EFFECT OF POST-ANTHESIS CANOPY DEFOLIATION ON YIELD AND YIELD COMPONENTS OF WHEAT VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of Post-anthesis Canopy Defoliation on Yield and Yield Components of Wheat Varieties**" 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 bona fide research work carried out by **Uchhas Paul**, Registration number: **11-04496** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
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DEDICATED TO

MY

BELOVED PARENTS

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EFFECT OF POST-ANTHESIS CANOPY DEFOLIATION ON YIELD AND YIELD COMPONENTS OF WHEAT VARIETIES

ABSTRACT

The experiment was conducted at the experimental site of Sher-e-Bangla Agricultural University (SAU) during the period from November 2016 to February 2017 to study the response of wheat varieties as influenced by different levels of leaf clipping treatment. The experiment comprised of two varieties viz., BARI Gom 26 (V_1) and BARI Gom 30 (V_2) and five different levels of leaf clipping viz., clipping of all leaves except flag leaf (L_1), clipping of flag leaf only (L_2), clipping of all leaves except flag leaf & it's immediate leaf (L_3), clipping of all leaves except flag leaf & first two leaves beneath flag leaf (L_4) and control/No clipping (L_5). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Significant variation was recorded for plant height, number of tillers, effective tillers and non-effective tillers, stem dry weight, panicle dry weight, number of spikes, spikelet per spike and grain per spike. Moreover, 1000 seed weight, straw yield, grain yield and harvest index were also significantly influenced by varieties and/or leaf clipping treatments. Results demonstrated that BARI Gom 26 produced the maximum seed yield (1.53 t/ha). The control treatment (L_5) showed highest seed yield (1.742 t/ha). Among the ten treatment combinations, the variety BARI Gom 30 showed the best performance with maximum yield (1.833 t/ha) and harvest index (54.51 %) when remained unclipped and it can be recommended for further trial. Moreover, results described that L_1, L_2, L_3 and L_4 treatments caused reduction in seed yield of BARI Gom 30 by 32.89%, 21.27%, 30.00% and 23.07%, respectively. Moreover, seed yield of BARI Gom 26 was also decreased by 12.5%, 10.12% and 17.39% with the application of L_1, L_3 and L_4, respectively.

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LIST OF ACRONYMS

AEZ	Agro- Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
cm	Centimeter
CV (%)	Percent Coefficient of Variance
cv.	Cultivar (s)
^{0}C	Degree Centigrade
DAS	Days After Sowing
et al.	And others
FAO	Food and Agriculture Organization
g	Gram (s)
HI	Harvest Index
Kg	Kilogram (s)
LSD	Least Significant Difference
m^2	Meter squares
MP	Muriate of Potash
N	Nitrogen
SAU	Sher-e- Bangla Agricultural University
SRDI	Soil Resource Development Institute
TSP	Triple Super Phosphate
t/ha	Ton per hectare
Wt.	Weight
%	Percentage

CHAPTER 1

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the major cereals in the world. It belongs to the family Poaceae and it is the world's most widely grown cereal crop which is positioned first followed by rice. Due to its higher seed protein content, wheat is more preferable to rice. It ranks top both in acreage and production among the cereal crops of the world (FAO, 2008). About one third of the world population lives on wheat grains for their subsistence (FAO, 2007). Wheat grain is enriched with quality food value i.e. 12% protein, 1.72% fat, 69.60% carbohydrate and 27.20% minerals (BARI, 2006).

Bangladesh is an over populated country. Increasing agricultural production per unit area of land is becoming most important step to cope with the present population growth in Bangladesh. Rice is the staple food of Bangladesh but its total production is not sufficient to feed her growing population. Wheat (*Triticum aestivum* L.) commonly grown in Bangladesh known as spring wheat is ranked second in respect of total area of land (4.53 lakh hectares) and production (13.75 lakh mt) after rice. The average yield of wheat is only 3.04 t/ha (BBS, 2017) and it can be increased up to 6.8 t/ha (RARS, 2002). So, there is an immense opportunity to increase production of wheat per unit area through application of improved agronomic practices. Thus, wheat can be a good supplement of rice and it can play a vital role to feed this vast population. But, stem lodging due to heavy rainfall and storm could be a limiting factor to get highest wheat yield in Bangladesh. Moreover, the insect and pathogen could be serious pests resulting yield losses up to 20%.

In wheat, major photosynthetic organs are leaves; especially the flag leaves. Mostly lower leaves are shaded by the upper ones and maximum solar absorption occurs in flag leaves. Thus, flag leaf and photosnythetic area above flag leaf was indicated the importance of these structures to increase grain yields (Hsu and Walton, 1971; Mohiuddin and Croy, 1980; Sen and Prasad, 1996 and Cruz-aguoda *et al*., 1999). The flag leaf blade and total photosynthetic area above the flag leaf node have positive correlation with weight of grain per plant (Briggs and Aytenfisu, 1980; Mohuiddin and Croy, 1980).

Contribution of upper leaves to grain yield and its components are estimated with different methodologies such as defoliation, shading or inoculation. Although these techniques are commonly used, the methodologies used are quite different. Indeed, some scientists attributed the magnitude of losses due to defoliation to contribution by comparing yields of treatments lacking specific leaves with a non-defoliated check (Subba *et al.*, 1989; Ali *et al*., 2010). When top leaves are removed, the lower ones supply assimilates to the grain. Effect of removal of flag leaf has been reported primarily to reduce grain yield. Removal of flag leaf and its combination with awns affected grain yield more adversely in dwarf genotypes than taller ones (Chhabra and Sethi, 1989). Das and Mukherjee (1991) found that contribution to yield of flag leaf alone is 19%. Mahmood *et al.* (1991) reported that there was 16.1% reduction in grain yield after flag leaf removal at the heading. Up to 13.2- 22.9 % grain yield reduction has been reported by Singh and Singh (1992) and 34.5% grain reduction was shown by Mahmood and Chowdhry (1997). The upper three leaves are of great importance to grain filling, which determines cereal yield potential (Birsin *et al.*, 2005; Sen and Prasad, 1996). Importance of these leaves, especially flag leaf and penultimate leaf, in elaborating grain yield and its components, has been widely discussed (Singh *et al*., 1983; Seck *et al*., 1991; Jebbouj and El Yousfi, 2006a). But, wheat flag leaf was found to contribute to grain filling more than 50% (Auriau *et al*., 1992), while its defoliation generated grain yield losses of 18 to 30% (Youssef and Salem, 1976; Banitaba *et al*., 2007). Flag leaf contribution to grain yield was 39%, and its defoliation resulted in a yield loss of 21% (Jebbouj and El Yousfi, 2006a, 2009). Other studies pointed out to the role of lower leaves that increases when flag leaf area is affected, either by shading or defoliation (Ahmadi and Joudi, 2007). Singh and Randhawa (1983) studied effects of defoliation of all leaves and observed 30% to 40% reduction in grain yield. Thus, the canopy removal or leaf clipping operations has significant effects on grain yield or other agronomic traits of wheat. It was observed that, removing one half of the wheat leaves decreased main shoot yield by 15%. In other research, it was found that defoliation of all leaves in wheat reduce 30-40% of grain yield in main shoot (Singh and Singh, 1992). Therefore, the study will help us to evaluate the canopy defoliation results as indicators of yield prediction under lodging or leaf damage due to insect and disease pest of wheat in Bangladesh.

The present study was undertaken with the following objectives:

- To compare the growth of wheat varieties treated with different levels of leaf clipping treatment
- To evaluate the leaf defoliation effects on yield performance of wheat varieties

CHAPTER 2

REVIEW OF LITERATURE

Alam *et al.* (2008) conducted a research work at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, Rajshahi, Bangladesh during the period from 2005 to 2006 to study the effect of source-sink manipulation on grain yield in wheat was with twenty wheat varieties/lines to study the effect of source manipulation on grain yield in wheat. Significant variations among the genotypes were observed for grains/spike, 100-grain weight and grain yield/spike. He reported that, removal of flag leaf caused decrease in grains/spike, 100-grain weight and grain yield/spike by 9.94%, 7.65% and 16.88%, respectively.

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

Elsahookie and Wuhaib (1988) found that grain yield per plant was increased up to 38% for plants with their upper half leaves cut in the spring grown maize.

Wang *et al.* (1997) reported that removal of one half of the leaves reduced grain mass/spike 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 but Agrani and SAN-127 caused high reduction in 1000-grain weight. The variety SAN-119, Agrani and Shotabdi showed high decrease in grain yield/spike by defoliation treatments.

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

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

Khalifa *et al.* (2008) conducted several field experiments during two summer seasons of 2003 and 2004 to study the effect of leaf cutting on physiological traits and yield of two rice cultivars hybrid (H_5) (IR 70368 A /G 178) and inbred rice. The leaf cutting was followed from flag leaf as follows: 1.) L; Control = without leaf cutting, 2.) L_1; flag leaf cut, 3.) L_2; second leaf cut, 4.) L_3; third leaf cut, 5.) L_4; both flag leaf and second leaf cut. 6.) L_5; flag leaf, second leaf and third leaf cut together. A split plot design with four replications was used; the main plots were devoted to the cutting of leaves, while the sub-plots were assigned to the two rice cultivars. Chlorophyll, sugar, starch and grain yield parameters were severely affected by L_5, followed by L_4, L_1, L_3 and L_2 in sequence. However, as a single component affecting maximum to these parameters is the removal of flag leaf. The flag leaf contributed maximum to the yield of rice grains. L_5, L_4, L_1, L_2 and L_3 treatments grain yield (relative % of control) by 59.87, 94.92, 44.89, 29.58 and 19.98 % respectively. Flag leaf contributed to 45% of grain yield and is the single most component for yield loss. The contribution of removal of leaf in hybrid rice was minimum, suggesting the probability of maximum translocation of photosynthesis from stem to the grain during grain feeling stage of hybrid rice after leaf removal.

Ali *et al.* (2010) carried out an experiment where five spring wheat varieties were utilized to study the contribution of flag leaf and awns on grain yield and its attributes. The characters associated with the photosynthetic activity were examined in relation to the grain yield and its attributes. The study revealed significant variation among different varieties, treatments and varieties × treatment. The treatments (removal of flag leaf, awns & both) caused considerable reduction in grain yield and its related characters. Removal of flag leaf had less effect on yield and related components than awns detachment. Nonetheless the detachment of flag leaf + awns revealed greater effects than individual treatment. Flag leaf area, awn length, number of grains per spike and 1000 grain weight demonstrated positive and significant association with grain yield per plant. Number of grains per spike, grain weight per spike 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.

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

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

Davidson (1965) found that the effects on variety Olympic wheat of maintaining the leaf area index (LAI), once attained, at approximately 3 and 1, and of removing all 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 per spikelet and mean grain weight by about 50%. These effects followed earlier reductions in the rate of development of the shoot apex. The results are discussed in relation to the yields obtained and conclusions reached by English workers, and to possible scope for yield improvement.

Dann (1968) conducted a study where wheat (CV. Heron) was subjected to various clipping treatments at Yanco, New South Wales, in 1963 and 1964. Clipping of vegetative structures reduced straw and grain yields in both years, but the reduction in yield was much greater in 1963 than in 1964. Weight per grain was the key grain yield component decreased by clipping. Highly significant correlation was obtained between dry matter removed at clipping, weight per grain and grain yield.

Busso and Richards (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.

Rockwood (1973) reported 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 whatsoever. 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.

Painter and Detling (1981) carried out an experiment where net photosynthesis and regrowth of 60 day old *Agropyron smithii* Rydb. Plants were investigated over a 10 day period following defoliation to stimulate grazing. Plants grown hydroponically in full strength Hoagland's solution were moderately defoliated (1/2 tillers clipped at 5 cm.), heavily defoliated (3/4 tillers clipped at 5 cm), or left as unclipped controls. Thirty minutes after clipping, rates of the youngest fully expanded leaf of a remaining undamaged tiller had declined by 6 to 7% in both groups of defoliated plants. Rates of were subsequently monitored on the same leaves at 2 day intervals. By day 2, (per unit of leaf area) of both defoliated groups had increased to rates 5 to 10% higher than those preceding treatment, while of control plants had reduced about 6%. From Day 2 through Day 10, rates of control plants averaged 90% of their pre-clipping rates, while rates of moderately and heavily defoliated plants averaged 106% and 114% of their pre-clipping rates, respectively. Defoliation had no significant effect on tiller production over this 10 day period. While total new biomass production of controls was almost twice that of either of the defoliated groups, the proportion of the new growth allocated to shoots, crowns and roots did not differ among the three groups.

Gardner and Wiggans (1960) found that delayed or repeated clipping at 4-leaf stage increased forage yield of two oat varieties. Single clippings at the 4-, 5-, and 7-leaf stage reduced grain yield by 9, 28, and 98%, respectively. Clipping diminished floral development and reduced lodging and test weight. Nitrogen fertilization did not compensate for the deleterious clipping effect.

Conover (1988) reported that Canada geese (*Branta Canadensis*) often graze during the fall and winter in fields of rye that are planted as cover crops to reduce soil erosion and improve soil qualities. He also found that, grazing by Canada geese had an adverse impact on rye. In 11 Connecticut fields frequented by geese, the leaf biomass of rye by mid-winter was 535% higher inside exclosures than in grazed portions of the same fields. By spring, rye leaf biomass was 177% higher inside than outside of the exclosures. In another experiment, rye was clipped to simulate grazing by Canada geese to determine whether leaf loss slowed the rye plants growth during winter and spring. Plants that suffered leaf loss had lower total biomass, leaf and stem biomass, and root biomass than uninjured plants regardless of time during fall and winter when the leaves were clipped. Plants receiving multiple clippings grew slower than those receiving only a single clipping.

Remison and Omueti (1982) investigated the effects of N nutrition and leaf clipping after mid-silk of maize. N increased yield components and defoliation reduced weight of ears, grains, total dry matter aboveground, harvest index and grain moisture. Crude protein was increased, specially with maximum clipping.

Carter (1995) carried out an experiment regarding early-season frost-damage effects on corn (*Zea mays* L.) which restricts the ability of producers to make decisions regarding replanting and yield expectations. First objective of the study was to monitor corn growth and yield within fields with a range of late-spring frost injury. The second objective was to evaluate effects of post-frost clipping on plant growth and yield. Several days after a severe 21 June 1992 frost, plots were established at several Wisconsin sites in which within-field frost-damage to corn with 9 to 12 emerged leaves ranged from major (65 to 100% of leaves damaged) to minor (less than 5% of leaves damaged). Damage within fields varied primarily due to slight topography differences, with greatest damage in low-lying areas. Although nearly all plants recovered from the injury, plants with greatest damage were delayed in silking (7 to 10 d later), had reduced final plant (16 to 25 in. shorter) and ear (12 to 20 in. shorter) height and lower grain yield (42 to 59% lower) compared with plants with least damage. Post-frost clipping reduced grain yield by 15 to 34% at three sites, resulted in no differences at two sites, and increased yield about 10% at one site. Based on the results obtained and previous studies, there is little consistent benefit to clipping frost-damaged corn.

Arzadún *et al.* (2006) In Argentinean Pampas, new wheat (*Triticum aestivum* L.) cultivars are routinely introduced to farmers for dual-purpose production. The objective of this study was to evaluate the effect of planting date, clipping height on forage, and grain yield for wheat cultivars. Treatments were arranged as a 3 × 3 × 3 factorial distributed in a split-split plot within a randomized complete block design. Main plots were planting date (March, April, and May); split-plots were clipping height (3 cm, 7 cm, and no clipping); and split-split plots were a facultative cultivar Pincen, and two nonfacultative cultivars Charrua and Bordenave 223 (Bve223). In 1995 and 1996 forage yield decreased in response to a delayed planting date from March to May, whereas in 1997 it was not affected by planting date. The 3-cm clipping height yielded 21% more forage than plots clipped at 7 cm. Bve223 and Charrua produced significantly more forage than Pincen each year. Grain yield increased as planting date progressed from March to May. Clipping at 3 cm reduced grain yield compared with no clipping, while during 2 to 3 yr, 7 cm produced no significant change in grain yield compared with no clipping. In all years Bve223 produced more grain than Charrua or Pincen. Forage yield lost in response to later planting date ranged between 0 and 81% during the 3 yr; whereas grain yield increased from 40 to 190% for wheat planted in May compared with March. In conclusion, dual-purpose wheat planted during April had both good forage and grain production, and its success was influenced by cultivars.

Compton (1960) conducted a study in order to determine to what extent corm size is likely to be affected by fluorine injury to the leaves of gladiolus. In the experiment, tips of mature leaves of the Beacon and Picardy varieties were cut back 2, 4, 6 or 8 inches, either periodically as each leaf matured or once only at spike emergence. Corm weights were reduced in proportion to the extent of the clipping, the effect being more severe on Beacon than on Picardy. In the Beacon variety removal of 8 inches of the tip reduced corm weights by 46% with periodic clipping and by 31% with a single clipping. Significant reductions in corm weight were obtained only after about 11 % of the total leaf area of the plant had been removed.

Alexander and Thompson (1982) investigated the effect of clipping frequency on competition between *Lolium perenne* and *Agrostis tenuis*was. The yield of clippings of both species increased and then declined during the 12-week period of the experiment, but the clip yield of *Lolium* was always significantly greater than that of *Agrostis. Lolium* was clearly the better competitor in unclipped controls. 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.

Piening and Kaufmann (1969) carried out several experiments were in a growth cabinet 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.

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

Elsahookie and Wuhaib (1988) conducted an experiment to study the effect of leaf clipping on maize (*Zea mays* L.) performance, nine different treatments were tested on an open-pollinated genotype of maize. In the spring grown maize, grain yield/plant was increased up to 38% for plants with their upper half leaves cut. Root weight/plant 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

Jalilian and Delkhoshi (2014) carried out an experiment to investigate the role of leaf position on yield and yield component of maize, this research was conducted based on randomized complete block design with three replicates at the research field of Urmia University, Urmia, Iran, in 2011. To determine the role of leaf position in maize yield, the leaf removing (clipping) treatments were used. Leaf clipping treatments contain ear leaf clipping, above ear leaf clipping, below ear leaf clipping and control (without leaf clipping) that imposed at one week after ear initiation. Leaf removing had a significant effect on all measured traits (number of seed per row, row number per ear, ear length, 1000 seed weight, seed yield, biological yield), except harvest index. Removing of above leaves decreased 6.68% the number of seeds on ear compared to control. The highest 1000 seed weight (274 g) was observed in plants without leaf clipping. Ear leaf clipping and below ear leaf defoliation both were ranked second for 1000 seed weight. Whereas plants without any leaf clipping had the utmost seed yield (8.77 t/ha) but defoliating of leaf above ear lead to lower seed yield (6.77 t/ha).

Jebbouj and El Yousfi (2009) gave specific definitions to each of these terms, in which they have defined grain yield losses due to defoliation by comparing a defoliating treatment to a non-defoliated check, while contribution is defined as a comparison of a specific defoliating treatment to the one, where the plants have lost all their upper three leaves. Looking forward to estimate the importance of the three upper leaves of wheat under Moroccan conditions, the present study adopted the same nomenclature defined above, and carried out greenhouse and field experiments to evaluate contribution to yield and estimate grain yield losses using defoliating treatments under healthy and diseased conditions

Oyewole (2017) conducted a pot trial at the Faculty of Agriculture, Kogi State University Anyigba, within the southern Guinea savanna agro ecological zone of Nigeria, with daily temperature range between 250C - 350C. The experiment, a Randomized Complete Block Design (RCBD) with eight treatments (defoliation at 25% above the ear, 25% under the ear, 50% above the ear, 50% under the ear, 75% above the ear, 75% under the ear, 100% defoliation and no defoliation as control) was replicated four times. Treatment was imposed at ear initiation. Growth and yield parameters collected were: number of leaves per plant, leaf area, plant height, stem girth, days to ear initiation, number of cobs/plant, days to crop maturity, cob weight, cob length, seed rows per cob, 100-seed weight as well as total cob yield/ha. All data collected were subjected to analysis of variance (ANOVA) and New Duncan Multiple Range Test (NDMRT) was used to estimate the differences among significant means at 5% level of probability. Prior to imposition of the treatment, analyzed results indicate no significant differences between number of leaves at 2, 4 and 6 WAS, as well as plant heights and stem girth at 2, 4, 6, 8 and 10 WAS. However there were significant differences between leaf areas at 4 and 6 WAS. In addition, there were significant effects of defoliation on cob length and dry cob weight with the highest cob weight obtained in 25% defoliation carried out above the ear. In addition, there were significant differences in the number of rows per cob and grain yield per ha with 0% defoliation giving the highest result while the least was in 100% defoliation. Generally, it was found that defoliation at any rate and position influenced maize yield, notwithstanding that the treatment was imposed at cob initiation, an indication that harvest of solar radiation post cob initiation plays important role on eventual maize yield.

Hamzi *et al*. (2018) conducted an experiment to study the relation between sink and source in corn plants, a field 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. Grain yield reduction was observed in 700, 406 and 301 in ascending order. The highest grain yield was observed in all cultivars under control treatment. 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. The highest oil, globulin, glutamine, prolamine and carbohydrate belonged to the cultivar 604. Globulin concentration in grain of 604 and 700 cultivars and prolamine in grain of 604 and 301 cultivars were similar. Cultivar 301 produced the lowest globulin and prolamine but its oil, glutamine and carbohydrates were similar to 700 and 301 cultivars. Cultivar 700 produced the highest albumins under above ear leaf clipping treatment.

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the agronomy field of Sher-e-Bangla Agricultural University, Dhaka from November 2016 to February 2017. This chapter contains a brief description of experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recording and their analyses.

3.1 Experimental Site

The experiment was carried out at the agronomy field of Sher-e-Bangla Agricultural University farm, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28 during the Rabi season of 2017. The land area is situated at 23°41′N latitude and 90°22′E longitude at an altitude of 8.6 meter above sea level. The experimental site is indicated in the AEZ map of Bangladesh in Appendix I.

3.2 Climate

The experimental area is under sub-tropical climate with high temperature, high humidity and heavy rainfall with occasional heavy winds in Kharif season (April-September) and less rainfall associated with moderately low temperature during the Rabi season (October-March). The weather data during the study period of the experimental site is shown in Appendix II.

3.3 Soil

The field belongs to General soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunshine was available during the experimental period. The analyses were done by Soil Resources and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix III.

3.4 Treatments

The experiment consisted of two treatment factors as mentioned below:

Factor A: Variety (2)

V_1= BARI Gom 26

V_2= BARI Gom 30

Factor B: Leaf clipping (5)

L_1=Clipping of all leaves except flag leaf

L_2=Clipping of flag leaf only

L_3=Clipping of all leaves except flag leaf & it's immediate leaf

L_4=Clipping of all leaves except flag leaf & first two leaves beneath flag leaf

L_5=Control/ No clipping

3.5 Plant materials & features

Seeds of BARI Gom 26 and BARI Gom 30 were collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh. BARI Gom 26 is a high yielding heat tolerant variety. Due to high temperature tolerant late planting yield is high It was released in 2010. Leaf is broad, recurved and deep green, in younger stage tiller is intermediate, plant deep green, a lot of hair present in upper culm node, flag leaf broad and erect. Plant height ranges from 92-96 cm producing 5-6 tillers plant^{-1}, 45-50 grains spike^{-1} containing seed colour white. It matures within 104-110 days and yield varies between 3500-4500 Kg ha^{-1}. The cultivar is claimed to be tolerant to leaf rust and leaf spot disease (blight). BARI Gom 30 is a short duration high yielding heat tolerant variety. It was released in 2014. Plant height ranges from 95-100 cm producing 4-5 tillers plant^{-1}, 45-50 grains spike^{-1}. It matures within 100-105 days and yield varies between 4500-5500 Kg ha^{-1}. This variety is tolerant to leaf rust and leaf spot disease (blight).

3.6 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The size of the individual plot was 3.0 m x 2.0 m and total numbers of plots were 30. There were 10 treatment combinations. Each block was divided into 10 unit plots. Layout of the experiment was done on November 9, 2016 with inter-plot spacing of 0.50 m and inters block spacing of 1.0 m. The experimental design presented in Appendix IV.

3.7 Preparation of experimental land

The land of the experimental field was first opened on 28 October, 2016 with a power tiller. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. Deep ploughing was done to produce a good tilth, which was necessary to get better yield of the crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field. The final land preparation was done on 14 November, 2016.

3.8 Fertilizer dose and methods of application

All the fertilizers were applied at the rate of BARI recommended dose as 115 kg ha^{-1} N, 67 kg ha^{-1} P_2O_5, 60 kg ha^{-1} K_2O, 20 kg ha^{-1} S and 4 $kgha^{-1}$ Zn. Fertilizers other than nitrogen were given during final land preparation.

At the time of first ploughing cowdung at the rate of 10 t ha-1 was applied. The experimental area was fertilized with 3.5, 2.6, 2.4, 1 and 0.2 kg N, P_2O_5, K_2O and S respectively. The entire amounts of P_2O_5, K_2O and S were applied at final land preparation as a basal dose. 3.5 kg N was applied as three equal split doses of 1.15 kg at three different growth stages of wheat.

3.9 Seed treatment

Seeds were treated with Vitavex-200 @ 0.25% before sowing to prevent seeds from the attack of soil borne diseases.

3.10 Sowing of seeds

Seeds were sown on 16 November, 2016 by hand. 3.68 kg Seeds (122.4 g/ plot) were sown in line at recommended rate of 120 kg ha^{-1} and then covered properly with soil. The line to line distance for wheat was 20 cm and plant to plant distance was 4 - 5 cm.

3.11 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of wheat:

3.11.1 Thinning

Emergence of seedling was shown within 10 days after sowing. Overcrowded seedlings were thinned out for two times. First thinning was done after 12 days of sowing on 28 November, 2016 which was done to remove unhealthy and lineless seedlings. The second thinning was done 10 days after first thinning on 8 December, 2016.

3.11.2 Weeding

The experimental field was kept free from weeds by hand weeding as per requirements.

3.11.3 Irrigation

The first irrigation was done at crown root initiation stage (19 DAS) on 5 December, 2016. Second irrigation was provided at 55 DAS which was the panicle initiation stage of wheat and the last irrigation was done at grain filling stage (75 DAS). Well managed drainage system was also installed for draining out excess water.

3.11.4 Disease and pest management

Field was infested by Fusarium or Sclerotium root rot during the early growing stage of seedlings. Spraying Bavistin at recommended dose controlled these fungi. The fungicide was sprayed three times at 7-10 days interval. 1^{st}, 2^{nd} and 3^{rd} spraying of Bavistin 0.2% was applied on 11 December, 2016, 18 December, 2016 and 28 December, 2016 respectively. Rodents were also controlled by using rodenticide at recommended dose.

3.12 General observations of the experimental field

Regular observation was done to inspect the growth stages of the crop. The field was observed time to time to detect visual difference among the treatment and any kind of infestation by weeds, insects and diseases so that considerable losses by pest was minimized.

3.13 Application of treatments

At post-anthesis stage different levels of leaf clipping treatments (L_1=Clipping of all leaves except flag leaf, L_2=Clipping of flag leaf only, L_3=Clipping of all leaves except flag leaf & it's immediate leaf, L_4=Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5=Control/ No clipping) were applied on wheat plants by scissor.

3.14 Sampling

Ten plants of the inner rows were selected randomly and growth parameters data were taken from these 10 plants at maturity.

3.15 Harvest and post-harvest operation

The crop was harvested when it reached maturity. At maturity, when leaves, stems and pods became yellowish in colors, then the plants were harvested. One square meter area from the central position of each plot was harvested for yield data and it was converted to t $ha^{-1.}$ The harvested plants were tied into bundles and carried to the threshing floor. The crops were sun dried by spreading on the threshing floor. The seeds were separated from the plants by pedal thresher and thereafter were cleaned, dried and weighed. The weights of the dry straw were also taken from the same demarcated area and were converted to t/ha.

3.16 Collection of data

3.16.1 Crop growth parameters

a. Plant height (cm) at 25, 50, 70, 80 and 90 DAS.

b. Number of total tillers (effective & non-effective) per linear meter of row

c. Plant dry weight (g)

d. Panicle weight (g)

3.16.2 Yield contributing characters

a. Number of effective tillers/linear meter

b. Number of spikes/linear meter

c. Number of spikelets/spike

d. Number of grains/spike

e. Weight of 1000 grains (g)

3.16.3 Yield and harvest index

a. Seed yield (t/ha)

b. Straw yield (t/ha)

c. Harvest index (%)

3.17 Procedure of sampling for growth study during the crop growth period

Plant height (cm)

The height of the wheat plants was recorded at 25, 50, 70, 80 & 90 DAS. Height of the plant was measured from the ground level up to tip of the flag leaf. The average height of ten preselected plants was considered as the height of the plant for each plot.

Number of tillers/linear meter

Number of tillers of one linear meter from each plot was counted and number of effective and non-effective tillers was also recorded accordingly.

Plant dry weight (g)

Plants at different days after sowing (45, 65, 85 DAS and at harvest) were collected from 25cm area of each plot and dried at oven for 48 hours. The dried samples were then weighed and data was averaged before collection.

Panicle weight (g)

Panicles at different days after sowing (45, 65, 85 DAS and at harvest) were collected from 25cm area of each plot and dried at oven for 48 hours. The dried samples were then weighed and data was averaged before collection.

3.18 Procedure of data collection for yield and yield components

For assessing attributes, data were collected from 10 randomly selected plants from each of the plots. For yield measurement, an area of 1.0 m^2 from center of each plot was harvested.

Number of effective tillers/linear meter

The panicles which had at least one grain was considered as effective tiller. The total number of effective tillers of one linear meter was counted.

Number of spikelets/spike

Data on the number of spikelets/spike was counted. Five spike bearing plants were randomly selected and the average data of the spikelets was collected.

Number of grains/spike

Presence of any food material in the grains was considered as filled grain. The total number of grain from randomly selected 5 spikes were counted and the average data was collected to have the number of filled grains $spike^{-1}$.

Weight of 1000 grains (g)

1000 cleaned & dried grains were randomly collected from the seed stock of each plot and were sun dried properly and weighed by using an electric balance.

Seed and straw yield (t/ha)

An area of 3.0 m^2 was harvested for yield measurement. The crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were threshed and dried in open sunshine and then grains were cleaned. The seed and straw weights for each plot were recorded after proper drying in sun. Then the yield data were converted for 1 m^2 and collected.

Harvest index (%)

It denotes the ratio of economic yield to biological yield and was calculated with the following formula.

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

Statistical analysis

The data collected on different parameters were statistically analyzed with RCBD using the MSTATC computer package program developed. Least Significant Difference (LSD) technique at 5% level of significance was used to compare the mean differences among the treatments.

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CHAPTER 4

RESULTS AND DISCUSSION

4.1. Crop growth characters

4.1.1 Plant height (cm)

4.1.1.1 Effect of variety

Plant height varied significantly between the two varieties (Fig 1). At, 25 DAS, BARI Gom 26 showed the taller plant height (22.65 cm) and BARI Gom 30 recorded the shorter plant height (21.39 cm). At 50 DAS, BARI Gom 26 showed the higher plant height (53.48 cm) compared to BARI Gom 30 (52.45 cm).

BARI Gom 26 showed the taller plant height (68.23 cm) and BARI Gom 30 recorded the shorter plant height (62.07 cm) at 70 DAS. At, 80 DAS, BARI Gom 26 recorded the taller plant height (70.70 cm) and BARI Gom 30 recorded the shorter plant height (65.64 cm). At, 90 DAS, during harvesting, BARI Gom 26 showed the taller plant height (72.23 cm) compared to BARI Gom 30 (67.21 cm).

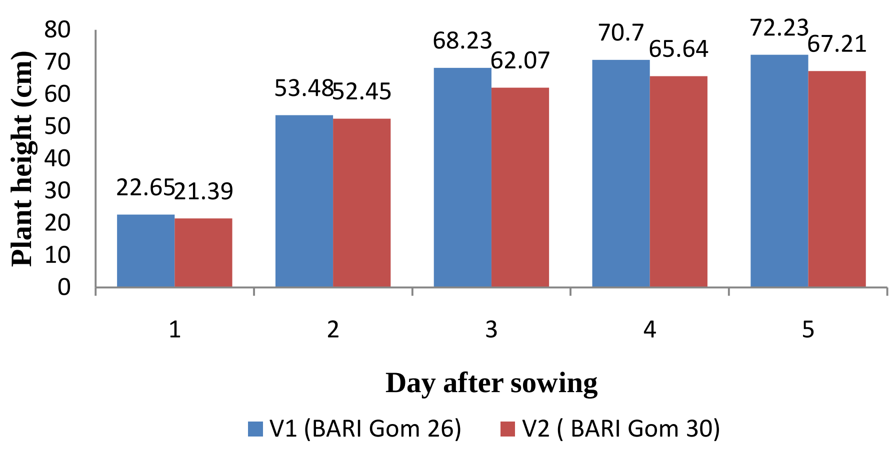

Fig 1. Plant height at five different DAS

(1) 25 DAS (2) 50 DAS (3) 70 DAS (4) 80 DAS (5) 90 DAS

4.1.1.2 Effect of leaf clipping

Plant height varied significantly due to various level of leaf clipping (Fig 2). At 25 DAS, L_5 showed the tallest plant (22.79 cm) which was statistically similar with L_2 and L_3. However, the shortest plant (21.70 cm) was observed in L_1 which was statistically similar with L_4. At 50 DAS, L_3 showed the tallest plant (54.37 cm). L_1, L_2 and L_5 produced statistically similar result. The shortest plant (51.87cm) was observed in L_4 which was statistically similar with L_4.

At 70 DAS, L_2 recorded the tallest plant (67.33 cm). L_1 produced plant (64.58 cm) which was statistically similar to L_3 and L_4. However, the shortest plant (63.26 cm) was observed in L_5. At 80 DAS, L_2 again showed the tallest plant (70.96 cm) which was statistically similar with L_3. L_4 produced plant (67.48 cm) which was statistically similar to L_1. However, the shortest plant (65.87 cm) was observed in L_5. At 90 DAS, L_2 again showed the tallest plant (71.74 cm) and L_3 produced plant (70.28 cm). L_1 produced plant (69.59 cm) which was statistically similar to L_4. The shortest plant (67.63 cm) was observed in L_5.

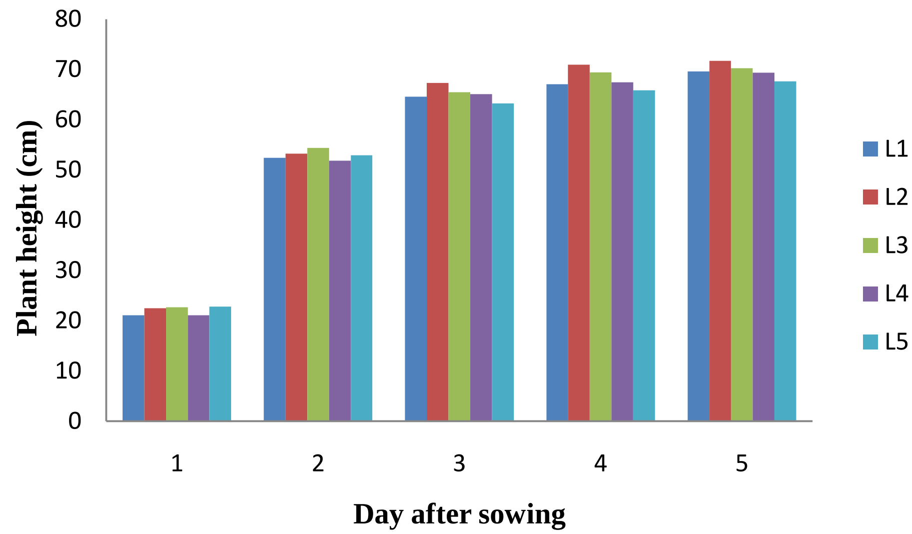

Fig 2. Effect of leaf clipping on plant height at different day after sowing

Here, L_1= Clipping of all leaves except flag leaf, L_2=Clipping of flag leaf only, L_3=Clipping of all leaves except flag leaf & it's immediate leaf, L_4=Clipping of all leaves except flag leaf & first two leaves beneath flag leaf and L_5=Control. And, (1) 25 DAS (2) 50 DAS (3) 70 DAS (4) 80 DAS (5) 90 DAS.

4.1.1.3 Effect of interaction between variety and leaf clipping

Plant height varied significantly due to various treatment combinations of variety and leaf clipping (Table 1). At 25 DAS, the treatment combinations of V_1L_2 recorded the tallest plant (24.35 cm) which was statistically similar with V_1L_5. However, the treatment combination V_2L_2 recorded the shortest plant (20.56 cm) which was statistically similar to V_1L_4, V_2L_1 and V_2L_4. At 50 DAS, the treatment combinations of V_1L_3 recorded the tallest plant (54.75 cm) which was statistically similar with V_1L_1, V_1L_2 and V_2L_3. However, the treatment combination V_2L_1 recorded the shortest plant (50.89 cm) which was statistically similar to V_2L_4. At 70 DAS, the treatment combination of V_1L_2 recorded the tallest plant (73.06 cm). The shortest plant (61.30 cm) height was observed in the treatment combination of V_2L_3 which was statistically similar to V_2L_2 and V_2L_4. At 80 DAS, the treatment combination of V1L2 recorded the tallest plant (75.36 cm). The shortest plant (64.74 cm) height was observed in the treatment combination of V_2L_1 which was statistically similar to

V_2L_2, V_2L_3, V_2L_4, V_2L_5 and V_1L_5. At 90 DAS, the treatment combination of V_1L_2 again recorded the tallest plant (75.84 cm). The shortest plant (66.69 cm) height was observed in the treatment combination of V_2L_1 which was statistically similar to V_2L_3, V_2L_4 and V_2L_5.

Table 1. Interaction effect of variety and leaf clipping on plant height

Treatments	Plant height (cm)				
	25 DAS	**50 DAS**	**70 DAS**	**80 DAS**	**90 DAS**
V_1L_1	21.15 de	54.02 ab	66.02 c	69.45 c	72.49 c
V_1L_2	24.35 a	53.80 abc	73.06 a	75.36 a	75.84 a
V_1L_3	23.20 b	54.75 a	69.67 b	72.14 b	73.40 b
V_1L_4	21.06 e	52.10 de	68.38 b	69.67 c	71.56 d
V_1L_5	23.50 ab	52.73 cde	64.00 d	66.87 d	67.88 e
V_2L_1	20.96 e	50.89 f	63.15 de	64.74 d	66.69 f
V_2L_2	20.56 e	52.65 de	61.61 f	66.56 d	67.63 e
V_2L_3	22.19 c	53.99 ab	61.30 f	66.74 d	67.16 ef
V_2L_4	21.14 de	51.63 ef	61.79 f	65.29 d	67.19 ef
V_2L_5	22.07 cd	53.08 bcd	62.52 ef	64.87 d	67.38 ef
LSD $_{(0.05\%)}$	**0.9749**	**1.133**	**1.312**	**2.175**	**0.8864**
CV (%)	**2.58%**	**1.25%**	**1.17%**	**1.86%**	**0.74%**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Here, V_1= BARI Gom 26, V_2= BARI Gom 30, L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.1.2 Number of tillers/linear meter

4.1.2.1 Effect of variety

Number of total tillers per linear meter area varied between the two varieties (Fig 3). The V_2 (BARI Gom 30) showed higher number of tillers (41.87 tillers/linear meter) compared to V_1 (BARI Gom 26) which recorded (32.27 tillers/linear meter).

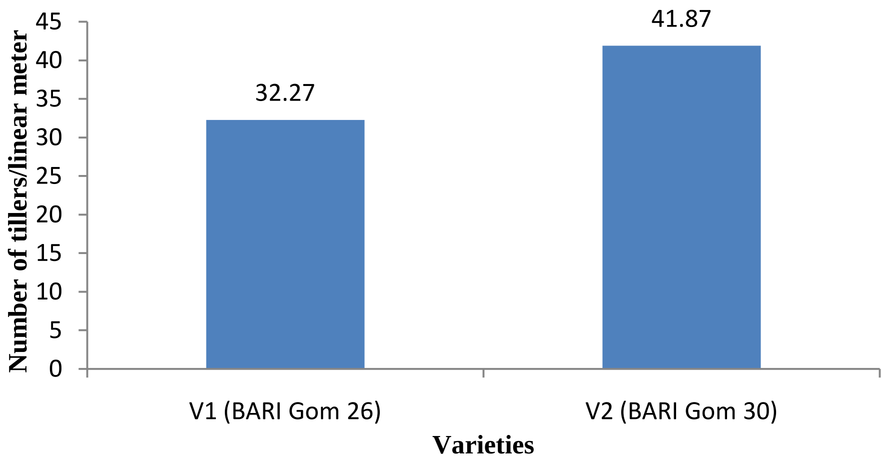

Fig 3. Effect of varieties on number of tillers/linear meter

4.1.2.2 Effect of leaf clipping

The study found that number of total tillers per linear meter area varied with various levels of leaf clipping (Fig 4). The L_5 recorded highest number of tillers (39.50 tillers/linear meter). The L_1 showed the lowest number of tillers (35.83 tillers/linear meter) which was statistically similar to L_2, L_3 and L_4.

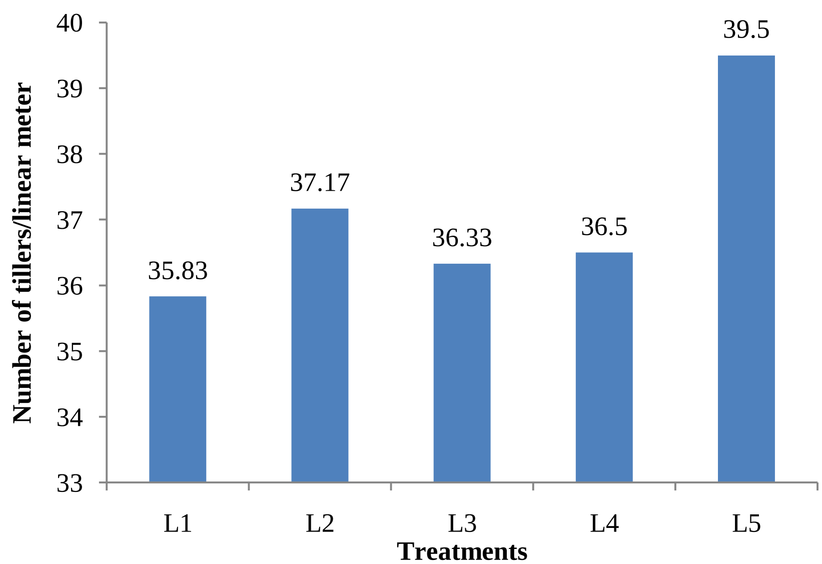

Fig 4. Effect of leaf clipping on number of tillers/linear meter

Here, L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.1.2.3 Effect of interaction between variety and leaf clipping

Number of total tillers per linear meter area varied due to various treatment combinations of variety and leaf clipping (Table 2). The treatment combinations of V_2L_3 recorded the highest number of total tillers (44.67 tillers/linear meter) which was statistically similar with V_2L_2 and V_2L_5. V_1L_3 showed the lowest number of tillers (28.00 tillers/linear meter).

Table 2. Interaction effect of variety and leaf clipping on number of total tillers, effective tillers and non-effective tillers/linear meter

Treatments	Number of tillers/linear meter	Number of effective tillers/linear meter	Number of non-effective tillers/linear meter
V_1L_1	35.00 c	34.33 c	0.6667 ab
V_1L_2	31.67 d	31.33 d	0.3333 b
V_1L_3	28.00 e	27.67 e	0.3333 b
V_1L_4	31.00 d	31.00 d	0.0000 b
V_1L_5	35.67 c	34.67 c	1.000 ab
V_2L_1	36.67 c	35.67 c	1.000 ab
V_2L_2	42.67 ab	41.33 ab	1.333 ab
V_2L_3	44.67 a	43.33 a	1.333 ab
V_2L_4	42.00 b	39.67 b	2.333 a
V_2L_5	43.33 ab	42.33 a	1.000 ab
$LSD_{(0.05\%)}$	**2.256**	**2.457**	**1.712**
CV (%)	**3.55**	**3.96**	**106.94**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability.

Here, V_1= BARI Gom 26, V_2= BARI Gom 30, L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.1.3 Number of effective tillers/linear meter

4.1.3.1 Effect of variety

This study showed that the number of effective tillers per linear meter area varied between two varieties (Fig 5). V_2 (BARI Gom 30) showed highest number of effective tillers (40.47 tillers/linear meter). And, V_1 (BARI Gom 26) recorded the lowest (31.80 tillers/linear meter).

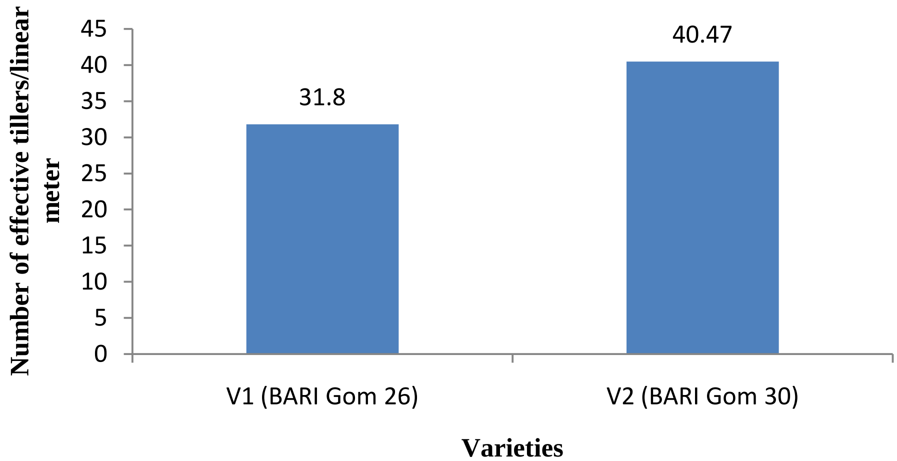

Fig 5. Effect of varieties on number of effective tillers/linear meter

4.1.3.2 Effect of leaf clipping

Number of effective tillers per linear meter area varied with various levels of leaf clipping (Fig 6). The L_5 recorded highest number of effective tillers (38.50 tillers/linear meter). The L_1 showed the lowest number of effective tillers (35.00 tillers/linear meter) which was statistically similar to L_2, L_3 and L_4.

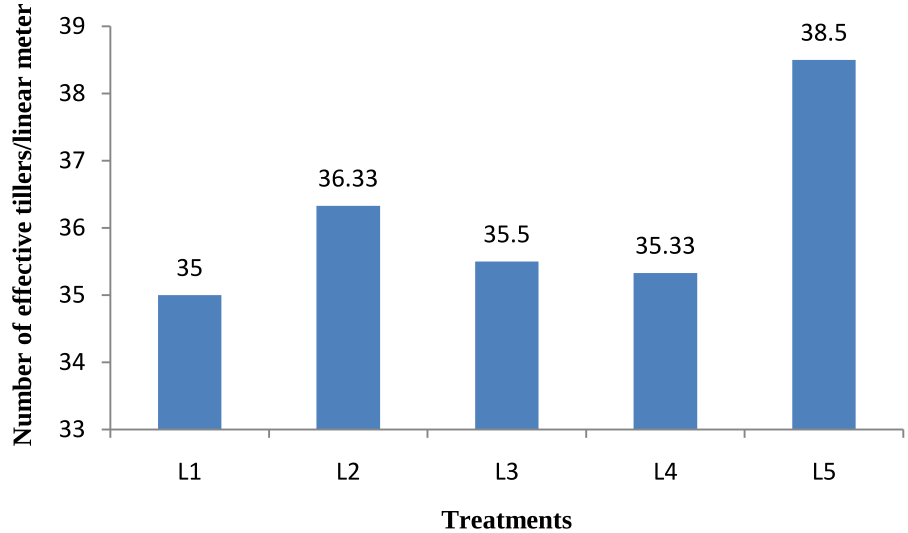

Fig 6. Effect of leaf clipping on number of effective tillers/linear meter

L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.1.3.3 Effect of interaction between variety and leaf clipping

The study exhibited that the number of effective tillers per linear meter area varied with various treatment combinations of variety and leaf clipping (Table 2). The treatment combinations of V_2L_3 recorded the highest number of effective tillers (43.33 tillers/linear meter) which was statistically similar with V_2L_2 and V_2L_5. The V_1L_3 showed the lowest number of effective tillers (27.67 tillers/linear meter).

4.1.4 Number of non-effective tillers/linear meter

4.1.4.1 Effect of variety

Number of non-effective tillers per linear meter area varied between the two varieties (Fig 7). The V_2 (BARI Gom 30) showed higher number of non-effective tillers (1.400 tillers/linear meter) compared to V_1 (BARI Gom 26) which recorded (0.467 tillers/linear meter).

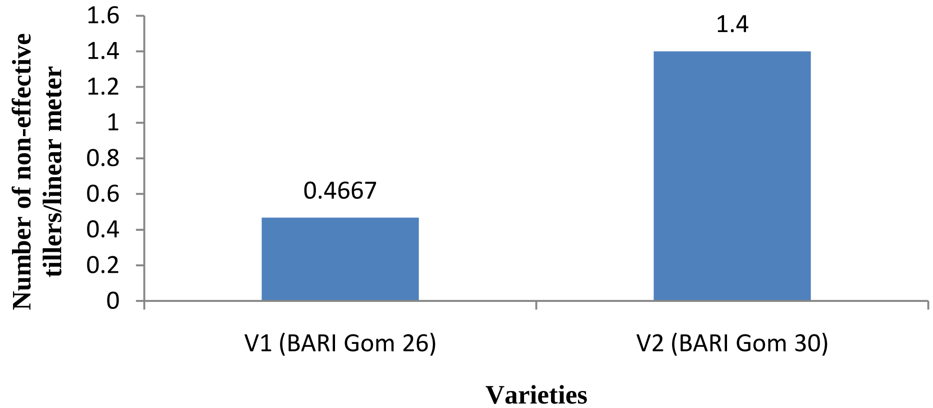

Fig 7. Effect of variety on number of non-effective tillers/linear meter

4.1.4.2 Effect of leaf clipping

This study found that the number of non-effective tillers per linear meter area varied with various levels of leaf clipping (Fig 8). The L_4 recorded highest number of non-effective tillers (1.167 tillers/linear meter) which was statistically similar to L_1, L_2, L_3 and L_5.

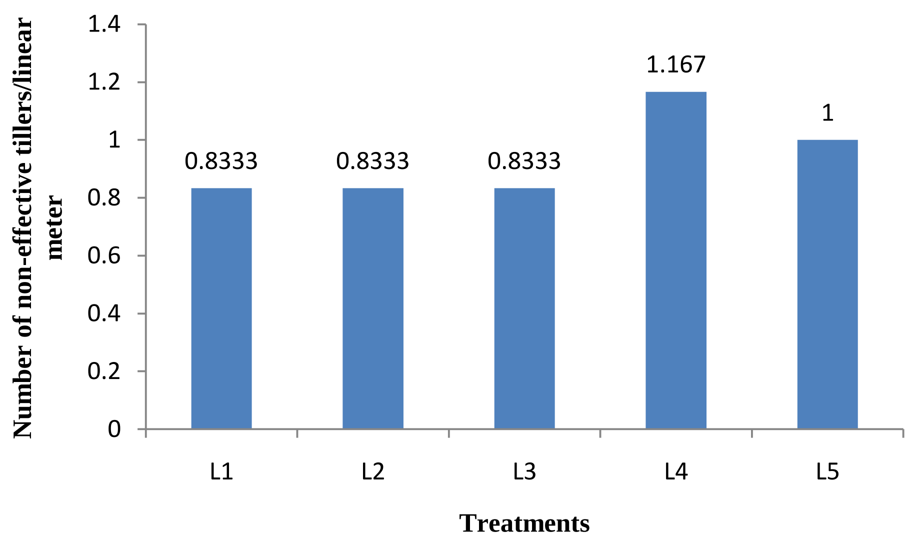

Fig 8. Effect of leaf clipping on number of non effective tillers/linear meter

L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.1.4.3 Effect of interaction between variety and leaf clipping

Number of non-effective tillers per linear meter area varied with various treatment combinations of variety and leaf clipping (Table 2). The treatment combinations of V_2L_4 recorded the highest number of non-effective tillers (2.333 tillers/linear meter) which was statistically similar with V_1L_1, V_1L_5, V_2L_1, V_2L_2, V_2L_3 and V_2L_5. V_1L_4 showed the lowest number of effective tillers (0.00 tillers/linear meter) which was statistically similar to V_1L_2 and V_1L_3.

4.1.5 Plant dry weight (g)

4.1.5.1 Effect of variety

The study exhibited that the plant dry weight varied between two varieties (Fig 9). The V_1 (BARI Gom 26) recorded higher stem dry weight (11.26 g) and V_2 (BARI Gom 30) recorded lower (9.649 g).

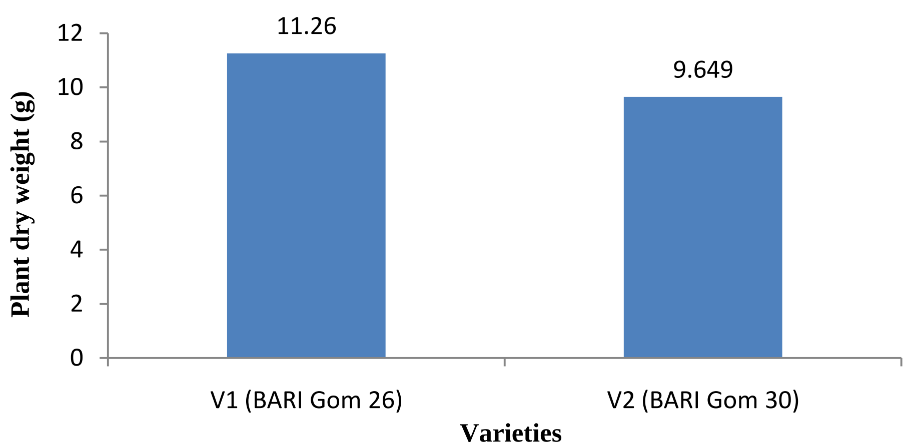

Fig 9. Effect of varieties on plant dry weight

4.1.5.2 Effect of leaf clipping

Plant dry weigh varied with various levels of leaf clipping (Fig 10). The L_1 recorded highest plant dry weight (11.55 g) which was statistically similar to L_2. The lowest plant dry weight (9.640 g) was recorded for L_5 which was statistically similar to L_3 and L_4.

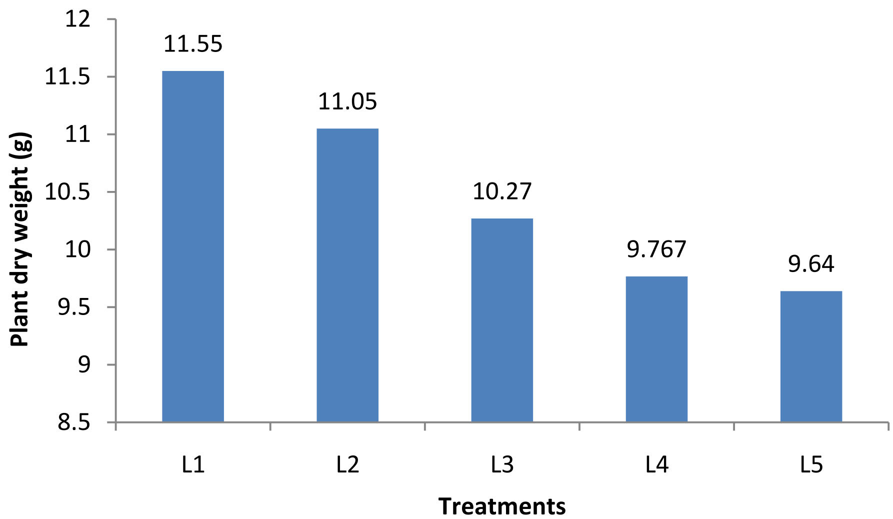

Fig 10. Effect of leaf clipping on plant dry weight

L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.1.5.3 Effect of interaction between variety and leaf clipping

The study showed that plant dry weight varied due to various treatment combinations of variety and leaf clipping (Table 3). The treatment combinations of V_1L_1 recorded the highest plant dry weight (13.41 g) which was statistically similar with V_1L_2. The combination of V_1L_4 showed the lowest plant dry weight (9.103 g) which was statistically similar to V_1L_5, V_2L_1, V_2L_2, V_2L_3 and V_2L_5.

Table.3. Interaction effect of variety and leaf clipping on plant dry weight and panicle weight

Treatments	Stem dry weight (g)	Panicle weight (g)
V_1L_1	13.41 a	6.200 bc
V_1L_2	12.95 a	5.583 cd
V_1L_3	11.08 b	4.650 f
V_1L_4	9.103 d	4.403 f
V_1L_5	9.747 cd	4.887 ef
V_2L_1	9.690 cd	5.640 cd
V_2L_2	9.140 d	7.843 a
V_2L_3	9.453 cd	5.353 de
V_2L_4	10.43 bc	6.390 b
V_2L_5	9.533 cd	6.720 b
$LSD_{(0.05\%)}$	**1.116**	**0.6732**
CV (%)	**6.22**	**6.80**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability.

Here, V_1= BARI Gom 26, V_2= BARI Gom 30, L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.1.6 Panicle weight (g)

4.1.6.1 Effect of variety

Panicle weight varied between the two varieties (Fig 11). The V_2 (BARI Gom 30) recorded higher panicle weight (6.389 g) than V_1 (BARI Gom 26) which recorded (5.145 g).

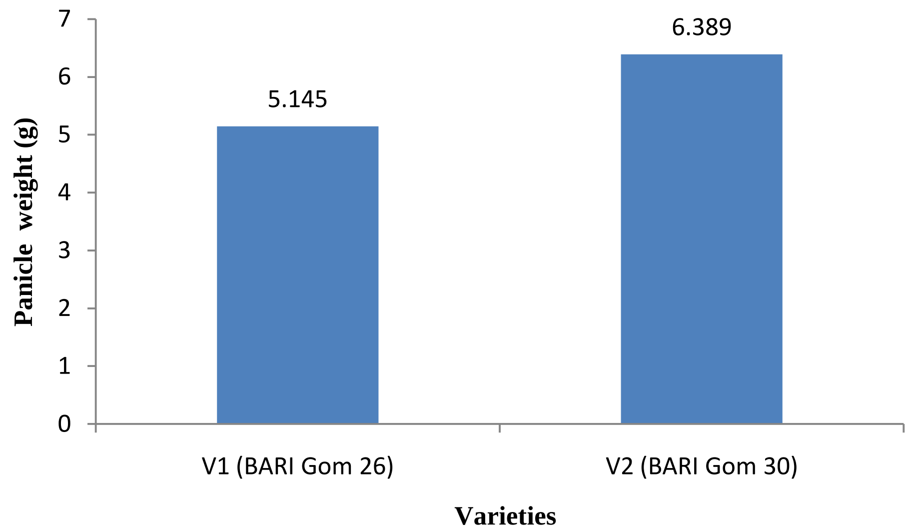

Fig 11. Effect of variety on panicle weight

4.1.6.2 Effect of leaf clipping

The study found that the panicle weight varied with various levels of leaf clipping (Fig 12). The L_2 recorded highest panicle weight (6.713 g). The lowest stem dry weight (5.002 g) was recorded for L_3 which was statistically similar to L_4.

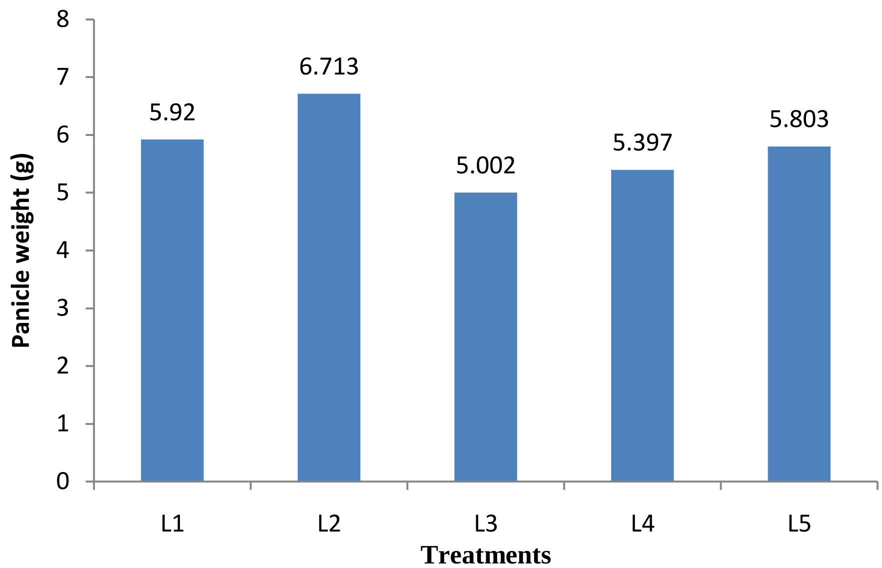

Fig 12. Effect of leaf clipping on panicle dry weight

L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.1.6.3 Effect of interaction between variety and leaf clipping

This study showed that the panicle dry weight varied with various treatment combinations of variety and leaf clipping (Table 3). The treatment combinations of V_2L_2 recorded the highest stem dry weight (7.843 g). The V_1L_4 showed the lowest panicle dry weight (4.403 g) which was statistically similar to V_1L_3 and V_1L_5.

4.2. Yield contributing characters

4.2.1 Number of spikes/linear meter

4.2.1.1 Effect of variety

Number of spikes per linear meter varied between the two varieties (Fig 13). V_2 (BARI Gom 30) produced higher number of spikes (40.47 spikes/linear meter) than V_1 (BARI Gom 26) which recorded (31.80 spikes/linear meter).

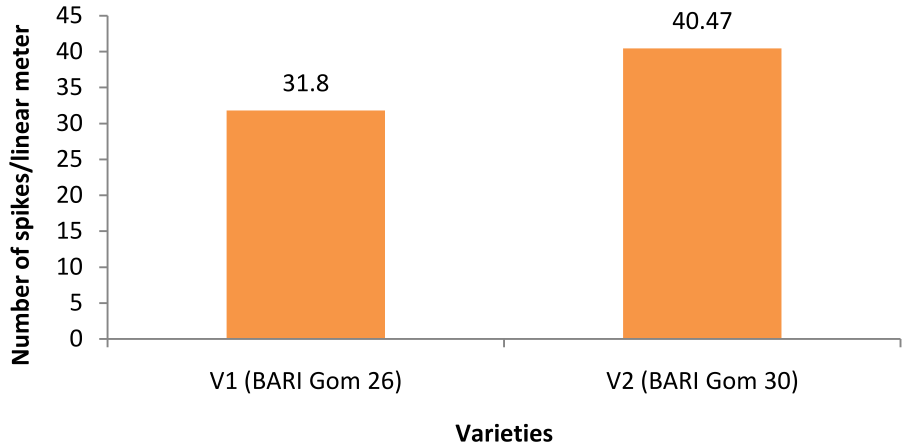

Fig 13. Effect of variety on number of spikes/linear meter

4.2.1.2 Effect of leaf clipping

The study exhibited that the number of spikes per linear meter varied with various levels of leaf clipping (Fig 14). The L_5 recorded highest number of spike (38.50 spikes/linear meter). The lowest number of spike (35.00 spikes/linear meter) was recorded for L_1 which was statistically similar to L_2, L_3 and L_4.

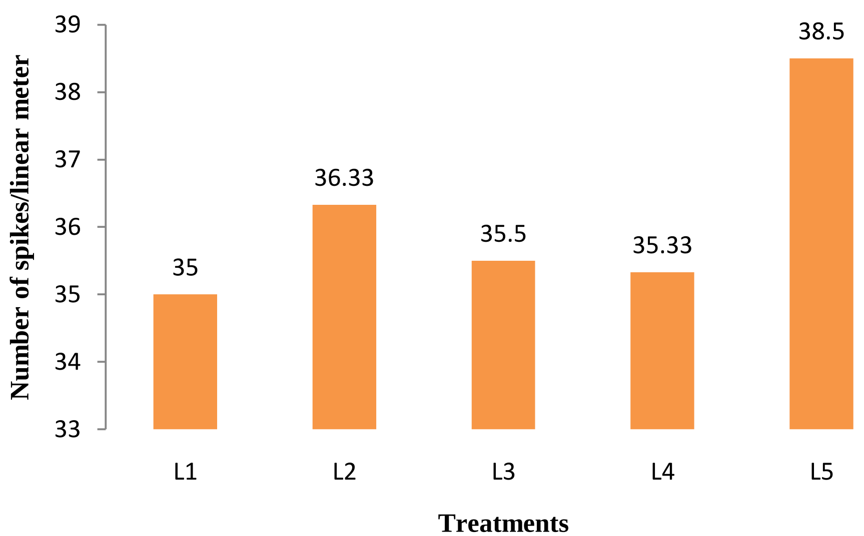

Fig 14. Effect of leaf clipping on number of spikes/linear meter

L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.2.1.3 Effect of interaction between variety and leaf clipping

Number of spikes per linear meter varied due to various treatment combinations of variety and leaf clipping (Table 4). The treatment combinations of V_2L_3 recorded the highest number of spike (43.33 spikes/linear meter) which was statistically similar to V_2L_5 and V_2L_2. V_1L_3 showed the lowest number of spike (27.67 spikes/linear meter).

4.2.2 Number of spikelets/spike

4.2.2.1 Effect of variety

This study found that the number of spikelets per spike varied between the two varieties (Fig 15). The V_1 (BARI Gom 26) produced higher number of spikelets (14.00 spikelets/spike) than V_2 (BARI Gom 30) which recorded (12.20 spikelets/spike).

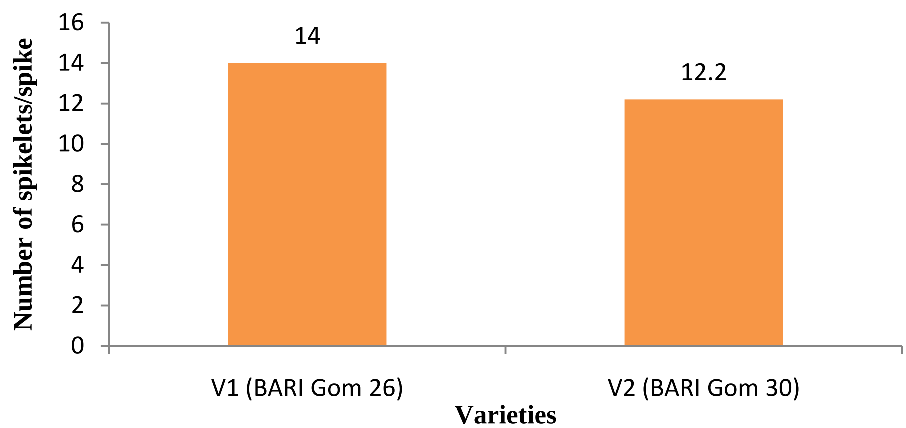

Fig 15. Effect of variety on number of spikelets/spike

4.2.2.2 Effect of leaf clipping

Number of spikelets per spike varied with various levels of leaf clipping (Fig 16). The L_3 recorded highest number of spikelets (13.33 spikelets/spike) which was statistically similar to L_1, L_2 and L_4. The lowest number of spikelets (12.67 spikelets/spike) was recorded for L_5 which was statistically similar to L_2, L_3 and L_4.

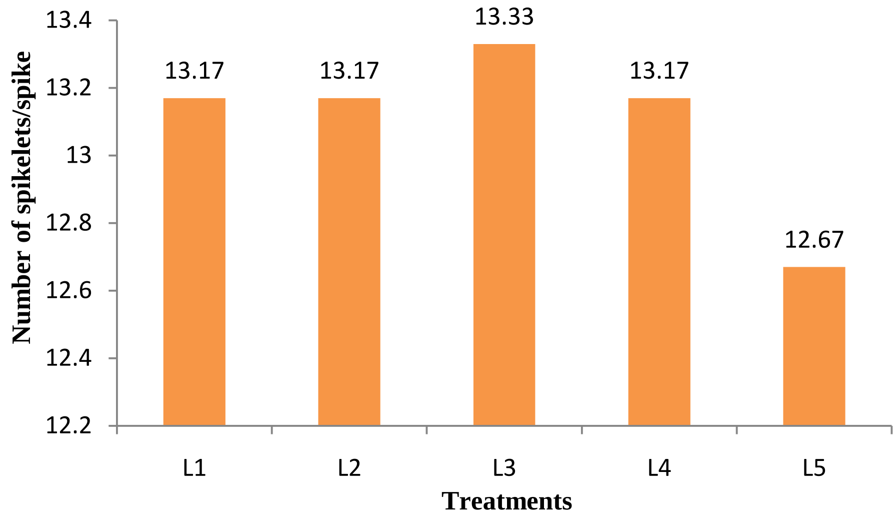

Fig 16. Effect of leaf clipping on number of spikelets/spike

L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.2.2.3 Effect of interaction between variety and leaf clipping

The study exhibited that the number of spikelets per spike varied with various treatment combinations of variety and leaf clipping (Table 4). The treatment combinations of V_1L_1 recorded the highest number of spikelets (14.67 spikelets/spike) which was statistically similar to V_1L_2 and V_1L_3. V_2L_1 showed the lowest number of spikelets (11.67 spikelets/spike).

Table 4. Interaction effect of variety and leaf clipping on number of spikes/linear meter, number of spikelets/spike and number on grains/spike

Treatments	Number of spikes/linear meter	Number of spikelets/spike	Number of grains/spike
V_1L_1	34.33 c	14.67 a	45.00 a
V_1L_2	31.33 d	14.33 ab	43.33 a
V_1L_3	27.67 e	14.33 ab	42.67 a
V_1L_4	31.00 d	13.67 bc	39.67 b
V_1L_5	34.67 c	13.00 cd	38.00 bc
V_2L_1	35.67 c	11.67 f	35.00 d
V_2L_2	41.33 ab	12.00 ef	36.00 cd
V_2L_3	43.33 a	12.33 def	36.33 cd
V_2L_4	39.67 b	12.67 de	37.00 cd
V_2L_5	42.33 a	12.33 def	36.33 cd
LSD $_{(0.05\%)}$	**2.457**	**0.8979**	**2.647**
CV (%)	**3.96**	**4.00**	**3.96**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability.

Here, V_1= BARI Gom 26, V_2= BARI Gom 30, L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.2.3 Number of grains/spike

4.2.3.1 Effect of variety

Number of grains per spike varied between the two varieties (Fig 17). The V_1 (BARI Gom 26) produced higher number of grains (41.73 grains/spike) than V_2 (BARI Gom 30) which recorded (36.13 grains/spike).

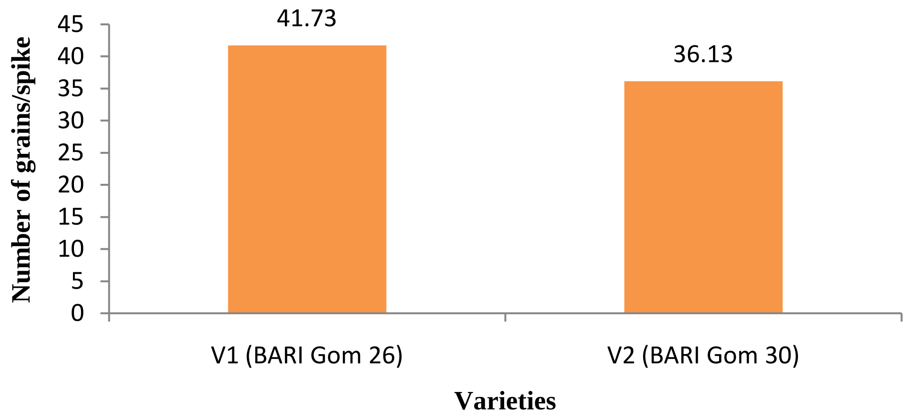

Fig 17. Effect of variety on number of grains/spike

4.2.3.2 Effect of leaf clipping

This study found that the number of grains per spike varied with various levels of leaf clipping (Fig 18). The L_1 recorded highest number of grain (40.00/spike) which was statistically similar to L_2, L_3 and L_4. The lowest number of grain (37.17 grains/spike) was recorded for L_5. This finding is dissimilar to that of Alam *et al.* (2008) and Chowdhry *et al.* (1999). Alam *et al.* (2008) reported that removal of flag leaf caused 9.94% decrease in grains/spike. Chowdhry *et al.* (1999) found that removal of all leaves caused 17.17% reduction in grains/spike. But, the finding of this study showed higher number of grains/spike for removal of all leaves except flag leaf (40.00 grains/spike) and removal of flag leaf (39.67 grains/ spike) than control or no leaf clipping treatment (37.17 grains/spike). Probable causes of this dissimilarity could be the damage of grains by fungal disease infestation or high temperature.

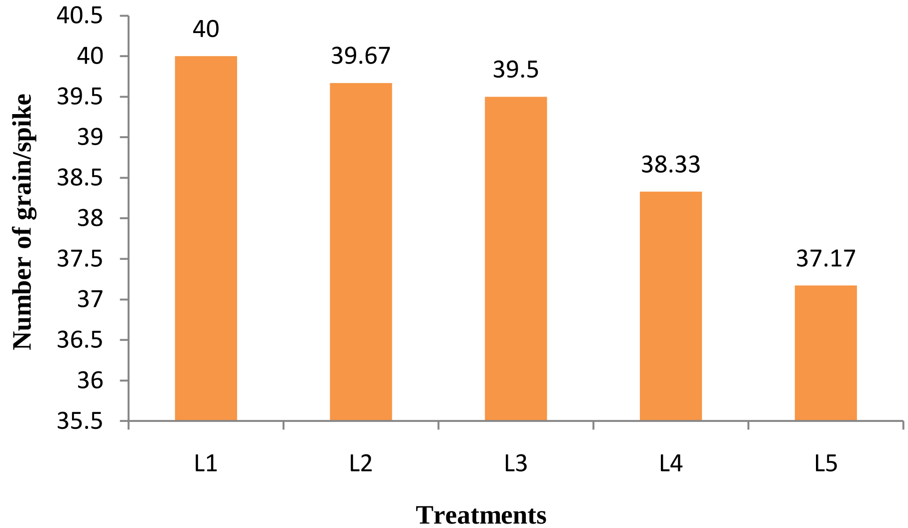

Fig 18. Effect of leaf clipping on number of grains/spike

L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.2.3.3 Effect of interaction between variety and leaf clipping

Number of grains per spike varied due to various treatment combinations of variety and leaf clipping (Table 4). The treatment combinations of V_1L_1 recorded the highest number of grains (45.00 grains/spike) which was statistically similar to V_1L_2 and V_1L_3. V_2L_1 showed the lowest number of grains (35.00 grains/spike).

4.2.4 1000 grain weight (g)

4.2.4.1 Effect of variety

The study showed the 1000 grain weight varied between two varieties (Fig 19). The V_1 (BARI Gom 26) recorded higher 1000 grain weight (50.90 g) than V_2 (BARI Gom 30) which recorded (47.72 g).

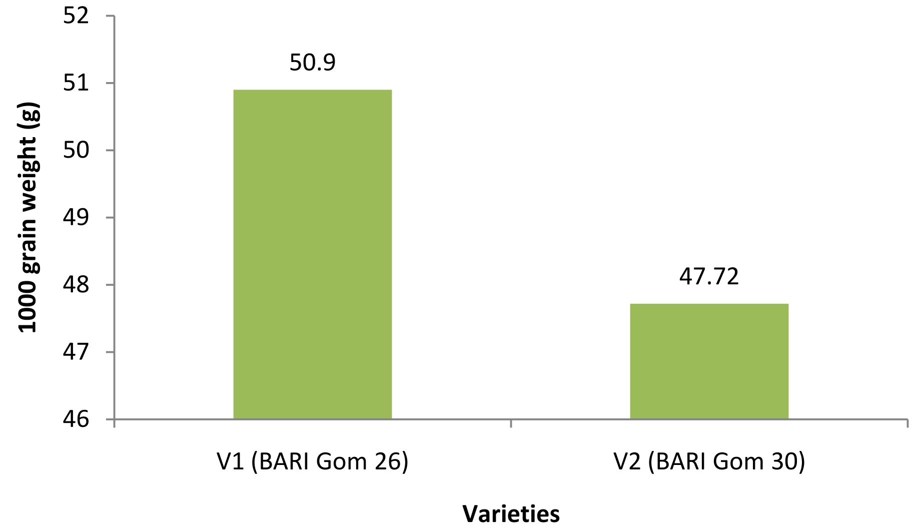

Fig.19. Effect of variety on 1000 grain weight

4.2.4.2 Effect of leaf clipping

The study exhibited that the 1000 grain weight varied due to various levels of leaf clipping (Fig 20). The L_1 recorded highest 1000 grain weight (51.97 g) which was statistically similar to L_3. The lowest 1000 grain weight (49.02 g) was recorded for L_4 which was statistically similar to L_2. The finding is almost dissimilar to that of Alam *et al.* (2008) and Chowdhry *et al.* (1999). Alam *et al.* (2008) found that removal of flag leaf caused 7.65% reduction in 1000 grain weight. Chowdhry *et al.* (1999) reported that removal of all leaves caused 13.27% decrease in 1000 grain weight. But, the finding of this study showed higher 1000 grain weight for removal of all leaves except flag leaf (51.97 g) and removal of flag leaf (49.85 g) than control or no leaf clipping treatment (45.75g). Probable causes of this dissimilarity could be the loss of grains due to fungal disease infestation or high temperature.

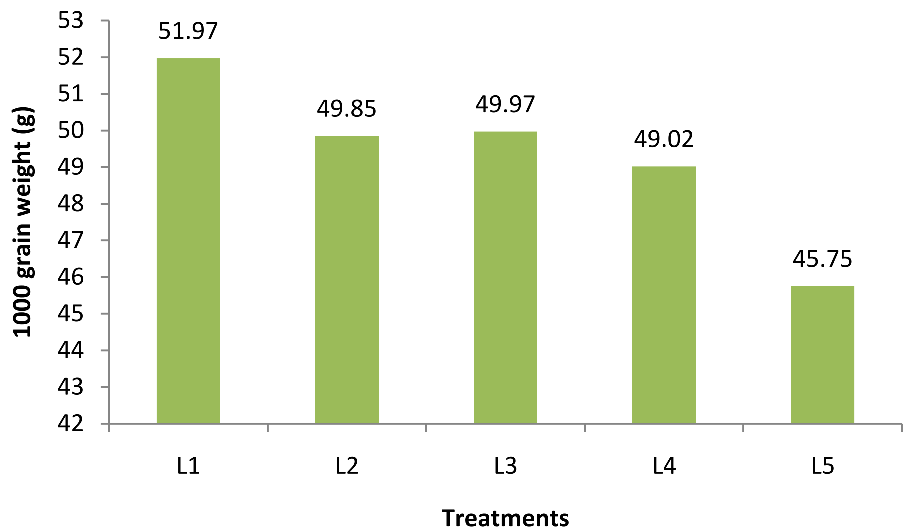

Fig.20. Effect of leaf clipping on 1000 grain weight

L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.2.4.3 Effect of interaction between variety and leaf clipping

The 1000 grain weight varied with various treatment combinations of variety and leaf clipping (Table 5). The treatment combinations of V_1L_1 recorded the highest 1000 grain weight (52.33 g) which was statistically similar to V_1L_2, V_1L_3, V_1L_4, V_2L_1 and V_2L_2. V_2L_5 showed the lowest 1000 grain weight (42.53 g).

4.3. Yield and harvest index

4.3.1 Straw yield (t/ha)

4.3.1.1 Effect of variety

The study found that the Straw yield per hectare area varied between two varieties (Fig 21). The V_1 (BARI Gom 26) recorded higher straw yield (1.635 t/ha) compared to V_2 (BARI Gom 30) which recorded (1.408 t/ha).

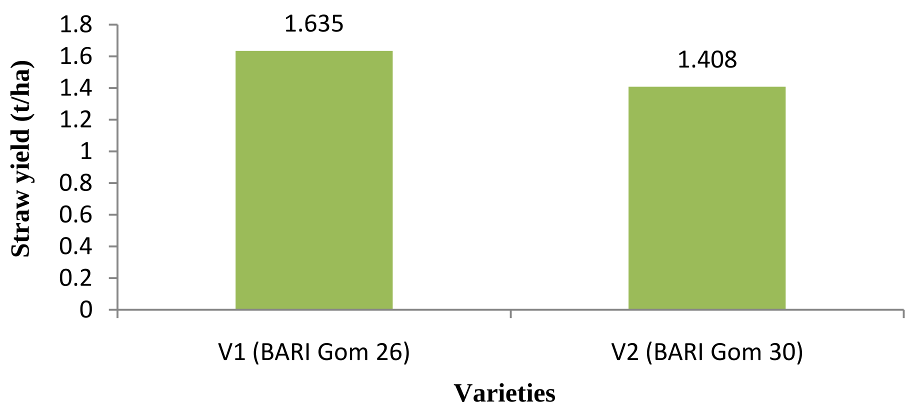

Fig 21. Effect of variety on straw yield

4.3.1.2 Effect of leaf clipping

Straw yield varied with various levels of leaf clipping (Fig 22). The L_2 recorded highest straw yield (1.680 t/ha). The lowest straw yield (1.332 t/ha) was recorded for L_1.

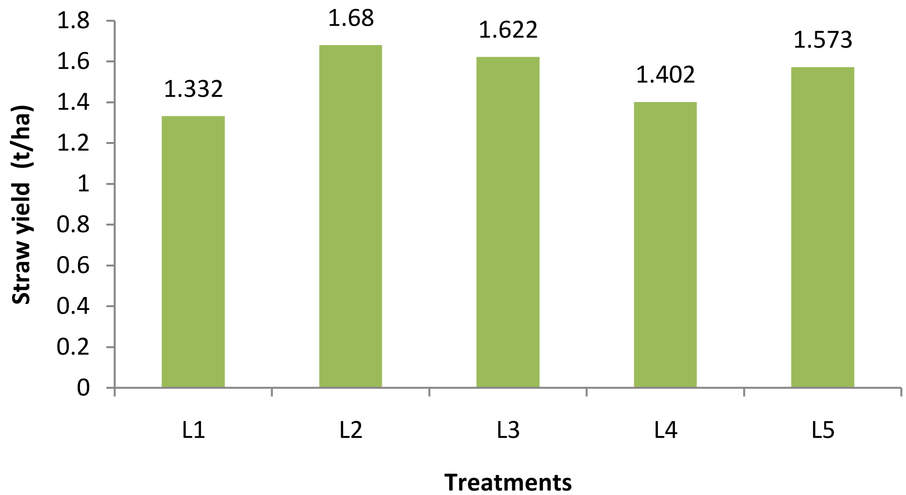

Fig 22. Effect of leaf clipping on straw yield

L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.3.1.3 Effect of interaction between variety and leaf clipping

This study exhibited that the Straw yield varied due to various treatment combinations of variety and leaf clipping (Table 5). The treatment combinations of V_1L_2 recorded the highest straw yield (1.923 t/ha). The V_2L_1 showed the lowest straw yield (1.203 t/ha).

4.3.2 Seed yield (t/ha)

4.3.2.1 Effect of variety

Seed yield per hectare varied between the two varieties (Fig 23). V_1 (BARI Gom 26) recorded higher grain yield (1.533 t/ha) compared to V_2 (BARI Gom 30) which recorded (1.440 t/ha).

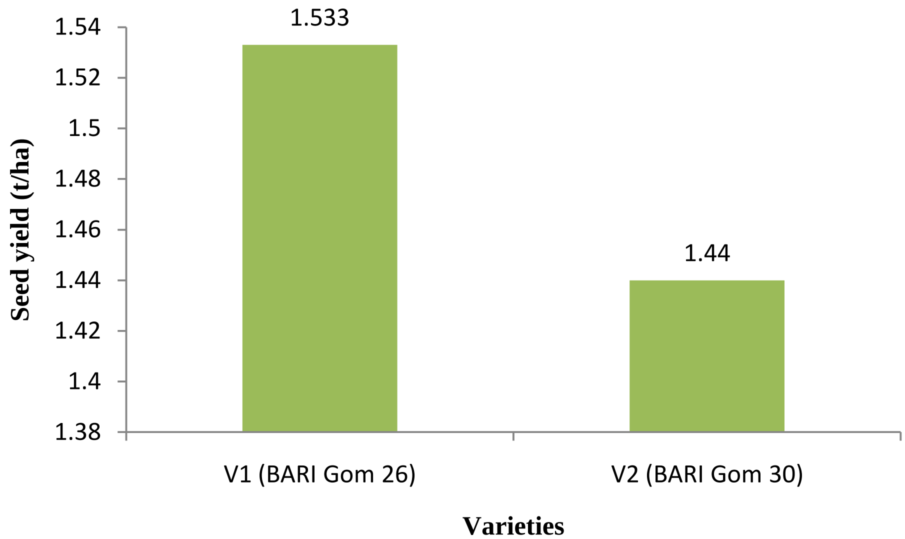

Fig 23. Effect of variety on seed yield

4.3.2.2 Effect of leaf clipping

The study found that the seed yield significantly varied with various levels of leaf clipping (Fig 24). The L_5 recorded highest seed yield (1.742 t/ha). The lowest seed yield (1.337 t/ha) was recorded for L_1. This finding was almost similar to that of Mahmood and Chowdhry (1997), Singh and Randhawa (1983), Singh and Singh (1992) and Wang *et al.* (1997). Singh and Randhawa (1983) studied effects of defoliation of all leaves and observed 30% to 40% reduction in grain yield. Up to 13.2-22.9 % grain yield reduction has been reported by Singh and Singh (1992) and 34.5% grain reduction was shown by Mahmood and Chowdhry (1997). Results showed that removal of all leaves except flag leaf (1.337 t/ha) had larger reducing effects than that of flag leaf alone (1.585 t/ha) and that was supported by finding of Wang *et al.* (1997). Though, the study found lowest number of spikelets/spike (12.67 spikelets/spike) and grains/spike (37.17 grains/spike) for the control or no clipping treatment, this control treatment reported highest seed yield (1.742 t/ha). This happened due to the highest number of tillers (39.5 tillers/linear meter) and spikes (38.5 spikes/linear meter) in case of control or no clipping treatment.

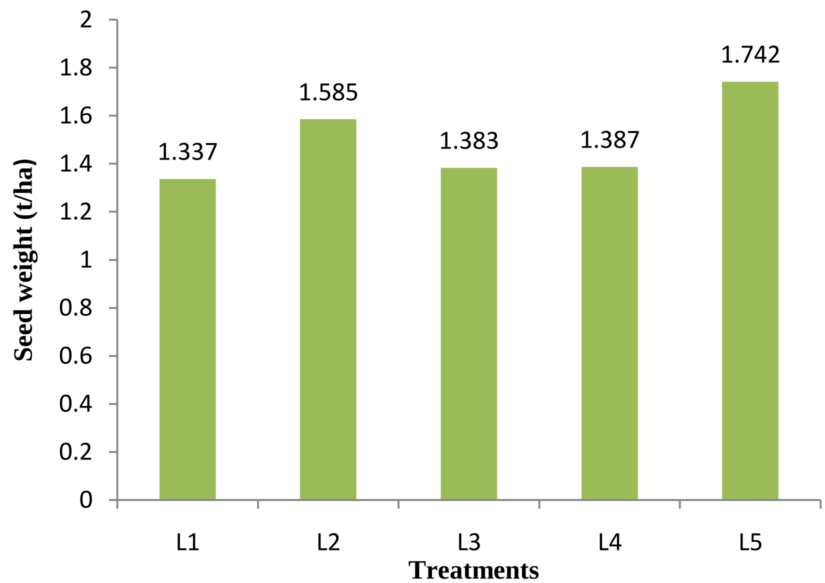

Fig 24. Effect of leaf clipping on seed weight

L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.3.2.3 Effect of interaction between variety and leaf clipping

Seed yield significantly varied due to various treatment combinations of variety and leaf clipping (Table 5). The treatment combinations of V_2L_5 recorded the highest seed yield (1.833 t/ha). The V_2L_1 showed the lowest seed yield (1.230 t/ha) which was statistically similar to V_2L_3.

4.3.3 Harvest Index (%)

4.3.3.1 Effect of variety

Harvest index significantly varied between the two varieties (Fig. 25). The V_2 (BARI Gom 30) recorded higher harvest index (50.41%) than V_1 (BARI Gom 26) which recorded (48.43%).

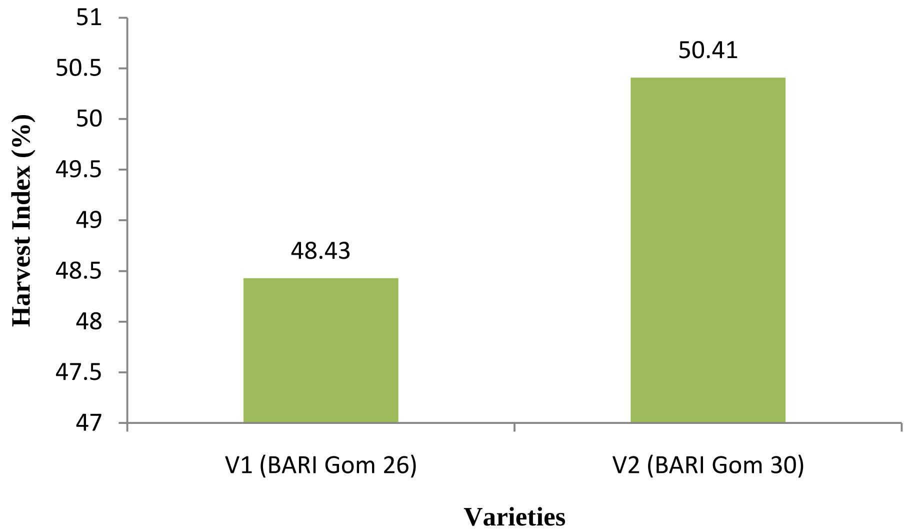

Fig 25. Effect of variety on Harvest Index (%)

4.3.3.2 Effect of leaf clipping

The study exhibited that the harvest index significantly varied with various levels of leaf clipping (Fig 26). The L_5 recorded highest harvest index (52.51 %). The lowest harvest index (46.00%) was recorded for L_3.

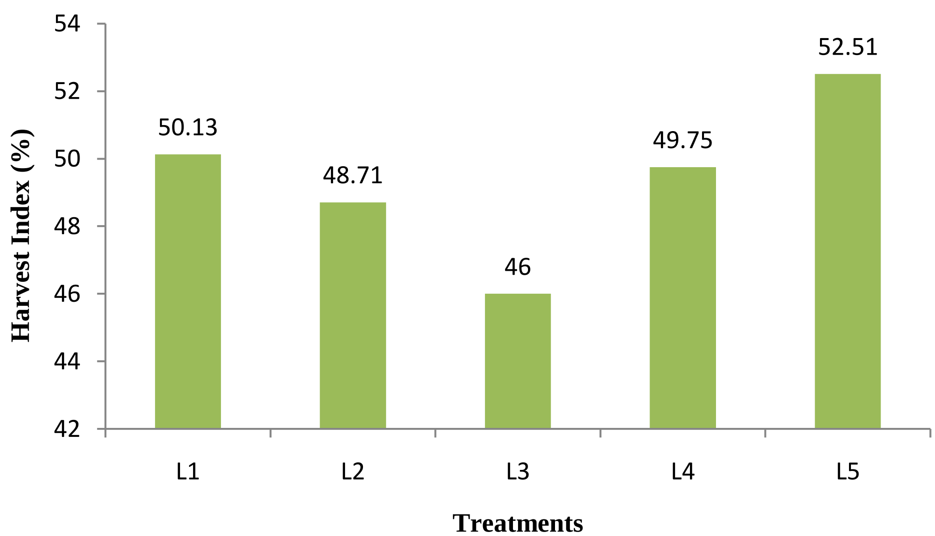

Fig 26. Effect of leaf clipping on Harvest Index (%)

L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

4.3.3.3 Effect of interaction between variety and leaf clipping

This study showed that the harvest index significantly varied due to various treatment combinations of variety and leaf clipping (Table 5). The treatment combinations of V_2L_5 recorded the highest straw weight (54.51%). The V_2L_3 showed the lowest straw weight (45.56%) which was statistically similar to V_1L_3.

Table 5. Effect of interaction between variety and leaf clipping on 1000 grain weight, straw weight, seed yield and harvest index

Treatments	1000 grain weight (g)	Straw yield (t/ha)	Seed yield (t/ha)	Harvest Index (%)
V_1L_1	52.33 a	1.460 e	1.443 de	49.71 c
V_1L_2	49.90 abc	1.923 a	1.727 b	47.31 de
V_1L_3	51.77 ab	1.710 b	1.483 d	46.45 ef
V_1L_4	51.53 ab	1.467 e	1.363 f	48.17 d
V_1L_5	48.97 bcd	1.617 c	1.650 c	50.51 bc
V_2L_1	51.60 ab	1.203 g	1.230 g	50.54 bc
V_2L_2	49.80 abc	1.437 e	1.443 de	50.11 bc
V_2L_3	48.17 cd	1.533 d	1.283 g	45.56 f
V_2L_4	46.50 d	1.337 f	1.410 ef	51.34 b
V_2L_5	42.53 e	1.530 d	1.833 a	54.51 a
LSD (0.05%)	**2.83**	**0.0467**	**0.05425**	**1.274**
CV (%)	**3.35%**	**1.99%**	**2.33%**	**1.50%**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability. Here, V_1= BARI Gom 26, V_2= BARI Gom 30, L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

Table 6. Changes in seed yield (t/ha) due to the application of different leaf clipping treatments over control/no clipping (L_5) treatment

Varieties	Treatments	Seed yield (t/ha)	Yield changes over control treatment (%)
V_1	L_1	1.443	-12.5
	L_2	1.727	4.67
	L_3	1.483	-10.12
	L_4	1.363	-17.39
	L_5	**1.650***	
V_2	L_1	1.230	-32.89
	L_2	1.443	-21.27
	L_3	1.283	-30.00
	L_4	1.410	-23.07
	L_5	**1.833****	

Here, V_1= BARI Gom 26, V_2= BARI Gom 30, L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

*Seed yield of V_1 at control treatment L_5

** Seed yield of V_2 at control treatment L_5

Yield changes over control treatment (%) calculated as follows $= \frac{\text{Difference of seed yield between control and other treatments} \times 100}{\text{Seed yield at control treatment}}$

e.g. $\frac{(\text{Seed yield at L5} - \text{Seed yield at L1}) \times 100}{\text{Seed yield at L5}}$

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November 2016 to February 2017 to study the varietal response of leaf clipping treatment in wheat. The experiment comprised of two varieties viz., V_1 (BARI Gom 26) and V_2 (BARI Gom and five different levels of leaf clipping viz., L_1 (Clipping of all leaves except flag leaf), L_2 (Clipping of flag leaf only), L_3 (Clipping of all leaves except flag leaf & it's immediate leaf), L_4 (Clipping of all leaves except flag leaf & first two leaves beneath flag leaf), L_5 (Control). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

Variations on plant height, number of tillers/linear meter, number of effective and non-effective tillers/linear meter, plant dry weight, panicle weight, number of spikes/linear meter, number of spikelets/spike, number of grains/spike, 1000 seed weight, straw yield, grain yield and harvest index were found significant due to varieties . At 25, 50, 70, 80 and 90 DAS, the tallest plants (22.65, 53.48, 68.23, 70.70 and 72.23 cm) were recorded in BARI Gom 26. The maximum plant dry weight (11.26 gm), number of spikelets/spike (14.00), number of grains/spike (41.73), 1000 grain weight (50.90 gm), straw weight (1.635 t/ha) and grain weight were also found from BARI Gom 26. But the maximum panicle weight (6.389 gm), number of tillers/linear meter (41.87), number of effective tillers/linear meter (40.47), number of non effective tillers/linear meter (1.400), number of spikes/linear meter (40.47) and harvest index (50.41 %) were recorded in BARI Gom 30.

The result also indicated significant variations on plant height, number of tillers/ linear meter, number of effective and non-effective tillers/linear meter, plant dry weight, panicle weight, number of spikes/linear meter, number of spikelets/ spike, number of grains/spike, 1000 seed weight, straw yield, grain yield and harvest index due to leaf clipping treatments. At 25 and 50 DAS the tallest plants (22.79 and 54.37 cm) were found in L_5 and L_3 respectively. At 70, 80 and 90 DAS, the tallest plants (67.33, 70.96 and 71.74 cm) were recorded from L_2. The maximum plant dry weight (11.55 g), number of grains/spike (40.00) and 1000 grain weight (51.97 g) were found from L_1. Highest panicle weight (6.713 g) and straw weight (1.68 t/ha) were recorded form L_2. L_3 showed maximum number of spikelets/spike (13.33). Maximum number of tillers/linear meter (39.50), number of effective tillers/linear meter (38.50), number of spikes/linear meter (38.50), grain weight (1.74 t/ha) and harvest index (52.51 %) were recorded from L_5.

Significant variations on plant height, number of tillers/linear meter, number of effective and non-effective tillers/linear meter, plant dry weight, panicle weight, number of spikes/linear meter, number of spikelets/spike, number of grains/spike, 1000 seed weight, straw yield, grain yield and harvest index were also recorded due to interaction of treatments. At 25, 70, 80 and 90 DAS the tallest plants (24.35, 73.06, 75.36 and 75.84 cm) were found in V_1L_2. The maximum stem dry weight (13.41 g), number of spikelets/spike (14.67), 1000 grain weight (52.33 g) and number of grains/spike (45.00) were found from V_1L_1. Highest straw weight (1.92 t/ha) was found in V_1L_2 and highest panicle dry weight (7.843 g) was recorded form V_2L_2. V_2L_3 showed maximum number of tillers/linear meter (44.67) and number of spikes/ linear meter (43.33). Highest grain weight (1.83 t/ha) and harvest index (54.51 %) were recorded from V_2L_5.

Moreover, L_1, L_2, L_3 and L_4 treatments caused decrease in seed yield of BARI Gom 30 by 32.89%, 21.27%, 30.00% and 23.07% respectively. And, seed yield of BARI Gom 26 was also reduced by 12.5%, 10.12% and 17.39% with the application of L_1, L_3, L_4 treatments respectively.

It might be concluded within the scope and limitation of the present study that BARI Gom 26 showed the best result on the basis of grain yield. And, the higher yield of

BARI Gom 30 could be obtained by applying no leaf clipping. However, further studies are necessary to arrive at a definite conclusion.

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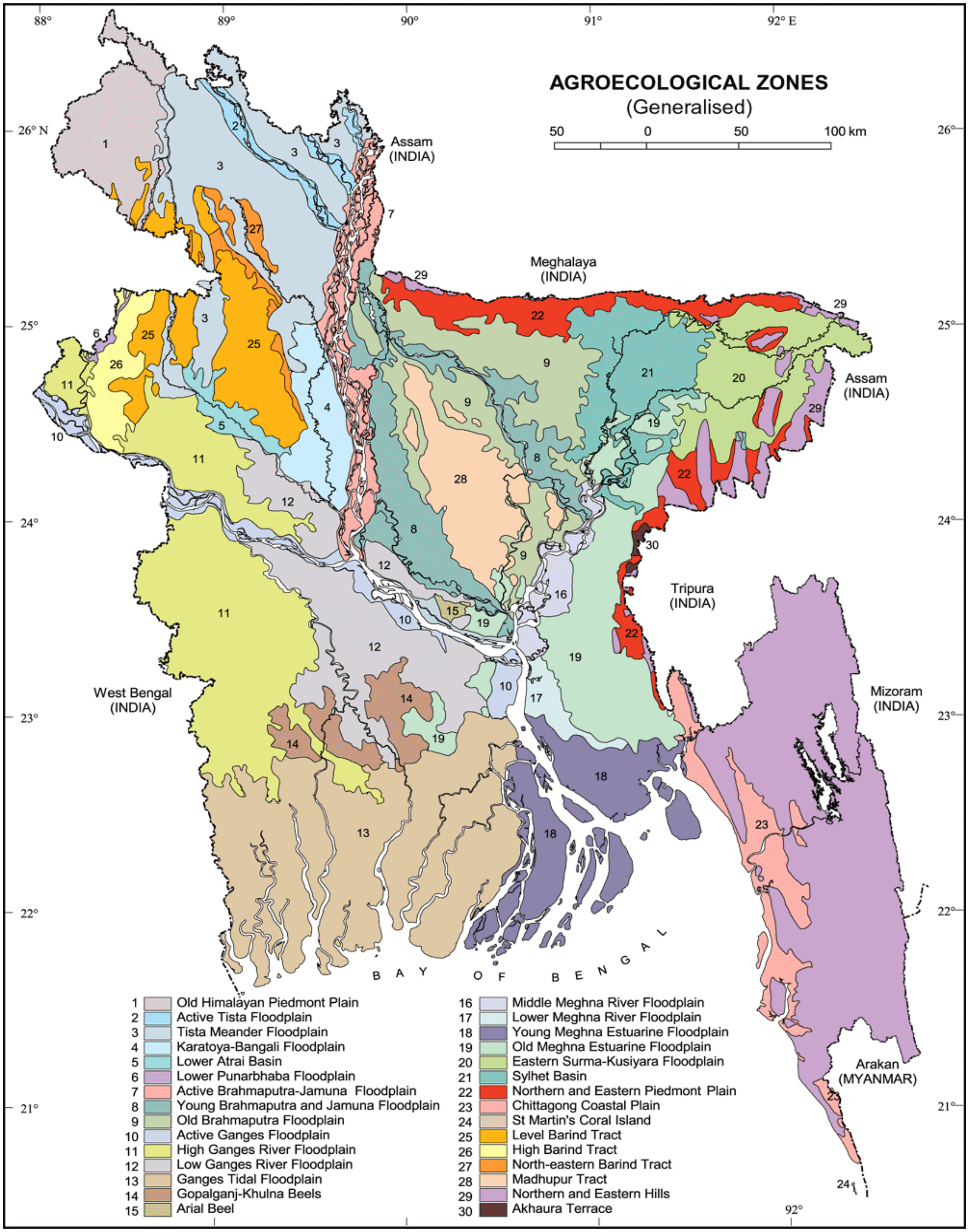
APPENDICES

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



Appendix II. Morphological characteristics of the experimental field

Morphology	Characteristics
Location	SAU Farm, Dhaka.
Agro-ecological zone	Madhupur Tract (AEZ- 28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Terrace.
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

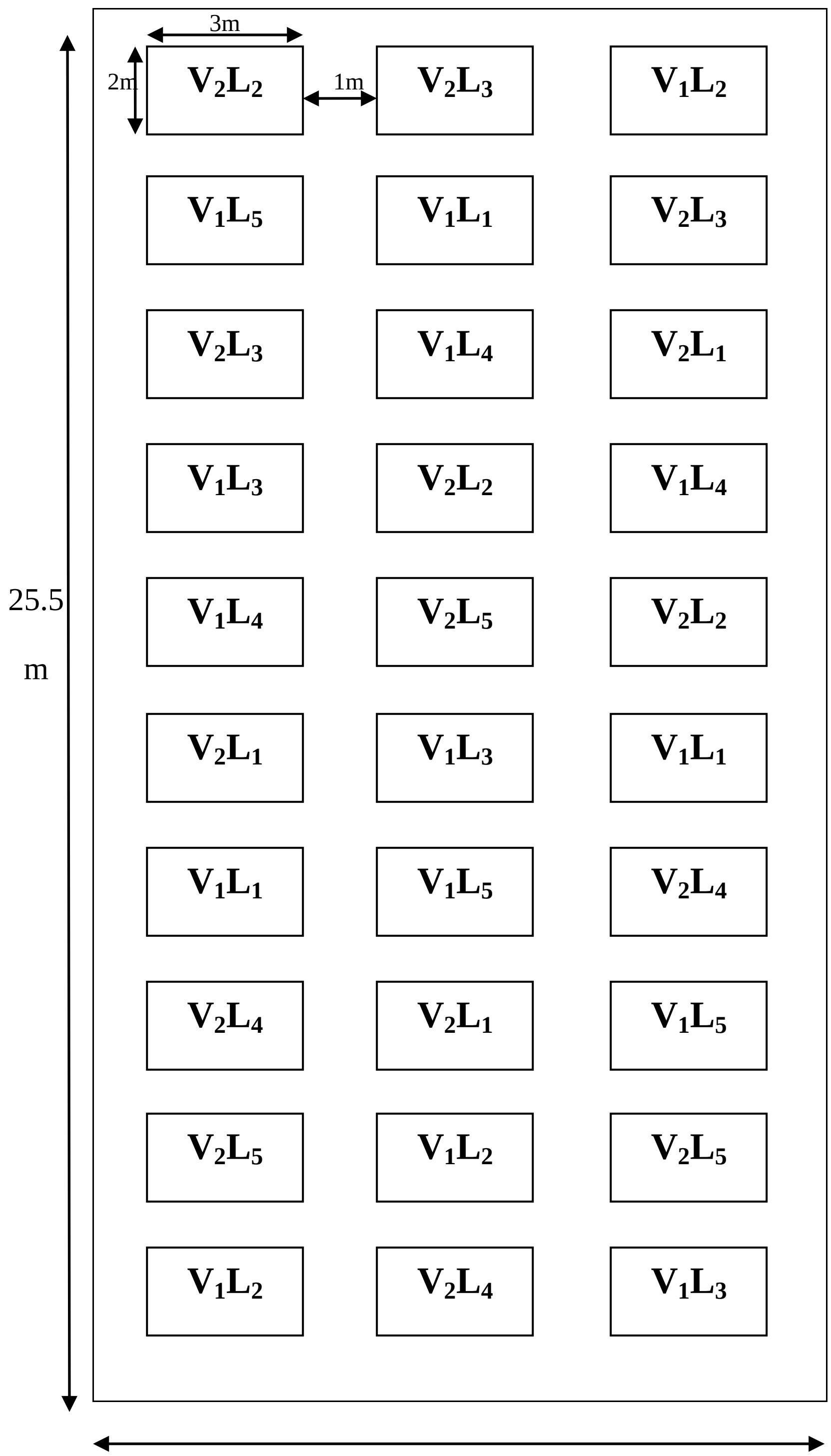
(SAU Farm, Dhaka)

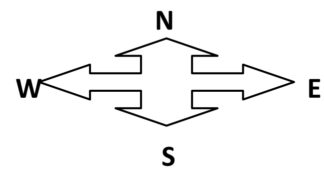
Appendix III. Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	22.26
% Silt (0.02-0.002 mm)	56.72
% Clay (<0.002 mm)	20.75
Textural class	Silt Loam
pH (1: 2.5 soil- water)	5.9
Organic Matter (%)	1.09
Total N (%)	0.028
Available K (ppm)	15.625
Available P (ppm)	7.988
Available S (ppm)	2.066

(SAU Farm, Dhaka)

Appendix IV. Layout of the experimental field





Total area= 306 m^2

Single plot area = 6m^2

Column to column distance=1m

Row to row distance= 0.5 m

V_1= BARI Gom 26

V_2= BARI Gom 30

L_1= Clipping of all leaves except flag leaf

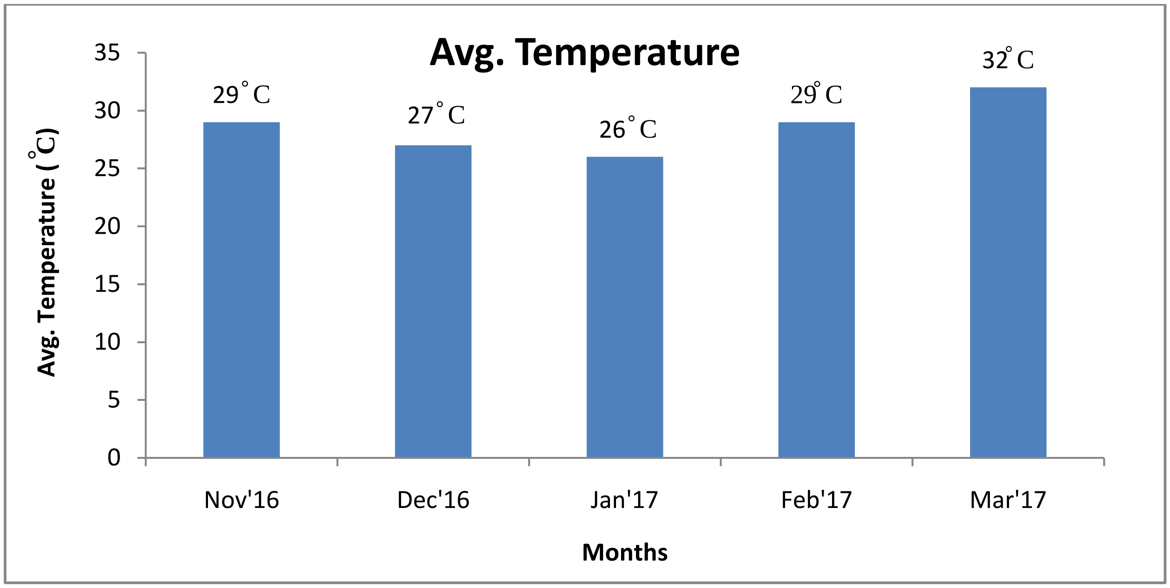
L_2= Clipping of flag leaf only

L_3= Clipping of all leaves except flag leaf & it's immediate leaf

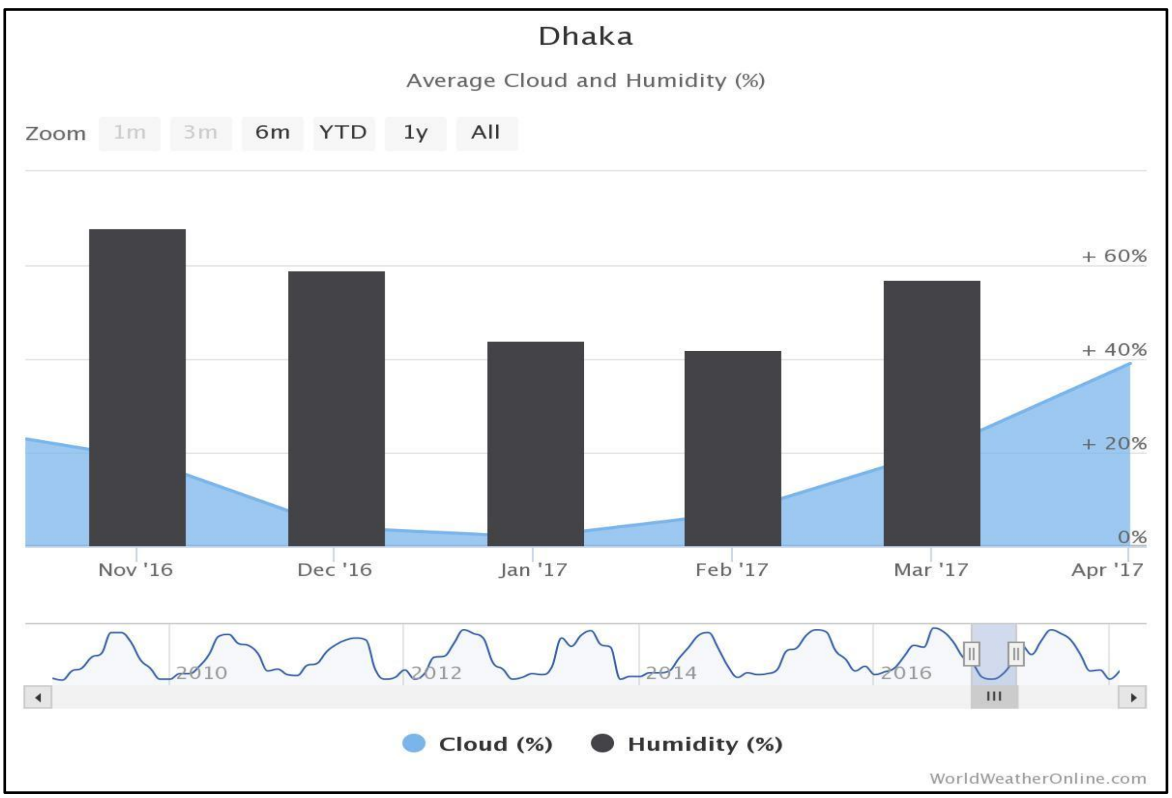
L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf

L_5= Control.

Appendix V. Monthly weather data of Dhaka during experiment (from Nov'2016 to Mar'2017)



(Source- WWW.WorldWeatherOnline.com)



(Source- WWW.WorldWeatherOnline.com)

Appendix VI. Analysis of variance of the data on plant height of parameters of BARI Gom 26 and BARI Gom 30

Sources of variation	Degrees of freedom	Mean square				
		Plant height				
		25 DAS	50 DAS	70 DAS	80 DAS	90 DAS
Replication	2	0.219	0.350	0.696	0.348	0.326
Factor A (Variety)	1	12.021**	7.967**	283.853*	191.825**	189.254*
Factor B (Leaf clipping)	4	4.520**	5.269**	13.173**	24.483**	13.320**
A X B	4	3.534**	2.514**	24.667**	9.020**	12.419**
Error	18	0.323	0.436	0.585	1.608	0.267

* Significant at 5% level

** Significant at 1% level

Appendix VII. Analysis of variance of the data for crop growth and yield parameters of BARI Gom 26 and BARI Gom 30

Sources of Variation	Degrees of freedom	Mean square values											
		Number of tillers per linear meter	Number of effective tillers per linear meter	Number of non-effective tillers per linear meter	Stem dry weight	Panicle dry weight	Number of spikes/ linear meter	Number of spikelets/ spike	Number of grains/ spike	1000 grain weight	Straw yield	Grain yield	Harvest Index
Replication	2	0.433	0.533	0.033	0.799	0.168	0.533	1.200	4.233	0.592	0.000	0.001	0.775
Factor A (Variety)	1	691.200**	563.333**	6.533*	19.425*	11.619*	563.333**	24.300*	235.200*	75.843**	0.388**	0.065*	29.502*
Factor B (Leaf clipping)	4	12.467**	11.950**	0.133*	4.084**	2.465**	11.950**	0.383**	8.217**	30.810**	0.132**	0.177**	33.482**
A × B	4	45.200**	39.583** *	1.200*	7.456**	2.054**	39.583**	1.383*	17.617*	11.126*	0.037**	0.059**	5.895**
Error	18	1.730	2.052	0.996	0.423	0.154	2.052	0.274	2.381	2.722	0.001	0.001	0.552

* Significant at 5% level

** Significant at 1% level

Appendix VIII. Effect of variety on growth and yield parameters of BARI Gom 26 and BARI Gom 30

Treatments	Number of tillers per linear meter	Number of effective tillers per linear meter	Number of non-effective tillers per linear meter	Stem dry weight (g)	Panicle dry weight (g)	Number of spike per linear meter	Number of spikelet per spike	Number of grain per spike	1000 grain weight (g)	Straw yield (t/ha)	Grain yield (t/ha)	Harvest Index (%)
V_1	32.27 b	31.80 b	0.4667 b	11.26 a	5.145 b	31.80 b	14.00 a	41.73 a	50.90 a	1.635 a	1.533 a	48.43 b
V_2	41.87 a	40.47 a	1.400 a	9.649 b	6.389 a	40.47 a	12.20 b	36.13 b	47.72 b	1.408 b	1.440 b	50.41 a
$LSD_{0.05}$	1.009	1.099	0.7656	0.4989	0.3011	1.099	0.4016	1.184	1.266	0.020	0.02426	0.5700
CV %	3.55	3.96	106.94	6.22	6.80	3.96	4.00	3.96	3.35%	1.99%	2.33%	1.50%
Level of significane	**	**	*	*	*	*	*	*	**	**	*	*

V_1= BARI Gom 26, V_2= BARI Gom 30

* Significant at 5% level

** Significant at 1% level

Appendix IX. Effect of different levels of leaf clipping on growth and yield parameters of BARI Gom 26 and BARI Gom 30

Treatments	Number of tillers per linear meter	Number of effective tillers per linear meter	Number of non-effective tillers per linear meter	Stem dry weight (g)	Panicle dry weight (g)	Number of spike per linear meter	Number of spikelet per spike	Number of grain per spike	1000 grain weight (g)	Straw yield (t/ha)	Grain yield (t/ha)	Harvest Index (%)
L_1	35.83 b	35.00 b	0.8333 a	11.55 a	5.920 b	35.00 b	13.17 ab	40.00 a	51.97 a	1.332 e	1.337 d	50.13 b
L_2	37.17 b	36.33 b	0.8333 a	11.05 ab	6.713 a	36.33 b	13.17 ab	39.67 a	49.85 b	1.680 a	1.585 b	48.71 c
L_3	36.33 b	35.50 b	0.8333 a	10.27 bc	5.002 d	35.50 b	13.33 a	39.50 a	49.97 ab	1.622 b	1.383 c	46.00 d
L_4	36.50 b	35.33 b	1.167 a	9.767 c	5.397 cd	35.33 b	13.17 ab	38.33 ab	49.02 b	1.402 d	1.387 c	49.75 b
L_5	39.50 a	38.50 a	1.000 a	9.640 c	5.803 bc	38.50 a	12.67 b	37.17 b	45.75 c	1.573c	1.742 a	52.51 a
$LSD_{0.05}$	1.595	1.738	1.211	0.7889	0.4760	1.738	0.6349	1.872	2.001	0.0329	0.0383	0.9012
CV %	3.55	3.96	106.94	6.22	6.80	3.96	4.00	3.96	3.35%	1.99%	2.33%	1.50%
Level of significane	**	**	*	**	**	**	**	**	**	**	**	**

* Significant at 5% level   ** Significant at 1% level

L_1= Clipping of all leaves except flag leaf, L_2= Clipping of flag leaf only, L_3= Clipping of all leaves except flag leaf & it's immediate leaf, L_4= Clipping of all leaves except flag leaf & first two leaves beneath flag leaf, L_5= Control.

PLATES

PLATE 1. Emerging wheat seedling

PLATE 2. Arrangement of plots according to treatments

PLATE 3 Leaf clipping treatments

PLATE 4 Data collection