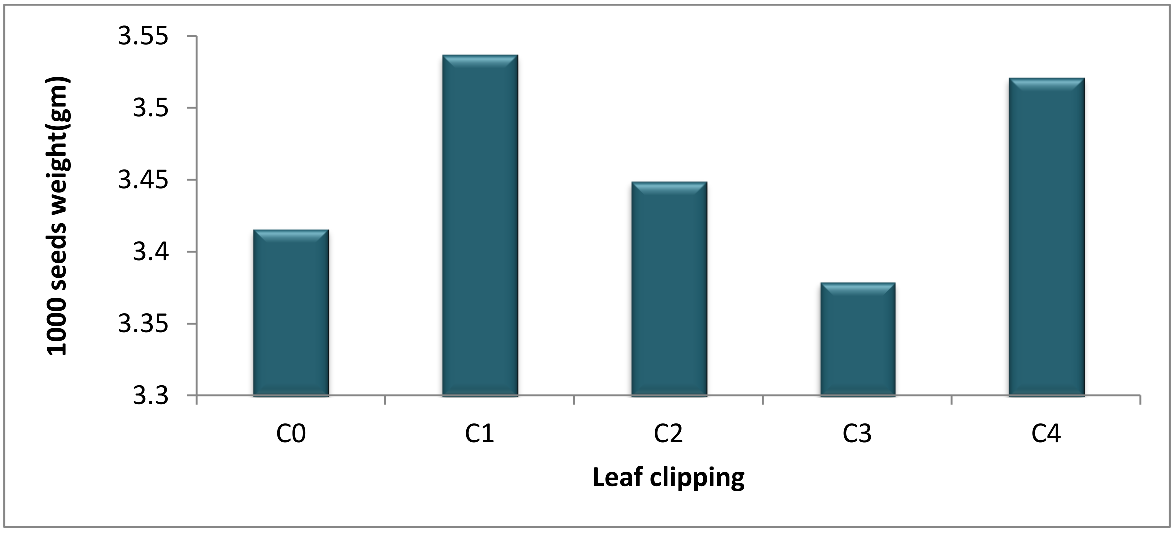


V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3= BARI Sarisha-17

Figure 15. Effect of varieties on thousand seed weight (LSD) $_{(0.05)}$ =0.2359)

4.8.2 Effect of leaf clipping

There was significant variation in the thousand seed weight due to the leaf clipping (Fig. 16). The maximum thousand seed weight (3.53 g) was obtained from C_1 which was statistically similar with C_2, C_3 and C_4.



C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem.

Figure 16. Effect of leaf clipping on thousand seed weight (LSD $_{(0.05)}$ =0.31

4.8.3 Combined effect of variety and leaf clipping

Interaction effect of different leaf clipping and varieties had a significant variation on thousand seed weight (Table 5). The highest thousand seed weight (3.82 g) was obtained from V_1C_1 and V_1C_2 treatment combination whiles the lowest (3.12g) was obtained from V_2C_1 which was statistically similar with V_1C_3,V_2C_1,V_2C_2,V_3C_0.

Table 5. Combined effect of leaf clipping on length of siliqua, seed/siliqua, siliqua/plant and 1000 seeds weight of mustard.

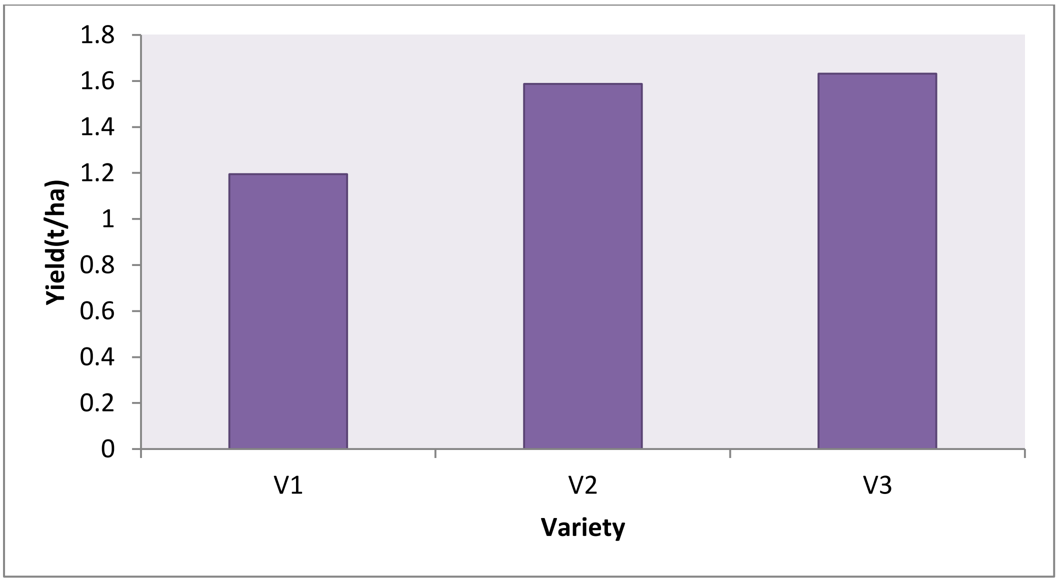
Treatment	Length of siliqua(cm)	Siliquae/plant(No)	Seed/siliqua(No)	1000 seeds weight(gm)
V_1C_0	4.76 a-c	61.93 f-g	21.10 cd	3.38 ab
V_1C_1	4.40 bc	59.13 fg	22.10 c	3.82 a
V_1C_2	5.06 a	77.00 b-e	24.40 b	3.82 a
V_1C_3	4.633 a-c	61.60 e-g	21.83 cd	3.18 b
V_1C_4	4.83 ab	52.13 g	22.17 c	3.41 ab
V_2C_0	4.57 bc	85.07 a-c	19.30 ef	3.61 ab
V_2C_1	4.30 c	93.60 ab	20.53 de	3.19 b
V_2C_2	4.70 a-c	102.4 a	19.04 f	3.12 b
V_2C_3	4.57 bc	94.07 ab	19.37 ef	3.44 ab
V_2C_4	4.50 bc	81.33 b-d	20.53 de	3.50 ab
V_3C_0	4.37 bc	57.87 fg	26.67 a	3.26 ab
V_3C_1	4.67 a-c	64.60 d-g	24.17 b	3.60 ab
V_3C_2	4.57 bc	70.40 c-f	24.07 b	3.40 ab
V_3C_3	4.43 bc	67.13 d-g	22.23 c	3.51 ab
V_3C_4	4.63 a-c	51.13 g	24.27 b	3.65 ab
$LSD_{(0.05)}$	0.4706	17.69	1.362	0.5275
CV (%)	6.08	14.59	3.65	9.03

C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem. V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3=BARI Sarisha-17 LSD=Least significance difference, CV=Coefficient of variation

4.9 Yield (t/ha)

4.9.1 Effect of variety

The yield of mustard was significantly varied with different varieties (Fig. 17). Yield is a function of various yields components such as number of siliquae plant^{-1}, seed siliqua^{-1} and 1000-seeds weight. The highest seed yield (1.63 t ha^{-1}) was recorded in V_3 variety which was statistically similar with V_2. In contrast, the lowest seed yield (1.2 t ha^{-1}) was recorded in V_1 variety. The probable reason of this difference might be due to higher number seeds/siliqua. The findings is in conformity with the findings of Zaman *et al.* (1991), Chakraborty *et al.* (1991) and Uddin *et al*. (1987) reported that yields were different among the varieties. . Genotypic variation in seed yield was also observed by Haque (1995) and Borah (1994).



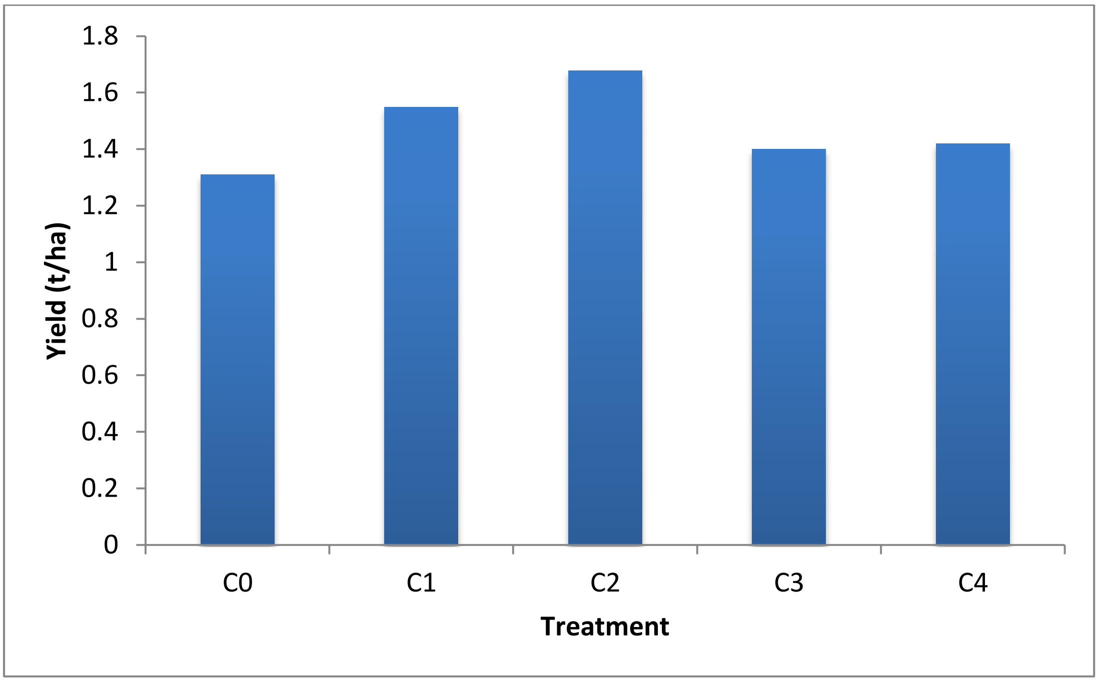
V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3= BARI Sarisha-17

Figure 17. Effect of varieties on seed yield ha^{-1} (LSD $_{(0.05)}$ =0.271

4.9.2 Effect of leaf clipping

There was significant variation in the seed yield ha^{-1} due to the leaf clipping (Fig. 18). The maximum seed yield hectare^{-1} (1.68 ton) was obtained from C_2 (Clipping of 2nd and 3rd leaf at main stem) and the minimum(1.31 ton) was obtained in C_0 Removing a specific organ of a plant, the growth of another organ may be modified (Hicks *et al*. 1977; Singh and Nair, 1975; Tollenaar and Daynard 1978 Thomson and Nafziger

2003). It has been reported that the removal of lower leaves together with inflorescences and axillary buds increased seed yield in mungbean (Clifford, 1979).



C_0 = No leaf clipping, C_1 = Clipping of 1st and 2nd leaf at main stem, C_2= Clipping of 2nd and 3rd leaf at main stem, C_3 =Clipping of 3rd and 4th leaf at main stem, C_4 = Clipping of 4th and 5th leaf at main stem.

Figure 18. Effect of leaf clipping on seed yield ha^{-1} ($LSD_{(0.05)}$ =0.35)

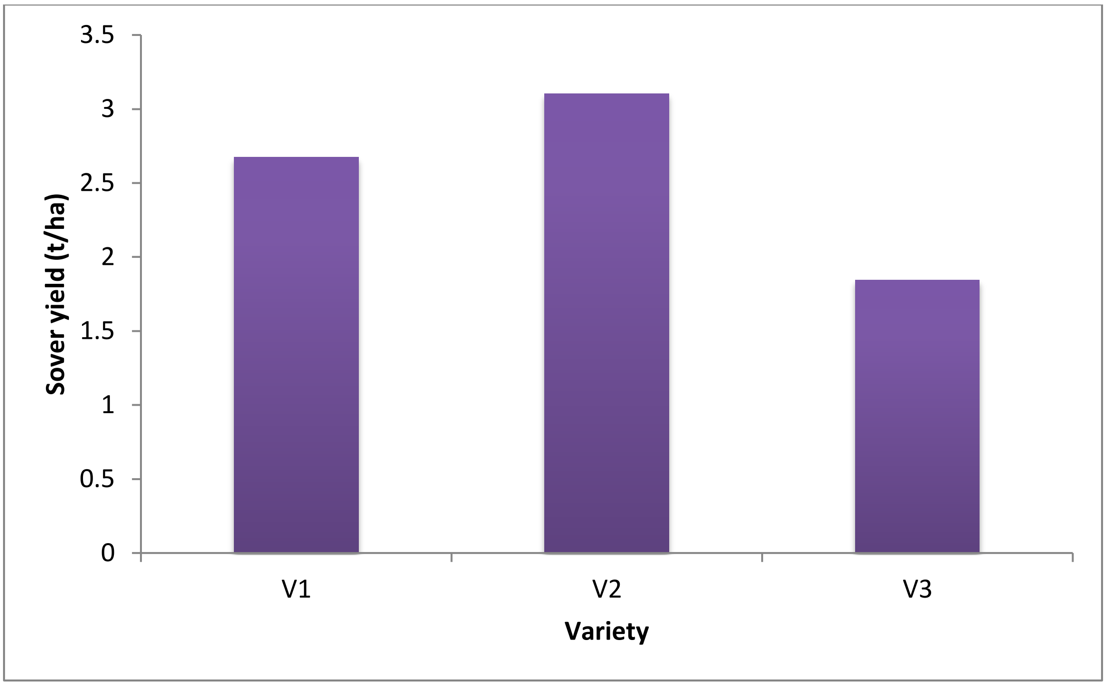
4.9.3 Combined effect of variety and leaf clipping

Interaction effect of different varieties and leaf clipping had a significant variation on seed yield ha^{-1}(Table 6). The highest seed yield (1.86 t ha^{-1}) was obtained from V_0C_2 treatment combination which is statistically similar with which is statistically similar V_2C_2,V_3C_1,V_3C_3 while the lowest (1.007 t ha^{-1}) from V_1C_3 treatment combination which was statistically similar withV_1C_0, V_1C_1, V_1C_2, V_1C_4, V_2C_0, V_2C_1, V_2C_3, V_2C_4, V_3C_0, V_3C_4. Hortensteiner and Felller (2002), Khan *et al.* (2007) showed that defoliation of older and senescing leaves allowed the growth of functional and efficient leaves.

4.10 Stover yield (t/ha)

4.10.1 Effect of variety

Varieties on stover yield in mustard genotypes had a significant variation(Fig. 19). Results revealed that the highest stover yield 3.11 t ha^{-1} was recorded fromV_2 which was statistically similar with V_1. Whereas, the lowest stover yield 1.85 t ha^{-1} was achieved from variety V_3. Varietal performance showed significant variation on stover yield which was supported by the findings of Parvez *et al*. (2013) and Hossain and Solaiman (2004).

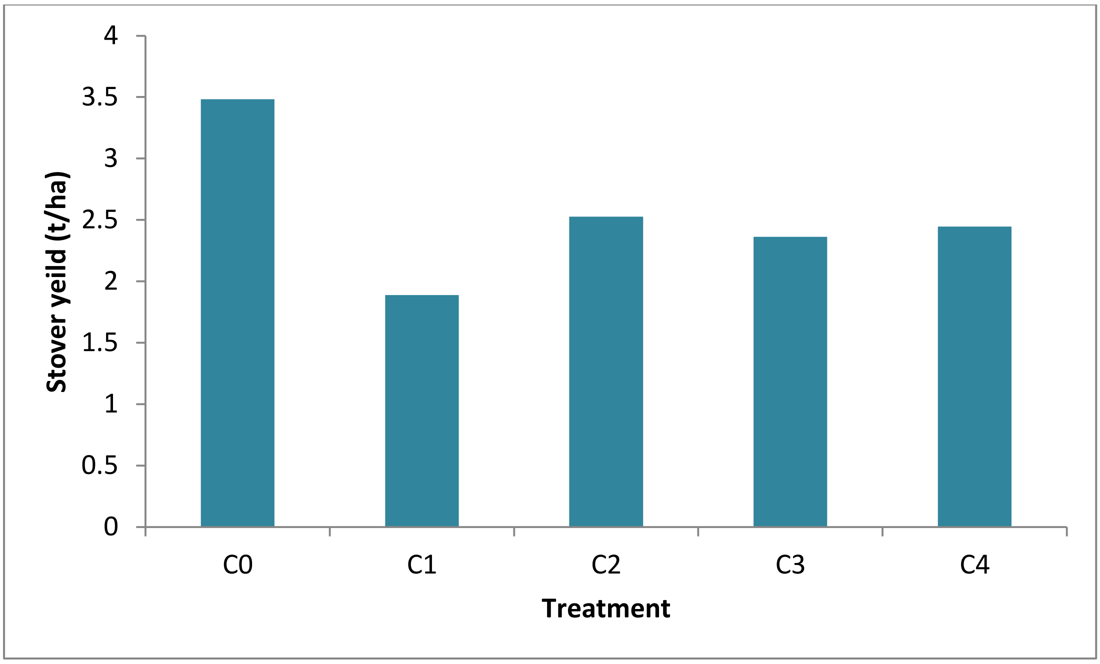


V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3= BARI Sarisha-17

Figure: 19. Effect of varieties on stover yield/ha (LSD $_{(0.05)}$ =0.57)

4.10.2 Effect of leaf clipping

Significant variation was observed in the different leaf clipping on stover yield (Fig. 20). Results revealed that the highest stover yield 3.48 t ha^{-1} was recorded from C_0 treatments. The lowest stover yield (1.89 t ha^{-1}) was recorded from C_1 treatment which was statistically similar with C_2, C_3,and C_4 treatment.



C_0 = No leaf clipping, C_1 = Clipping of 1st and 2nd leaf at main stem, C_2= Clipping of 2nd and 3rd leaf at main stem, C_3 =Clipping of 3rd and 4th leaf at main stem, C_4 = Clipping of 4th and 5th leaf at main stem

Figure 20. Effect of leaf clipping on stover yield /ha (LSD $_{(0.05)}$ =0.35)

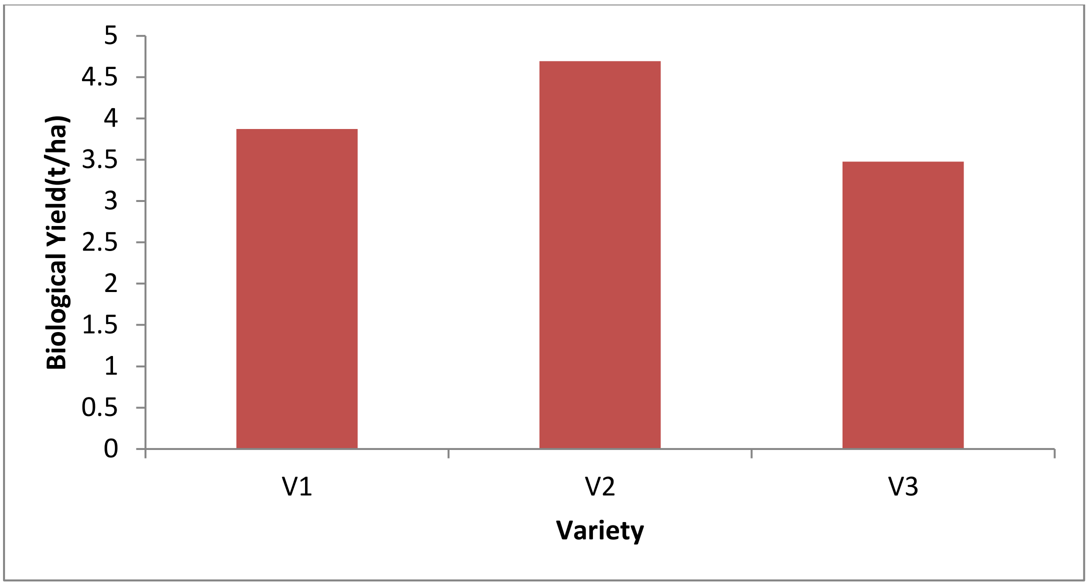
4.10.3 Combined effect of variety and leaf clipping

Significant variation was observed in the interaction effect of different types of varieties and leaf clipping on stover yield (Table 6). Results revealed that the highest stover yield 4.21 t ha^{-1} was recorded from V_2C_0 which was statistically similar with V_1C_0, V_1C_1, V_2C_2, V_2C_3 and V_2C_4 treatments. The lowest stover yield (0.88 t ha^{-1}) was recorded from V_2C_1 treatment combination which is statistically similar with V_1C_3, V_3C_1, V_3C_3 , V_3C_4 treatment combination.

4.11 Biological yield (t/ha)

4.11.1 Effect of variety

Biological yield of mustard was significantly influenced by variety (Fig. 21). The maximum biological yield (4.69 t ha^{-1}) was found in V_2 variety. The lowest biological yield (3.48 t ha^{-1}) was observed in V_3 which was statistically similar with V_1 variety. Varietal performance showed significant variation on biological yield which was supported by the findings of Parvez *et al*. (2013) and Hossain and Solaiman (2004).

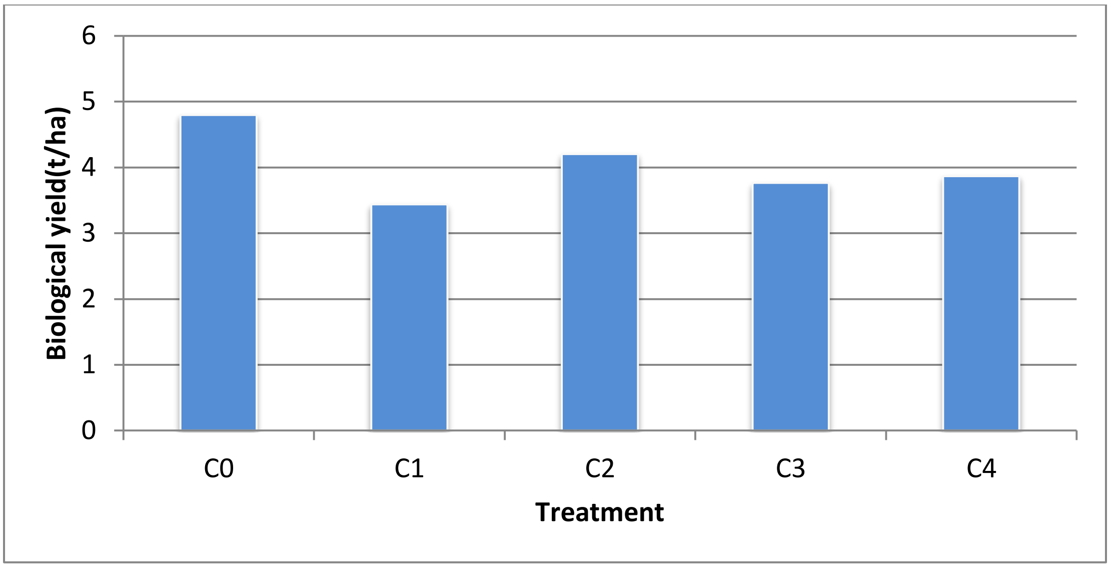


V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3= BARI Sarisha-17

Figure 21.Effect of varieties on on biological yield of mustard (LSD $_{(0.05)}$ =0.58)

4.11.2 Effect of leaf clipping

There was a significant influence in the biological yield of mustard due to leaf clipping (Fig.22). The maximum biological yield (4.80t ha^{-1}) was found from C_0 (Leaf clipping), which was statistically similar with C_2 and the minimum biological yield (3.44 t ha^{-1}) from C_1 which was statistically similar with C_3 and C_4.



C_0 = No leaf clipping, C_1 = Clipping of 1st and 2nd leaf at main stem, C_2 = Clipping of 2nd and 3rd leaf at main stem, C_3 = Clipping of 3rd and 4th leaf at main stem, C_4 = Clipping of 4th and 5th leaf at main stem

Figure 22.Effect of leaf clipping on biological yield of mustard (LSD $_{(0.05)}$ =0.35)

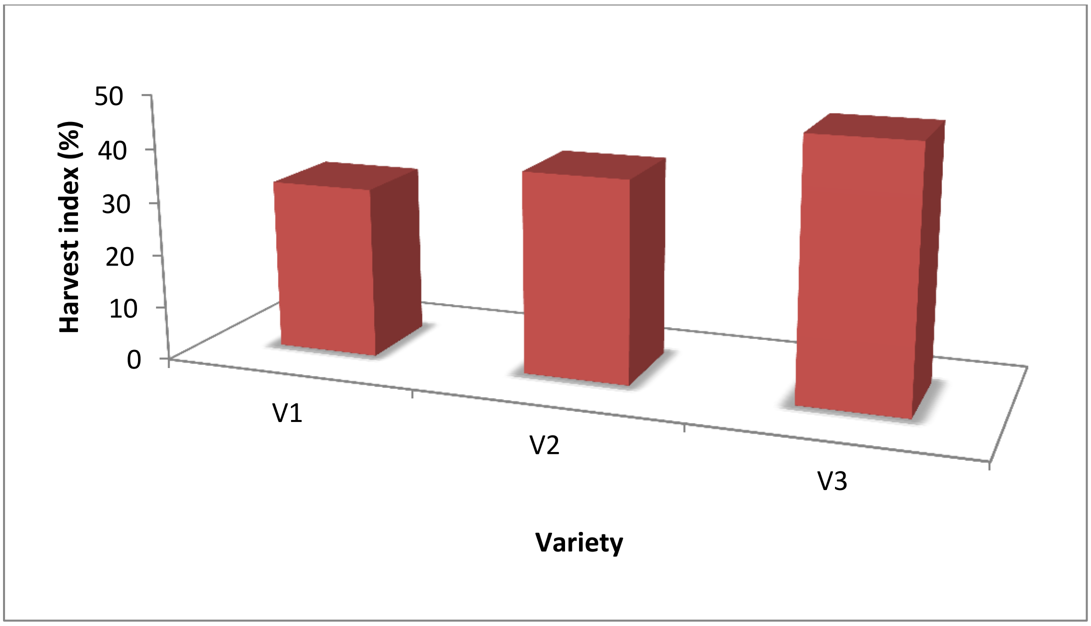
4.11.3 Combined effect of variety and leaf clipping on biological yield of mustard

Interaction of variety and leaf clipping had a significant influence on biological yield of mustard (Table 6). The highest biological yield (5.78 t ha^{-1}) was obtained from V_2C_2 which was statistically similar with V_1C_0, V_2C_3 and V_2C_4 treatment combination. The lowest biological yield (2.49 t ha^{-1}) was recorded from V2C1 which was statistically similar with V_1C_2, V_1C_4, V_3C_0, V_3C_1, V_3C_2, V_3C_3 and V_3C_4.

4.12 Harvest index

4.12.1 Effect of variety

Harvest index of mustard was significantly influenced by variety (Fig. 23). The maximum harvest index (47.95%) was found in V_3 variety. The lowest harvest index (32.05%) was observed in V_1 which was statistically similar with V_2 variety. The results are agreed with those of Islam et al. (1999) who observed that the harvest index varied markedly among varieties of different plant type of mustard. Mendham *et al.* (1981) stated that a low harvest index of rapeseed might be due to excessive pod and seed losses during flowering.

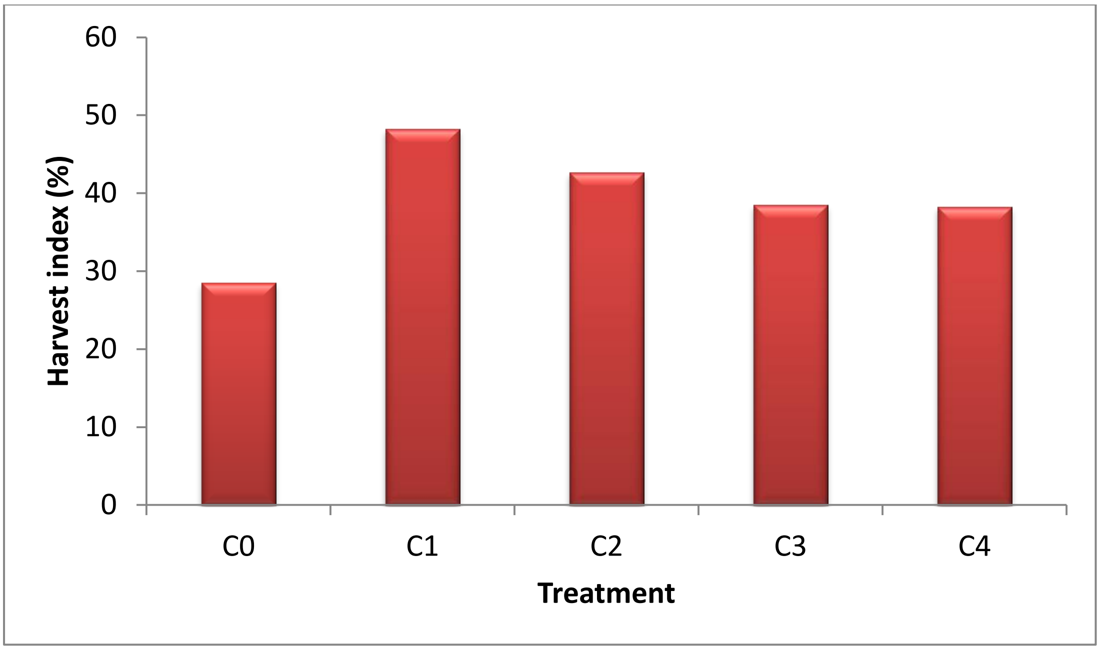


V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3= BARI Sarisha-17

Figure 23: Effect of varieties on harvest index of mustard (LSD $_{(0.05)}$ =7.16)

4.12.2 Effect of leaf clipping

There was a significant influence in the harvest index of mustard due to leaf clipping (Fig.24). The maximum harvest index (48.29%) was found from C_1 treatment which was statistically similar with C_2 and the minimum harvest index (28.51) from C_0.



C_0 = No leaf clipping,C_1 = Clipping of 1st and 2nd leaf at main stem,C_2= Clipping of 2nd and 3rd leaf at main stem,C_3 =Clipping of 3rd and 4th leaf at main stem,C_4 = Clipping of 4th and 5th leaf at main stem

Figure 24. Effect of leaf clipping on harvest index of mustard (LSD $_{(0.05)}$ =9.24)

4.12.3 Combined effect of variety and leaf clipping

Combined effect of variety and leaf clipping had a significant influence on harvest index of mustard (Table 6). The highest harvest index (64.62%) was obtained from V_2C_1 which was statistically similar with V_3C_1, V_3C_2 and V_3C_4 treatment combination. The lowest harvest index (24.61) was recorded from V_1C_0 treatment combination and V_1C_1, V_1C_2, V_1C_3, V_1C_4, V_2C_2, V_2C_3, V_2C_4, V_3C_0, V_3C_1, V_3C_2, V_3C_3 and V_3C_4 statistically similar with that.

Table 6: Combined effect of leaf leaf clipping and variety on seed yield, stover yield, biological yield and harvest index of mustard.

Treatment	Yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index(%)
V_1C_0	1.18 de	3.78 a	4.97 ab	24.61 f
V_1C_1	1.21 c-e	3.03 a-d	4.24 b-d	30.22 f
V_1C_2	1.37 a-e	2.29 b-a	3.65 c-e	36.83 c-f
V_1C_3	1.01 e	1.90 d-f	2.91 e	34.58 c-f
V_1C_4	1.22 c-d	2.38 b-e	3.60 c-e	33.98 d-f
V_2C_0	1.51 a-e	4.22 a	5.72 a	26.49 f
V_2C_1	1.62 a-e	0.88 f	2.50 e	64.62 a
V_2C_2	1.81 a-c	3.98 a	5.79 a	31.75 ef
V_2C_3	1.55 a-e	3.24 ab	4.79 a-c	34.43 c-f
V_2C_4	1.47 a-e	3.23 a-c	4.69 a-c	31.44 ef
V_3C_0	1.25 b-e	2.46 b-e	3.70 b-e	34.44 c-f
V_3C_1	1.83 ab	1.77 d-f	3.59 c-e	50.01 a-c
V_3C_2	1.86 a	1.33 ef	3.19 de	59.43 ab
V_3C_3	1.65 a-d	1.96 c-f	3.60 c-e	46.51 b-e
V_3C_4	1.59 a-e	1.74 ef	3.32 de	49.37 a-d
$LSD_{(0.05)}$	0.6076	1.28	1.293	16
CV (%)	24.46	29.89	19.12	24.20

C_0 = No leaf clipping, C_1 = Clipping of 1st and 2nd leaf at main stem, C_2= Clipping of 2nd and 3rd leaf at main stem, C_3 =Clipping of 3rd and 4th leaf at main stem, C_4 = Clipping of 4th and 5th leaf at main stem. V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3=BARI Sarisha-17 LSD=Least significance difference, CV=Coefficient of variance

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, during October 2017 to February 2018 to assess growth and yield response of mustard to leaf clipping. In this experiment, the treatment consisted of 5 leaf clipping viz. C_0 = No leaf clipping, C_1 = Clipping of 1^{st} and 2^{nd} leaf at main stem, C_2= Clipping of 2^{nd} and 3^{rd} leaf at main stem, C_3 =Clipping of 3^{rd} and 4^{th} leaf at main stem,C_4 = Clipping of 4^{th} and 5^{th} leaf at main stem and three mustard varieties *viz.* . V_1=BARI Sarisha-14, V_2=BARI Sarisha-15, V_3=BARI Sarisha-17. The experiment was laid out in a split plot with three replications. Data on different growth parameters, physiological parameters and yield contributing parameters of mustard were recorded. The collected data were statistically analyzed for evaluation of the treatment effect. A significant variation among the treatment was found while different level of leaf clipping and with variety.

Plant height was significantly influenced by leaf variety. At final harvest, the tallest plant (90.1 cm) was obtained from V_2 on the other hand the lowest plant height obtain from V_3 variety. The highest no. of leaves was (7.86). The number of branches plant^{-1}was also significantly influenced by variety. At harvest, the highest number of branches (9.51) was obtain in V_2 and the lowest no. of branches obtain from (1.96) V_3. Above ground dry matter plant^{-1} was also significantly influenced by variety. At harvest maximum dry matter plant^{-1} (14.87 g) was obtained from V_1 variety showed significant variation in siliqua length . The longest siliqua (4.74 cm) was recorded in V_1 and the shortest siliqua (4.5 cm) was observed in V_2. Siliquae plant^{-1} was affected significantly by different variety of mustard. The highest number of siliquae plant^{-1} of mustard (91.29) was obtained from V_2 variety and the lowest number of siliquae plant^{-1} of mustard (62.23) was obtained from V_3 variety. Seeds/siliqua was affected significantly by different variety of mustard . The highest number of seeds/siliqua of mustard (24.28) was obtained from V_3 variety. The lowest number of seeds/siliqua of mustard (19.75) was obtained from V_2 variety. Variety had significant variation in 1000-seed weight and it was also observed in studied varieties of mustard. The highest 1000-seed weight (3.37 g) was recorded in V_2. Variety had significant variation in fodder production after clipping and it was also observed in studied varieties of mustard. The highest fodder (1.09 t/ha) was recorded in V_1 while the lowest (0.75t/ha) was obtained from V_2 variety. Varieties on stover yield in mustard genotypes had a significant variation. Results revealed that the highest stover yield 3.11 t ha^{-1} was recorded fromV_2 whereas; the lowest stover yield 1.85 t ha^{-1} was achieved from V_3 variety. The yield of mustard was significantly varied with different varieties. Yield is a function of various yields components such as number of siliquae $plant^{-1}$, seed $siliqua^{-1}$ and 1000-seeds weight. The highest seed yield (1.63 t ha^{-1}) was recorded in V_3 variety. On the other hand, the lowest seed yield (1.2 t ha^{-1}) was recorded in V_1 variety. Biological yield of mustard was significantly influenced by variety. The maximum biological yield (4.69 t ha^{-1}) was found in V_2 variety. The lowest biological yield (3.48 t ha^{-1}) was observed in V_3. Harvest index of mustard was significantly influenced by variety. The maximum harvest index (47.95%) was found in V_3 variety. The lowest harvest index (32.05%) was observed in V_1.

There was a significant variation in plant height at different DAS in different leaf clipping. At 15 DAS, the tallest plant (8.66 cm) was obtained from C_2. At, harvest the tallest plant (88.09cm) was obtained from C_1. Number of leaves/plant significantly varied with the different clipping practices before leaf clipping. The highest no. of leaves (7.72) was obtained from C_4 and the lowest no. of leaves (7.01) obtained from C_1. Number of branches $plant^{-1}$was significantly varied with leaf clipping. At harvest, the highest number of branches (7.77) was obtained in C_4 treatment. Above Ground Dry Matter $Plant^{-1}$ was also significantly influenced by leaf clipping. At harvest, the highest dry weight of was obtained from C_0 (24.83 g) and the lowest dry weight was found from C_3 (16.45 g). There was a significant variation with the siliqua length of mustard due to the leaf clipping. Leaf clipping showed significant variation in siliqua length. The longest siliqua (4.78 cm) was recorded in C_2.The shortest siliqua (4.46 cm) was observed in C_1 treatment. Siliquae $plant^{-1}$ was affected significantly by different leaf clipping of mustard . The highest number of siliquae $plant^{-1}$ of mustard (91.29) was obtained from C_2 and the lowest number of siliquae $plant^{-1}$ of mustard (61.53) was obtained from C_4 treatment. Seeds/siliqua was affected significantly by different leaf clipping. The highest number of seeds/siliqua (22.50) was obtained from C_2 treatment and the lowest number of seeds/siliqua of mustard (21.14) was obtained from C_3 treatment. There was significant variation in the thousand seed weight due to the leaf clipping. The maximum thousand seed weight (3.53 g) was obtained from C1

.There was significant variation in fodder production after clipping due to the leaf clipping. The maximum fodder (1.41 t/ha) was obtained from C_2 and while the lowest (0.00t/ha) was obtained from C_0 (no clipping) treatment. Significant variation was observed in the different leaf clipping on husk yield. Significant variation was observed in the different leaf clipping on stover yield. Results revealed that the highest stover yield 3.48 t ha^{-1} was recorded from C_0. Treatments and the lowest stover yield (1.89 t ha^{-1}) was recorded from C_1 treatment .There was significant variation in the seed yield $hectare^{-1}$ due to the leaf clipping. The maximum seed yield $hectare^{-1}$ (1.68 ton/ha) was obtained from C_2 (Clipping of 2^{nd} and 3^{rd} leaf at main stem)and the minimum(1.31 ton) was obtained in C_0 There was a significant influence in the biological yield of mustard due to leaf clipping. The maximum biological yield (4.795 t ha^{-1}) was found from C_0 and the minimum biological yield (3.44 t ha^{-1}) from C_1There was a significant influence in the harvest index of mustard due to leaf clipping. The maximum harvest index (48.29%) was found from C1 treatment and the minimum harvest index (28.51) from C_0.

Interaction effect of leaf variety and clipping was significant in case of plant height of mustard. At harvest, the tallest plant (93.80cm) was obtained fromV_2C_0 .Interaction effect of varieties and leaf clipping was significant variation on number of leaves $plant^{-1}$ of mustard. The highest no. of leaves (8.28) was obtained from V_1C_0 and the lowest no. of leaves (6.58) obtained from V_2C_3Interaction effect of variety and leaf clipping was significant on number of branches $plant^{-1}$ .At harvest, the highest number of branches was obtained fromV_2C_0 (9.8) treatment combination and the lowest number of branches was obtained from V_3C_0 (5.47) treatment .Above Ground Dry Matter $Plant^{-1}$ was also significantly influenced by Interaction effect of variety and leaf clipping . At harvest, the highest dry weight was obtained from V_1C_0 (25.09 g) and the lowest dry weight was found from V_3C_3(14.48 g).Interaction effect of leaf clipping and variety was significant on siliqua length of mustard .The highest siliqua length (5.07 cm) was obtained from V_1C_2 treatment combination whiles the lowest (4.3cm) fromV_2C_1 siliquae $plant^{-1}$ was affected significantly by Interaction effect of variety and leaf clipping of mustard .The highest number of siliquae $plant^{-1}$ of mustard (102.4) was obtained from V_2C_2 treatment combination and the lowest number of siliquae $plant^{-1}$ of mustard (51.13) was obtained from V_3C_4 .Seeds/siliqua was affected significantly by Interaction effect of variety and leaf clipping of mustard . The highest number of seeds/siliqua of mustard (26.67) was obtained from V_3C_0 treatment combination and the lowest number of seeds/siliqua of mustard (19.04) was obtained from V_2C_2 treatment combination. Interaction effect of different leaf clipping and varieties had a significant variation on thousand seed weight. The highest thousand seed weight (3.82 g) was obtained from V_1C_1 and V_1C_2 treatment combination whiles the lowest (3.12g) was obtained from was obtained from V_2C_1. Combined effect of different leaf clipping and varieties had a significant variation fodder production after clipping. The highest fodder (1.597t/ha) was obtained and the lowest (0.00t/ha) was obtained from V_1C_0,V_2C_0 and V_3C_0. .Significant variation was observed in the interaction effect of different types of varieties and leaf clipping on stover yield.. Results revealed that the highest stover yield 4.21 t ha^{-1} was recorded from V_2C_0 and the lowest stover yield (0.88 t ha^{-1}) was recorded from V_2C_1 treatment combination. Interaction effect of different varieties and leaf clipping had a significant variation on seed yield. The highest seed yield (1.86 t ha^{-1}) was obtained from V_0C_2 treatment combination while the lowest (1.007 t ha^{-1}) from V_1C_3 treatment combination. Interaction of variety and leaf clipping had a significant influence on biological yield of mustard. The highest biological yield (5.78 t ha^{-1}) was obtained from V_2C_2 and the lowest biological yield (2.49 t ha^{-1}) was recorded from V_2C_1 Interaction of variety and leaf clipping had a significant influence on harvest index of mustard. The highest harvest index (64.62%) was obtained from V_2C_1 and the lowest harvest index (24.61) was recorded from V_1C_0.

Conclusion

From the above findings it can be concluded that BARI Sarisha-17 had better performance over other two varieties. Leaf clipping at 2^{nd} and 3^{rd} leaf on main stem during flower initiation showed better performance than other clipping practices. In combination V_3C_2 (BARI Sarisha-17 and clipping at 2^{nd} and 3^{rd} leaf on main stem during flower initiation) had greater yield (1.86 t ha^{-1}) advantage over other treatments as compared to other clipping.

Moreover leaf clipping can meat fodder needs of the farmers (produce max 1.5 t ha^{-1} fodder) which meat the two fold (grain and fodder) advantages for farmers.

Recommendations

The findings would be verified under different mustard growing areas to find out as the leaf clipping management is beneficial or not for farmers.

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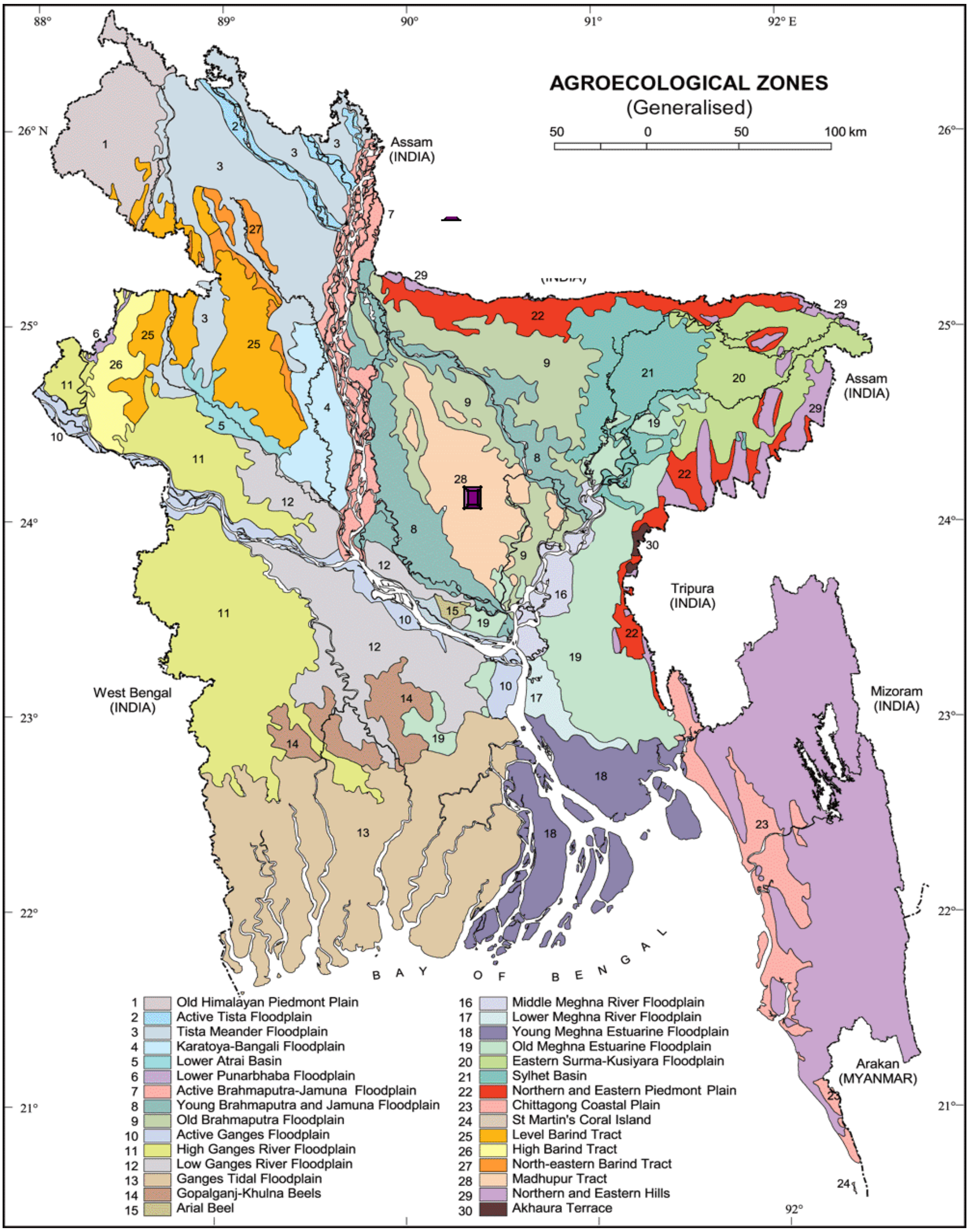
APPENDICES

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



Appendix II. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from November to February, 2017-2018

Month	Air temperature(^{0}c)		Relative humidity (%)	Total rainfall (mm)
	maximum	minimum		
October	30.32	16.66	75.36	00
November	29.88	14.56	70.23	00
December	26.75	14.25	69.67	00
January	25.00	13.11	68.31	00
February	30.11	17.59	52.19	00

Source: Bangladesh Mateorological Department (climate and weather division), Agargaon, Dhaka

Appendix III. Characteristics of the soil of experimental field

A. Morphological characteristics of the experimental field

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

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

Constituents	(%)
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

C. **Chemical composition:**

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

Source: Soil Resources Development Institute Khamarbari, Dhaka

Appendix IV. Analysis of variance of the data on plant height of mustard affected by leaf clipping and variety

Source of variation	df	Mean square value at different days after sowing					
		15DAS	30DAS	45DAS	60 DAS	75DAS	At harvest
Replication	2	6.291*	26.878^{NS}	54.996^{NS}	111.193^{NS}	125.334*	124.938*
Factor A	2	0.763^{NS}	360.184**	8.78	452.311**	427.636**	424.209**
Error	4	0.746	10.678	18.832	21.194	18.593	17.29
Factor B	4	0.138	7.302^{NS}	10.497	6.766	9.412	9.008
AB	8	0.687^{NS}	17.618*	50.533^{NS}	21.431	19.117	19.63
Error	24	0.45	7.221	31.805	49.964	50.688	51.063

**Significant at 5% and 1% level
*Significant at 5% level
^{NS} Non significant

Appendix V. Analysis of variance of the data on number of branches/plant

Source of variation	df	Mean square value at different days after sowing				
		30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Replication	2	2.794	4.023	10.881^{NS}	7.366^{NS}	6.438^{NS}
Factor A	2	13.663^{NS}	26.224^{NS}	35.748^{NS}	43.82*	43.297*
Error	4	3.63	4.841	7.154	5.105	5.476
Factor B	4	0.261	0.086	0.378	0.062	0.09
AB	8	0.753	0.608	0.69	0.562	0.59
Error	24	1.054	0.953	1.287	1.034	0.961

**Significant at 5% and 1% level
*Significant at 5% level
^{NS} Non significant

Appendix VI. Analysis of variance of the data on Above ground dry matter plant^{-1} of mustard as affected by leaf clipping and variety

Source of variation	df	Mean square value at different days after sowing					
		15DAS	30DAS	45DAS	60 DAS	75DAS	At harvest
Replication	2	0	0.151^{NS}	0.14^{NS}	40.49^{NS}	34.88^{NS}	33.30^{NS}
Factor A	2	0	0.373^{NS}	1.364**	1.47	32.03	0.827
Error	4	0	0.092	0.095	12.72	16.13	13.681
Factor B	4	0**	0.056^{NS}	0.346**	78.09**	63.08**	79.253**
AB	8	0^{NS}	0.027	0.066	16.10^{NS}	14.33^{NS}	15.924^{NS}
Error	24	0	0.042	0.071	10.361	9.73	9.679

**Significant at 5% and 1% level

*Significant at 5% level

^{NS} Non significant

Appendix VII. Analysis of variance of the data on fodder production by variety and leaf clipping

Source of variation	df	Mean square value at different days after sowing
		Fodder yield
Replication	2	0.149**
Factor A	2	0.446**
Error	4	0.007
Factor B	4	3.148**
AB	8	0.08^{NS}
Error	24	0.043

**Significant at 5% and 1% level

*Significant at 5% level

^{NS} Non significant

Appendix VIII. Analysis of variance of the data Length of siliqua, Siliqua/plant, Seed/siliqua and 1000 seed weight of mustard as affected by leaf clipping and variety

Source of variation	df	Mean square value at different days after sowing			
		Length of siliqua	Siliqua/plant	Seed/siliqua	1000 seed weight
Replication	2	0.101^{NS}	326.144^{NS}	0.117	0.22
Factor A	2	0.221^{NS}	4205.067**	77.277**	0.093
Error	4	0.059	220.535**	1.124	0.316
Factor B	4	0.134^{NS}	575.074	2.733**	0.041
AB	8	0.081^{NS}	28.592	5.441**	0.202^{NS}
Error	24	0.078	110.179	0.653	0.098

**Significant at 5% and 1% level

*Significant at 5% level

^{NS} Non significant

Appendix IX. Analysis of variance of the data on Seed yield, Stover yield, Biological yield and harvest index of mustard as affected by leaf clipping and variety

Source of variation	df	Mean square value at different days after sowing			
		Seed yield	Stover yield	Biological yield	Harvest index
Replication	2	0.243^{NS}	1.249^{NS}	2.574^{NS}	66.215^{NS}
Factor A	2	0.866*	6.148^{NS}	5.765^{NS}	974.294**
Error	4	0.098	1.071	1.736	19.54
Factor B	4	0.185^{NS}	3.052**	2.389**	472.821**
AB	8	0.05	2.173**	2.435**	269.916*
Error	24	0.13	0.577	0.589	90.18

**Significant at 5% and 1% level

*Significant at 5% level

^{NS} Non significant