INFLUENCE OF PLANTING METHOD AND LEAF CLIPPING ON THE YIELD PERFORMANCE OF WHITE MAIZE

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CERTIFICATE

This is to certify that the thesis entitled **"**INFLUENCE OF PLANTING METHOD AND LEAF CLIPPING ON THE YIELD PERFORMANCE OF WHITE MAIZE**"** submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **AGRONOMY**, embodies the results of a piece of *bona fide* research work carried out by **MD. RIPAN BEPARY**, Registration No. **17-08270**, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.

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

Dated: December, 2018
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Prof. Dr. Md. Jafar Ullah
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ABSTRACT

An experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207 during January 2018 to June 2018 to evaluate the influence of planting method and leaf clipping on the yield performance of white maize. The experiment was laid out in a split plot design with three replications. The experiment comprised of two factors. Factor A: Planting method - 2 types [P_1 = Sowing, P_2 = Transplanting] and Factor B: Leaf clipping - 4 levels [C_1 = no leaf clipping, C_2 = all leaf clipping, C_3 = clipping of four leaves above cob, C_4 = clipping of four leaves below cob]. White Maize Yungnuo 3000 was used for the experiment. Significant variation was observed on growth, yield and yield contributing parameters. In the case of planting method, the highest plant height (85.43, 163.56 and 212.34 cm, respectively) at different days after planting, leaf length (39.87 cm), cob length (17.63 cm), cob breadth (12.45 cm), number of cob bearing node (7.67), number of row cob^{-1} (13.67), number of grain row^{-1} (26.61), grain yield (7.46 t ha^{-1}), 100 seed weight (21.58 g), oven dried shell weight (15.72 g) and oven dried chaff weight (7.29 g) were recorded in P_1 treatment and those of the lowest from P_2. In the case of leaf clipping, the highest plant height (89.31, 168.32 and 217.21 cm, respectively) at different days after planting, leaf length (41.87 cm), cob length (19.77 cm), cob breadth (18.42 cm), number of cob bearing node (9.33), number of row cob^{-1} (14.67), number of grain row^{-1} (34.65), grain yield (8.69 t ha^{-1}), 100 seed weight (28.47 g), oven dried shell weight (17.87 g) and oven dried chaff weight (10.88 g) were recorded from C_1 treatment and those of the lowest from C_2. In the case of interaction, the highest plant height (91.38, 172.34 and 219.36 cm, respectively) at different days after planting, leaf length (42.19 cm), leaf breadth (6.08 cm), cob length (20.57 cm), cob breadth (18.79 cm), number of cob bearing node (10.67), number of row cob^{-1} (16.33), number of grain row^{-1} (36.89), grain yield (8.70 t ha^{-1}), 100 seed weight (29.45 g), oven dried shell weight (18.11 g) and oven dried chaff weight (11.05 g) were recorded from P_1C_1 treatment and those of the lowest from P_2C_2.

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LIST OF ABBREVIATIONS

%	Percent
@	At the rate of
^{0}C	Degree Celsius
AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
CV%	Percentage of Coefficient of Variation
EC	Emulsifiable Concentrate
e.g.	As for example
et al.	and others
i.e.	that is
kg ha^{-1}	kg per hectare
LSD	Least Significant Difference
g	Gram
cm	Centimeter
m	Meter
t ha^{-1}	Ton per hectare
SAU	Sher-e-Bangla Agricultural University

CHAPTER 1
INTRODUCTION

Maize (*Zea mays* L.) belongs to the family Poaceae and it is the third important cereal crop of the World after wheat and rice. It is grown extensively in temperate, subtropical and tropical regions of the world. United States of America (USA), China, Brazil, Mexico, Yugoslavia, Rumania, Argentina and Italy are the leading maize producing countries in the World. Maize is used as a staple food for human consumption and feed for livestock. It is estimated that about 70% production of maize is used directly or indirectly as food and rest of it find its way to starch manufacturing and poultry industry. Maize is produced primarily as an energy source crop, but specialized versions for protein oil, wax, sweet corn and popcorn are also available (Akbar *et al*., 2016).

Maize (*Zea mays* L.), an important cereal crop over the world, is now well-fits in diversified cropping systems in the Indo-Gangetic Plains (Gathala *et al*., 2015). Its demand is increasing day by day as various food items, fodder for livestock, feed for poultry, and fuel and raw materials for industry. Maize production doubled in the past 40 years due to increased yields resulting from the use of improved crop varieties, along with greater inputs of fertilizer, water and pesticides.

Maize is one of the most important food crops in the world and, together with rice and wheat, provides at least 30% of the food calories to more than 4.5 billion people in 94 developing countries. Its grain can be used for human consumption in various ways, such as corn meal, fried grain and flour. The crop has high nutritive value containing 66.2% starch, 11.1% protein, 7.12% oil and 1.5% minerals. Moreover, it contains 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin per 100 g grains. Maize oil is used as the best quality edible oil. The green parts of the plant and grain are used as livestock and poultry feed, respectively. Stover and dry leaves are used as good fuel for cooking. Like many other parts in the world, market demand for maize in South Asia and Bangladesh has significantly increased in the last decade as a result of the expanding poultry and fish feed industries, and for use in processed foods. The increasing use and demand of maize have caused escalation of area and production substantially in the region. This trend has been especially remarkable in Bangladesh, where cultivated land area with maize jumped from 0.05 M ha in (2000) to > 0.33 M ha in 2016 (FAOSTAT, 2016).

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions and in production next to wheat and rice in the world. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. Maize is a principal staple food crop that is grown worldwide, ranks first in worldwide production, and is quite adaptable to high temperature and dry environment in comparison to C_3 crops. Maize (*Zea mays* L.) is an important crop in the world; it is widely used for feed and industrial raw material. Maize ranks the third in world production following wheat and rice for the area and production (Chen *et al*., 2012).

Maize (*Zea mays* L.) is the third most important cereal crop after wheat and rice in the world. Although soil and climatic conditions favor successful production of maize but inappropriate planting methods significantly reduce the maize production. Adoption of modern management practices is imperative for boosting per hectare maize yield. Planting method is an important agronomic practice for enhancing crop yield. Inappropriate planting method caused reduction in germination, growth and development, ear size and increased susceptibility to diseases and lodging (Bakht *et al*., 2011).

Maize currently grown in Bangladesh is of yellow type and are used in the feed industry. White maize covers only 12% of the total acreage of the world which is mostly used as human food (FAO-CIMMYT, 1997). During 1970s the productivity of grown white maize was lower compared to those of yellow ones. With the advanced breeding approaches worldwide, recent reports demonstrate that the yield productivity of white maize is almost at par with those of the yellow ones.

Bangladesh is primarily an agricultural country and its agriculture is closely related to livestock. Livestock is a major component of agriculture in Bangladesh. Maize is considered an ideal forage crop because it grows quickly, produces high yields, is palatable, is rich in nutrients, and helps to increase body weight and milk quality in cattle. As fodder for livestock, maize is excellent, highly nutritive Whole-plant photosynthesis is instantaneously reduced in response to canopy removal by clipping. Large portions of the canopy of individual plants are frequently removed by grazing animals in a single grazing event (Abdullah *et al*., 2008). Maize growth and development is highly susceptible to available soil microenvironment. Appropriate planting method not only governs the development of suitable micro-environment but also facilitate intercultural practices, weeding, uniform irrigation and insect management. Furthermore, the degree of soil compaction, soil bulk density and soil moisture conditions are important factors which influence seedling emergence and crop yield.

Buttar *et al*. (2006) suggested to improve planting techniques for suitable seed bed preparation in order to ensure good stand establishment and optimum plant population. Maize biometrical parameters are significantly affected by planting methods. Rasheed *et al.* (2003) observed increased leaf area, leaf area index, crop growth rate and net assimilation rate in different planting methods.

Depending on the variety, a maize plant produces 15 to 20 leaves during its life cycle. Canopy structure of maize is such that adjoining leaves overlap one another and develop mutual shading. Khaliliaqdam *et al*. (2012) found that mutual shading, particularly at high population density, reduces number of grains cob^{-1}. After anthesis, the staminate inflorescence, the tassel may have very little or no effect on grain filling (Leakey *et al*., 2006), Similarly, the leaves below the cob may have less contribution to grain filling as they are mutually shaded and photosynthetically less efficient.

Very few or no research finding are available in our country on leaf clipping in white maize field. So, there is a wide scope to conduct research activities on the efficacy of leaf clipping in white maize and to relate with varietal performance of white maize. Considering the above facts, the present study was under taken with the following objectives:

- To evaluate the influence of planting methods on the yield performance of white maize
- To evaluate the effect of leaf clipping on the yield performance of white maize and
- To investigate the interaction effect of planting methods and leaf clipping on the yield performance of white maize.

CHAPTER II
REVIEW OF LITERATURE

Maize is one of the common and most important cereal crops of Bangladesh and as well as many countries of the world. For increasing the growth and yield of maize, abundant studies were conducted in the country and abroad. Many studies related to planting methods and leaf clipping in white maize have been carried out in the world, but in Bangladesh it is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the planting methods and leaf clipping on yield of maize have been reviewed in this chapter.

2.1 Effect of planting method

Santos *et al*. (2018) reported that herbage yield, dry matter and crude protein content of silage corn are not affected by direct or conventional sowing methods.

Amin *et al.* (2006) reported higher growth and yield of maize in ridge sowing than flat sowing. Furthermore, it was manifested that ridge sowing improved water and soil conservation and took less time to complete phenological stages and hence produced higher biomass and grain yield.

Belachew and Abera (2010) reported that better performance of maize on ridge sowing might be due to efficient use of irrigation water and nutrients for proper growth and development.

Abdullah *et al*. (2008) reported that ridge sowing significantly increased yield of maize when compared with other planting methods.

Shahzad and Khan (2003) confirmed that maize sown on ridge resulted maximum number of grain rows ear^{-1}. Flat and raised bed did not show any significant variation for grain rows ear^{-1}.

Siddique and Bakht (2005) reported that ridge sowing promote highest biological yield compared to other method.

Significant effect of ridge plantation on grain yield ha^{-1} and its components of maize has been reported by Bhagwandin and Bhatia (1990).

Siddique and Bakht (2005) reported that ridge sowing improved seedling emergence as well as plant fresh weight.

Bakht *et al*. (2006) concluded that maximum number of grains ear^{-1} was recorded in ridge sowing.

Khan and Shafi (2008) recorded maximum 1000-grain weight and biological yield from ridge sowing.

Rasheed *et al*. (2004) concluded that maximum grain yield was recorded in ridge sowing compared with other methods of sowing.

Belachew and Abera (2010) concluded that ridge sown maize produced maximum biological yield.

Lenka (2015) reported that delayed sowing in kharif and summer season reduced days to tasseling, silking and duration of crop and also the grain yield.

Berzsenyi *et al*. (1998) found that delay in sowing reduced the number of days from sowing to seedling emergence from 6 to 5 days. The leaf emergence was found rapid in delayed sowing and occurred early up to 54 days after emergence as against 61 days after emergence in normal condition than with early planting.

Ahsan *et al*. (2013) stated that the ratio between final seed number and dry matter at silking dropped dramatically for the late sowing, indicating a predominance of vegetative growth over reproductive growth.

Cirilo and Andrade (1994) reported that late sowing result in high crop growth rates during the vegetative period because of high radiation use efficiency (RUE) and high percentage radiation interception, but conversely result in low crop rates during grain filling because of low RUE and low incident radiation.

Maddonni *et al*. (1998) found that in late sowing, both solar radiation and temperature decline during grain filling. Thus, lowered solar radiation resulted in grain growth in excess of biomass production, indicating a possible source limitation. On the other hand, low temperature may have a negative effect on seed weight through reductions in both radiation use efficiency and biomass partitioning to the grains.

Moosavi *et al*. (2012) reported that delay in sowing from July 4 to August 6 decreased significantly the plant height, stem diameter, leaf area index, and total fresh and dry yield by 15.7, 20.9, 42.1, 24.7 and 25.9%, respectively in maize.

Beiragi *et al*. (2011) stated that yield reduction in late sowing could be attributed to a short growth duration, insect and disease pressure, heat and moisture stress during pollination.

Khan and Parvej (2010) reported that ridge sowing influence ear length more than other planting methods.

Otegui and Melon (1997) reported that delayed sowing generally accompanied by increased temperatures during the growing season, which accelerate crop development and decrease accumulated solar radiation, resulting in less biomass production, seed set and grain yield.

Badran (2001) stated that under late sowing conditions, transplanting of maize may be a viable alternative to direct sowing. Sowing of maize is a traditional practice whereas, transplantation of maize is a recent technique.

Basu and Sharma (2003) stated that transplantation technique in maize helps farmers to harvest a third crop in areas where none would have been possible because of late harvest of Rabi maize; as maize transplantation shortened the crop period of 8-10 days.

Anil and Sezer (2003) observed that there were significant differences between the cultivars in terms of number of grains and ear weight of transplanted sweet corn.

Kumar *et al*. (2014) reported that transplantation of 7 weeks old seedling attained maximum plant height at 30 and 60 days after transplanting but 90 DAT the plant height of 5 weeks old transplanted seedling was recorded maximum.

Uphoof (2003) stated that transplanted rice is capable of yielding 30% more than broadcasted rice. The other advantage of transplanting is effective utilization of rainy season and faster maturity of the rice crop particularly in rain-fed lowland rice ecosystems since the crop partly passes some of its growth stage in nursery.

Uphoof (2003) reported that rice yield could be increased by 1.35 to 2.48 t ha^{-1} by transplanting rather than seed broadcast sowing.

Mitchell *et al*. (2004) indicated a highly significant positive correlation between the performance of genotypes in direct seeding (DS) and transplanting (TP) experiments in which TP rice had a 6-30% yield advantage over DS rice.

Singh *et al*. (2002) reported that direct dry seeding of rice reduced yield by 23-41% on flat land and by 41-54% on raised beds compared with transplanted rice.

Mobasser *et al*. (2007) reported that transplanting of healthy seedlings ensures better rice yield by promoting better tillering and growth.

Pasuquin *et al*. (2004) stated that transplanting seedlings at optimum age induced higher tiller production and higher plant shoot dry matter accumulation and hence ensure higher rice grain yield.

Kumar *et al.* (2014) reported that the enhanced vegetative growth in terms of leaf area index, dry matter accumulation and root volume resulted in more grains per cob in transplanted maize.

Oswald *et al.* (2001) reported that sorghum yields were highest when seedlings were 7 to 10 days old when transplanted whilst 20 to 25 day old pearl millet seedlings were the best.

Waters *et al*. (1990) observed that increasing the age of seedlings at the time of transplanting decreased the time to harvest of maize by as much as 6 days. Plant growth and yield generally decreased with increased age at the time of planting.

Reddy *et al.* (1987) reported that cultivars have been reported to behave differently with transplanting. For instance, in India, two maize cultivars; a semi-dwarf and a tall cultivar responded differently to age of seedlings at transplanting. Both performed similarly after transplanting, but the tall cultivar performed better when transplanted late.

Dupriez and De Leener (1988) reported that root distribution may be modified when seedlings are transplanted or pricked out. They observed that shoots and roots could be trimmed at the same time and that in this way the roots are able to recover before the leaves begin to transpire abundantly and exhaustion of the re-born rootlets is avoided.

Abou-Khalif (2009) proved that early planting of hybrid varieties in Egypt produced higher plant height, leaf area index, number of grains per panicle, 1000-grain weight and grain yield.

Rakesh and Sharma (2004) reported that delay in transplanting resulted in a significant decrease in the number of productive tillers per m^2 and ultimately the grain yield of rice.

Pandey *et al*. (2001) reported that the number of fertile tillers per m^2 decreases with late transplanting. Late transplanting shortened the vegetative growth period of the plant, hence, reduced the leaf area per m^2 and number of kernels per panicle compared with early sowing in all hybrid and inbred varieties of rice.

Maiti and Sen (2003) reported that delay in transplanting date reduced plant height and other biomass related factors (number of tillers produced, leaf area index).

Akram *et al.* (2007) reported that the number of grains per panicle was significantly affected by the delayed sowing date.

Tari *et al*. (2007) found that appropriate time of transplanting resulted in higher 1000 grain weight.

Baloch *et al.* (2006) noted that delayed in transplanting resulted in decreasing grain yield due to delayed seeding might be associated with the significantly lower number of productive tillers per meter, less number of filled grains per panicle and low 1000 grain weight. Observations on varietal response to transplanting were made in field trials with five sorghum genotypes in India, where the genotypes CSH-1 and Swarna withstood transplanting better than others. They gave higher **grain yield** in association with higher mean dry weight per ear, grain weight per ear and 1000-grain weight. They also showed better growth in terms of **dry matter** accumulation and distribution in the ear, larger leaf area and higher **dry matter** production at the seedling and grain filling stages.

Mapfumo (2002) reported that transplanting sorghum and pearl millet varieties grown in nurseries shown to improve establishment in the field.

Mapfumo (2002) reported better crop establishment for sorghum transplants than direct sowing when no irrigation was applied. For transplants, as the sowing date was delayed, stand counts tended to decrease. This resulted in 20 days old transplants having a better stand than 30 and 40 days old transplants. This can be explained by the fact that 30 and 40 days old transplants had more leaf area due to advanced growth, which, translated into a larger transpiring, surface area. Thus, 30 and 40 days old transplants may have lost more water due to transpiration thereby reducing their survival rate after transplanting. However, the reduction in stand counts in older transplants did not result in a yield advantage for 20 days old transplants implying that the reductions in stand counts in older transplants were not significant enough to reduce yields.

Tenkouano *et al*. (1997) reported that transplanting had less depressive effects than late sowing cultivars.

2.2 Effect of leaf clipping

Boogaard *et al.* (2001) reported that the clipping of leaves maize leaf up to 50% at the time of feed shortage did not have adverse effect in grain and stover yield components of maize. Canopy growth, fruit yield, fruit quality and leaf size were not negatively impacted when annual leaf clipping did not exceed 25% of the total canopy leaf area.

Fasae *et al.* (2009) stated that clipping leaves in pollination phase decreased dry matter and grain yield significantly. The yield was not influenced by clipping, but plants defoliated before 6 months after planting had reduced leaf yield.

Ahmadi *et al.* (2009) reported that clipping significantly affect remobilization of grain yield and 1000-grain weight.

Hassen and Chauhan (2003) showed that an optimum rate of maize leaf clipping without affecting the grain, stover yield components and dry matter yield of under sown forage crops was harvested at the rate of 25-50% of clipping of maize leaf.

Echarte *et al.* (2006) reported that clipping decreases assimilate availability during grain filling, seed and biological yield. Different types of leaf clipping have various influences on dry matter accumulation when the leaf clipping occurs at the primary stage of grain development.

Burton *et al.* (1995) reported that maize leaf clipping at early season significantly decreased the stem length and leaf area but it did not have any effect on leaf emergence.

It was noticed that when the maize defoliation is severe and its time is closer to silking stage, forage yield would be decreased greatly.

Cheema *et al.* (2010) reported that in maize, seed number is determined in the range of silking and in this period there is high sensitivity is to provide assimilates. Maize leaf clipping caused the seed yield reduction because of the seed number decrease.

Barimavandi *et al.* (2010) noted that the number of rows per ear affected by complete leaf clipping, whereas one or more leaves had no impact on this trait.

Barimavandi *et al.* (2010) indicated that ear length is most affect by intensity of clipping and position of leaves on the plant.

Joshi (2005) stated that in any crop, the degree of yield reduction is directly proportional to the percentage of leaf area destroyed. The loss in the functional leaf area results in loss of photosynthetic area of the plant and reduces the assimilate availability. Then there is an imbalance between source (leaves) and sink (seed) which leads to reduction in seed yield and quality. In fact, seed yield is dependent on the number and weight of the seeds per ear, duration of seed filling, supply and rate of incorporation of photosynthesis into its structure from anthesis to fully development of seed. He also reported that, the percentage yield loss is depending on factors such as on the amount of removed leaves, leaf position on plant and also clipping time.

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, and harvest index and grain moisture. Crude protein was increased, especially with maximum clipping.

Carter (1995) conducted an experiment to investigate the early season frost damage effects on corn (*Zea mays* L.). 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 days later), had reduced final plant (16 to 25 inch shorter) and ear (12 to 20 inch 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.

Elsahookie and Wuhaib (1988) investigated 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) investigated the role of leaf position on yield and yield component of maize 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).

Oyewole (2017) conducted an experiment 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. Prior to imposition of the treatment, analyzed results indicate no significant differences between number of leaves at 2, 4 and 6 weeks after sowing, as well as plant heights and stem girth at 2, 4, 6, 8 and 10 weeks after sowing. However there were significant differences between leaf areas at 4 and 6 weeks after sowing. 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) investigated the relation between sink and source in corn plants. 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 2017 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.

Thomison (2005) reported that tassel clipping two days after silking increased the grain yield 6.7% more than the control cultivar due to increased grain weight. Leaf clipping of upper three leaves 2 and 16 days after tasseling decreased grain yield 24 and 9% respectively. When the leaf clipping occurs at the primary stage of grain development, the grain yield decrease would arise due to decreased grain number.

Complete leaf clipping at five-leaf stage in early maturing cultivars increased the yield compared to late-maturing cultivars at the same condition. The average of yield increment for three years was about 48 percent. By leaf clipping at five-leaf stage in early maturing cultivar, the yield was increased 26 percent more than late-maturing cultivar. So, the response of early maturing and late maturing cultivars was different, specifically at five-leaf stage (WIPO, 2006).

Bisoondat (2002) stated that leaf clipping at early season significantly decreased the stem length and leaf area but it did not have any effect on leaf emergence. Also, leaf clipping at early season decreased soluble grain carbohydrate in order to devote the carbohydrates for vegetative growth and reduce sucrose sources.

Burton (2004) reported that when clipping is severe and its time is closer to silking stage, forage yield and soluble sugars would be decreased greatly.

Lauer (2004) reported that 33% of maize leaf clipping in irrigated condition at 28 and 35 days after germination decreased the soluble protein rates more than stress condition with 33 and 67% clipping. The effect of leaf clipping on canopy photosynthesis and changing the sink and source carbohydrates showed that soluble sugars in plants with leaf clipped (control, above ear leaf clipping, below ear leaf clipping and full leaf clipping at flowering stage) was different.

Egile (2000) observed that full leaf clipping treatment made the most decreasement of canopy photosynthesis and changing the sink and source carbohydrates and the percentage of soluble sugar in different parts of plant such as grains.

Francis (1999) stated that hybrids which produced more grain number were affected by leaf clipping treatment very scarcely and their protein decreased less than the other hybrids.

Burton (2004) reported that leaf clipping at 1 leaf stage limits the plant re-growth. But clipping at 2 leaf stage provide enough time for carbohydrates recycling and leaf clipping at 4 leaf stage produce the most soluble carbohydrates and dry matter accumulation of tillers, roots and leaves.

Turner (2006) stated that below ear leaf clipping in early maturing cultivar at 5-leaf stage showed that some characteristics such as plant height, protein and oil percentage were higher than control cultivar. Oil percentage from early and medium maturing cultivars was more than late maturing cultivars.

Burton (2004) found that below ear leaf clipping in late maturing cultivars caused reduction in some soluble carbohydrates. Below ear leaf clipping in early, medium and late maturing cultivars made increment or unchanged globulin, glutenin, prolamine and albumin ratio.

Yang (2004) reported that above ear leaf clipping at pollination time in late maturing cultivars caused reduction in seed storage carbohydrate but not as severe as early maturing cultivars.

Kamath *et al*. (1992) investigated the effects of different levels of defoliation and leaf position in stem on grain yield and reported that cutting 10 upper leaf loss seed yield by 17.2 % whereas when treatment happened on 10 middle leaves reduced yield by 45.7% compared to control treatment

Abbaspour *et al*. (2001) reported that clipping of 1/3 middle stem leaves treatment caused to decrease in yield and yield components by decreasing grain number. Decreasing in grain numbers on cob probably is a result of partial number of flower primordia or slight pollination because of dichogamy.

Moriondo *et al.* (2003) investigated the cliiping of sunflower and no significant difference was observed in terms of plant height. He found that clipping influenced neither plant height nor lodging. Clipping affect seed number per head, so that 34.5% reduction in seed number occurred by removal of 6 leaves from lower part of the plant.

Dilnawaz *et al*. (2001) reported that during leaf clipping, chlorophyll content also decline but the rate of the decline is much slower than Rubisco content. Single leaf net photosynthetic rate (Pn) is closely correlated with Rubisco content. The decline in Pn is also correlated with loss of chlorophyll during leaf clipping. Therefore, the contents of Rubisco, Nitrogen and chlorophyll have been used to quantify leaf clipping.

Misra *et al*. (1997) studied with ^{14}C-sucrose feeding to clipped flag leaves and the distribution of ^{14}C- radio labels in sugar and starch amounted to 24% in the flag leaf, and 18% in grains, while that in the free and protein amino acids (nitrogenous compounds) amounted to 6.5% in the flag leaf and 6.2% in grains, indicating that a large proportion of ^{14}C was distributed in the sugar and starch fractions.

Mae (1997) reported that the top three leaves not only assimilate majority of carbon for grain filling during ripening phase but also provide large proportion of remobilized nitrogen for grain development during their clipping.

Abou-Khalifa *et al.* (2008) stated that in case of leaf cutting, hybrid rice cultivar H5 had relatively higher but non-significant TGW (Thousand Grain Weight) than the traditional inbred Egyptian local rice cultivar Sakha 103.

Georgias *et al.* (1989) showed that leaf clipping at transplanting does not immediately improve plant water status, but it may alleviate drought stress in clipped plants. It has also been reported that leaf clipping presumably removes transpiring biomass and conserves soil moisture. Conservation of soil moisture possibly allows transplants to survive for longer periods of time if no follow-up rains are received soon after transplanting. They also showed that severely clipped plants are less stressed than unclipped ones.

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka during the period from January 2018 to June 2018. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recording and their analyses.

3.1 Experimental site

The experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka - 1207, under the Agro-Ecological Zone of Madhupur Tract (AEZ-28). 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 shown in the AEZ Map of Bangladesh in Appendix I.

3.2 Climate

The experimental area is under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during the rabi season (October-March). The details have been presented in Appendix II.

3.3 Soil

The top soil of the experimental site is characterized by olive grey with common fine to medium especially dark yellowish brown mottle with silty clay in texture. Soil pH and organic carbon was sufficient for maize production. The experimental area was of good drainage and irrigation system and above from flood level and the plot of experimental field was medium to high land. The details have been presented in Appendix III.

3.4 Planting material

White Maize Yungnuo 3000 was used as study material.

3.5 Treatments

The following treatments were included in this experiment:

Factor A: Planting method - 2 types

- P_1 = Sowing
- P_2 = Transplanting

Factor B: Leaf clipping - 4 levels

- C_1 = No leaf clipping
- C_2 = All leaf clipping
- C_3 = Clipping of four leaves above cob
- C_4 = Clipping of four leaves below cob

3.6 Experimental design

The experiment was laid in split plot design with three replications (block). Each replication was first divided into 8 subplots where treatment combinations were assigned. Thus the total number of unit plots was 8×3=24. The size of the individual plot was 3 m x 1.4 m. The inter plot spacing was 0.20 m and inters block spacing was 0.60 m.

3.7 Crop management

3.7.1 Seed collection

Seeds of white maize variety Yungnuo 3000 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur-1701, Dhaka.

3.7.2 Land preparation

The plot selected for the experiment was opened in the first week of January 2018 with a power tiller, and was exposed to the sun for a week, after one week the land was harrowed, ploughed and cross ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and finally obtained a desirable tilth of soil for planting of maize seeds. The experimental plot was partitioned into the unit plots in accordance with the experimental design. Recommended doses of well rotten cowdung manure and chemical fertilizers were mixed with the soil of each unit plot. The size of each unit plot was 3 m × 1.4 m.

3.7.3 Manure and fertilizer application

Cowdung @ 5 ton ha^{-1} was used before final land preparation. Then the chemical fertilizers were applied as Urea, TSP, MOP, Gypsum, Zinc Sulphate and Boric acid @ 155-65-120-35-3-2 kg ha^{-1}. All fertilizers and one third portion of urea were applied as basal dose at the time of final land preparation. Rest of the urea were applied at two installments.

3.7.4 Seed treatment

For each treatment; dry, clean and homogenous air dried seeds were used. Seeds were treated with Provax 200FF @ 0.3% of seed weight.

3.7.5 Seed sowing and transplanting

Some seeds were planted in lines each having a line to line distance of 60 cm and plant to plant distance of 20 cm having 3 seeds hole^{-1} under direct sowing in the well prepared plot on 15th January, 2018. The seedlings were raised in seedbed. The plot was kept ready through tractor drawn cultivator for preparing seedbeds. The beds of 4 m long and 2.5 m wide were prepared. The seeds were sown in line keeping the 20 cm apart and covered with soil. The seedlings (4 weeks of age) were transplanted on 16th February, 2018 keeping the row to row distance of 60 cm and plant to plant 20 cm in each plot. The first light irrigation was given to the crop before transplanting for better establishment. Three healthy seedling was transplanted at each plot.

3.8 Intercultural operations

3.8.1 Weeding

Weeding were done to keep the plots free from weeds, easy aeration of soil and to conserve soil moisture, which ultimately ensured better growth and development. The weeds were uprooted carefully after complete emergence of maize seedlings as and whenever necessary. Breaking the crust of the soil, when needed was done through mulching.

3.8.2 Thinning and gap filling

The excess plants were thinned out from all of the plots at 35 days after sowing (DAS) for maintaining optimum population of the experimental plots.

3.8.3 Irrigation

First irrigation was given on 20 days after sowing. Second irrigation was given on 40 days after sowing. Third irrigation was given on 70 days after sowing and fourth irrigation was given on 90 days after sowing.

3.8.4 Plant protection measures

After 30 days of planting, first spray of Dursban 20EC was done against the pest such as cut worm. Ripcord 10EC was applied to control leaf feeder caterpillar during entire vegetative periods at times.

3.8.5 Harvesting, threshing and cleaning

Crops were harvested when 90% of the cob became golden in color. The matured crop was harvested and carried to the threshing floor. The crop was sun dried by spreading on the threshing floor. Seeds were then separated from the plants.

3.8.6 Drying and weighing

Grain and stovers thus collected were dried in the sun for a couple of days. Dried grain and stovers of each plot were weighed and subsequently converted into t ha^{-1} weight.

3.9 Data collection

The following data were collected during the experimentation.

3.9.1 Plant height

3.9.2 Leaf length

3.9.3 Leaf breadth

3.9.4 Cob length

3.9.5 Cob breadth

3.9.6 Number of cob bearing node

3.9.7 Number of row cob^{-1}

3.9.8 Number of grain row^{-1}

3.9.9 Grain yield

3.9.10 100 seed weight

3.9.11 Shell weight

3.9.12 Chaff weight

3.10 Data recording procedure

A brief outline of the data recording procedure followed during the study period is given below:

3.10.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 40 DAS, 80 DAS and at harvest. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

3.10.2 Leaf length

Leaf length was collected at 40DAS, 80DAS and at harvest. Leaf length was measured from the base to the tip of the leaf, which was collected from 5 randomly selected plants from each plot and then the mean were recorded in cm.

3.10.3 Leaf breadth

The wider part along with base and tip portion of the maize leaves were stretched and measured in cm and average was calculated. Such measurement was taken from 5 randomly selected plants from each plot. Three leaves from each plants were taken under consideration for length and breadth measurement.

3.10.4 Cob length

Cob length was measured in cm from the base of the cob to the apex. For this data calculation 10 cobs from each plot were selected then measured and then averaged.

3.10.5 Cob breadth

Measurement of widest part of the cobs was recorded in cm with the help of slide calipers. For this data calculation 10 cobs from each plot were selected then measured and then averaged.

3.10.6 Number of cob bearing node

The number of cob bearing node was counted at each of the five randomly selected plants in each plot and then averaged.

3.10.7 Number of row cob^{-1}

The number of rows of five cobs was counted at each of the five randomly selected plants in each plot and then averaged.

3.10.8 Number of grain row^{-1}

The number of grains of five cobs was counted at each of the five randomly selected plants in each plot and then averaged.

3.10.9 Grain yield

Grains obtained from each plot were sun-dried and weighed carefully. The dry weight of grain of the respective plot was recorded carefully and converted to t ha^{-1}.

3.10.10 100 seed weight

One hundred (100) seeds from 5 cobs were counted randomly from each plot and then weighed.

3.10.11 Shell weight

Shells were collected from 5 kernels of each plot; dried in an oven at 60^{0}C for 72 hours and then weighed.

3.10.12 Chaff weight

Chaff were collected from seeds of each plot; dried in an oven at 60^{0}C for 72 hours and then weighed.

3.11 Statistical analysis

The data were compiled and tabulated in proper form and were subjected to statistical analysis. Analysis of variance was done following the computer package MSTAT-C program developed by Russel (1986). The mean differences among the treatments were adjusted by Least Significant Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV
RESULTS AND DISCUSSION

The results obtained from the study have been presented, discussed and compared in this chapter through table(s), figure(s) and appendices. The results are interpreting under the following headings.

4.1 Plant height (cm)

Significant variation was observed on plant height at 40, 80 DAP and at harvest due to differences in planting method (Table 1 and Appendix V). The results revealed that at 40, 80 DAP and at harvest, the treatment P_1 produced the tallest plant (85.43, 163.56 and 212.34 cm) respectively and the treatment P_2 produced the shortest plant (82.87, 152.59 and 202.68 cm) respectively. This result is supported by Maiti and Sen (2003) who reported that delay in transplanting date reduced plant height and other biomass related factors (number of tillers produced, leaf area index).

Significant variation was observed on plant height at 40, 80 DAP and at harvest due to differences in leaf clipping (Table 1 and Appendix V). At 40 DAP, the highest plant height (89.31 cm) was recorded from C_1 and the lowest (74.12 cm) from C_2. At 80 DAP, the highest plant height (168.32 cm) was recorded from C_1 and the lowest (135.87 cm) from C_2. At harvest, the highest plant height (217.21 cm) was recorded from C_1 and the lowest (172.29 cm) from C_2.

Interaction effect of planting method and leaf clipping showed significant variation on plant height at 40, 80 DAP and at harvest (Table 2 and Appendix V). At 40 DAP, the highest plant height (91.38 cm) was recorded from P_1C_1 and the lowest (74.21 cm) from P_2C_2. At 80 DAP, the highest plant height (172.34 cm) from P_1C_1 and the lowest (142.87 cm) from P_2C_2. At harvest, the highest plant height (219.36 cm) was recorded from P_1C_1 and the lowest (181.66 cm) from P_2C_2.

Table 1: Effect of planting method and leaf clipping on plant height, leaf length and leaf breadth at different days after sowing and transplanting of white maize

Treatments	Plant height (cm)			Leaf length (cm)	Leaf breadth (cm)
	40 DAP	80 DAP	At harvest		
Effect of planting method					
P_1	85.43 a	163.56 a	212.34 a	39.87 a	5.17
P_2	82.87 b	152.59 b	202.68 b	36.44 b	4.67
LSD (0.05)	0.68	0.46	0.65	0.53	0.57
CV (%)	2.39	6.40	4.47	2.76	2.38
Effect of leaf clipping					
C_1	89.31 a	168.32 a	217.21 a	41.87 a	5.83
C_2	74.12 d	135.87 d	172.29 d	33.82 c	4.93
C_3	79.51 c	154.89 c	180.44 c	37.93 b	5.09
C_4	84.37 b	162.38 b	191.56 b	38.76 b	5.36
LSD (0.05)	0.68	0.64	0.67	1.13	0.96
CV (%)	3.86	5.95	5.74	3.58	4.81

P_1 = Sowing, P_2 = Transplanting
C_1 = No leaf Clipping, C_2 = All leaf clipping, C_3 = Clipping of four leaves above cob, C_4 = Clipping of four leaves below cob

4.2 Leaf length (cm)

Significant variation was observed on leaf length due to differences in planting method (Table 1 and Appendix V). The results revealed that, the treatment P_1 produced the highest leaf length (39.87 cm) and P_2 produced the lowest (36.44 cm). This result support the findings of Bisoondat (2002) who stated that leaf clipping at early season significantly decreased the stem and leaf length.

Significant variation was observed on leaf length due to differences in leaf clipping (Table 1 and Appendix V). The results revealed that, the treatment C_1 produced the highest leaf length (41.87 cm) and C_2 produced the lowest (33.82 cm).

Interaction effect of planting method and leaf clipping showed significant variation on leaf length (Table 2 and Appendix V). The highest leaf length (42.19 cm) was recorded from P_1C_1 which was statistically similar with P_1C_4 (40.95 cm) and the lowest (31.14 cm) from P_2C_2.

4.3 Leaf breadth (cm)

Non-significant variation was observed on leaf breadth due to differences in planting method (Table 1 and Appendix V).

Non-significant variation was observed on leaf breadth due to differences in leaf clipping (Table 1 and Appendix V).

Interaction effect of planting method and leaf clipping showed significant variation on leaf breadth (Table 2 and Appendix V). The highest leaf breadth (6.08 cm) was recorded from P_1C_1 which was statistically similar with P_1C_4 (5.81 cm) and the lowest (4.08 cm) from P_2C_2.

4.4 Cob length (cm)

Significant variation was observed on cob length due to differences in planting method (Table 3 and Appendix VI). The results revealed that, the treatment P_1 produced the highest cob length (17.63 cm) and P_2 produced the lowest (14.08 cm).

Significant variation was observed on cob length due to differences in leaf clipping (Table 3 and Appendix VI). The results revealed that, the treatment C_1 produced the highest cob length (19.77 cm) and C_2 produced the lowest (13.28 cm).

Interaction effect of planting method and leaf clipping showed significant variation on cob length (Table 4 and Appendix VI). The highest cob length (20.57 cm) was recorded from P_1C_1 which was statistically similar with P_1C_4 (19.91 cm) and the lowest (12.19 cm) from P_2C_2.

4.5 Cob breadth (cm)

Significant variation was observed on cob breadth due to differences in planting method (Table 3 and Appendix VI). The results revealed that, the treatment P_1 produced the highest cob breadth (12.45 cm) and P_2 produced the lowest (10.79 cm).

Significant variation was observed on cob breadth due to differences in leaf clipping (Table 3 and Appendix VI). The results revealed that, the treatment C_1 produced the highest cob breadth (18.42 cm) and C_2 produced the lowest (11.91 cm).

Interaction effect of planting method and leaf clipping showed significant variation on cob breadth (Table 4 and Appendix VI). The highest cob breadth (18.79 cm) was recorded from P_1C_1 and the lowest (10.44 cm) from P_2C_2.

Table 2: Interaction effect of planting method and leaf clipping on plant height, leaf length and leaf breadth at different days after sowing and transplanting of white maize

Treatments	Plant height (cm)		

	40 DAS	80 DAS	At harvest	Leaf length (cm)	Leaf breadth (cm)
P_1C_1	91.38 a	172.34 a	219.36 a	42.19 a	6.08 a
P_1C_2	80.11 d	161.25 d	202.39 c	37.12 b	4.91 c
P_1C_3	83.62 c	162.59 c	202.87 c	39.02 b	5.33 b
P_1C_4	86.74 b	167.84 b	209.55 b	40.95 a	5.81 a
P_2C_1	85.97 b	152.20 e	190.88 d	36.86 c	4.82 c
P_2C_2	74.21 f	142.87 g	181.66 f	31.14 e	4.08 e
P_2C_3	77.29 e	147.66 f	184.74 e	34.11 d	4.51 d
P_2C_4	82.92 c	151.83 e	187.21 d	36.22 c	4.66 c
LSD $_{(0.05)}$	0.72	0.58	0.63	1.92	0.37
CV (%)	2.58	5.22	3.67	3.10	4.26

P_1 = Sowing, P_2 = Transplanting
C_1 = No leaf Clipping, C_2 = All leaf clipping, C_3 = Clipping of four leaves above cob, C_4 = Clipping of four leaves below cob

4.6 Number of cob bearing node

Significant variation was observed on number of cob bearing node due to differences in planting method (Table 3 and Appendix VI). The results revealed that, the treatment P_1 produced the highest number of cob bearing node (7.67) and P_2 produced the lowest (5.33).

Significant variation was observed on number of cob bearing node due to differences in leaf clipping (Table 3 and Appendix VI). The results revealed that, the treatment C_1 produced the highest number of cob bearing node (9.33) which was statistically similar with C_4 (8.93) and C_2 produced the lowest (6.33).

Interaction effect of planting method and leaf clipping showed significant variation on number of cob bearing node (Table 4 and Appendix VI). The highest number of cob bearing node (10.67) was recorded from P_1C_1 which was statistically similar with P_1C_4 (9.93) and the lowest (5.33) from P_2C_2.

Table 3: Effect of planting method and leaf clipping on cob length, cob breadth, number of cob bearing node and number of row cob^{-1} of white maize

Treatments	Cob length (cm)	Cob breadth (cm)	Number of cob bearing node	Number of row cob^{-1}
Effect of planting method				
P_1	17.63 a	12.45 a	7.67 a	13.67 a

P_2	14.08 b	10.79 b	5.33 b	10.33 b
LSD (0.05)	0.88	0.67	0.73	0.92
CV (%)	4.45	3.59	6.26	4.16
Effect of leaf clipping				
C_1	19.77 a	18.42 a	9.33 a	14.67 a
C_2	13.28 c	11.91 c	6.33 c	11.33 c
C_3	17.22 b	15.48 b	7.67 b	12.57 b
C_4	17.67 b	16.34 b	8.93 a	13.33 b
LSD (0.05)	0.74	0.96	0.46	0.89
CV (%)	3.58	4.82	3.11	5.59

P_1 = Sowing, P_2 = Transplanting

C_1 = No leaf Clipping, C_2 = All leaf clipping, C_3 = Clipping of four leaves above cob, C_4 = Clipping of four leaves below cob

4.7 Number of row cob^{-1}

Significant variation was observed on number of row cob^{-1} due to differences in planting method (Table 3 and Appendix VI). The results revealed that, the treatment P_1 produced the highest number of row cob^{-1} (13.67) and P_2 produced the lowest (10.33). Significant variation was observed on number of row cob^{-1} due to differences in leaf clipping (Table 3 and Appendix VI). The results revealed that, the treatment C_1 produced the highest number of row cob^{-1} (14.67) and C_2 produced the lowest (13.33). Interaction effect of planting method and leaf clipping showed significant variation on number of row cob^{-1} (Table 4 and Appendix VI). The highest number of row cob^{-1} (16.33) was recorded from P_1C_1 and the lowest (10.67) from P_2C_2.

Table 4: Interaction effect of planting method and leaf clipping on cob length, cob breadth, number of cob bearing node and number of row cob^{-1} of white maize

Treatments	Cob length (cm)	Cob breadth (cm)	Number of cob bearing node	Number of row cob^{-1}
P_1C_1	20.57 a	18.79 a	10.67 a	16.33 a
P_1C_2	18.15 b	15.72 c	8.79 b	15.33 b
P_1C_3	18.67 b	16.96 b	9.33 b	14.67 c
P_1C_4	19.91 a	17.31 b	9.93 a	15.67 b

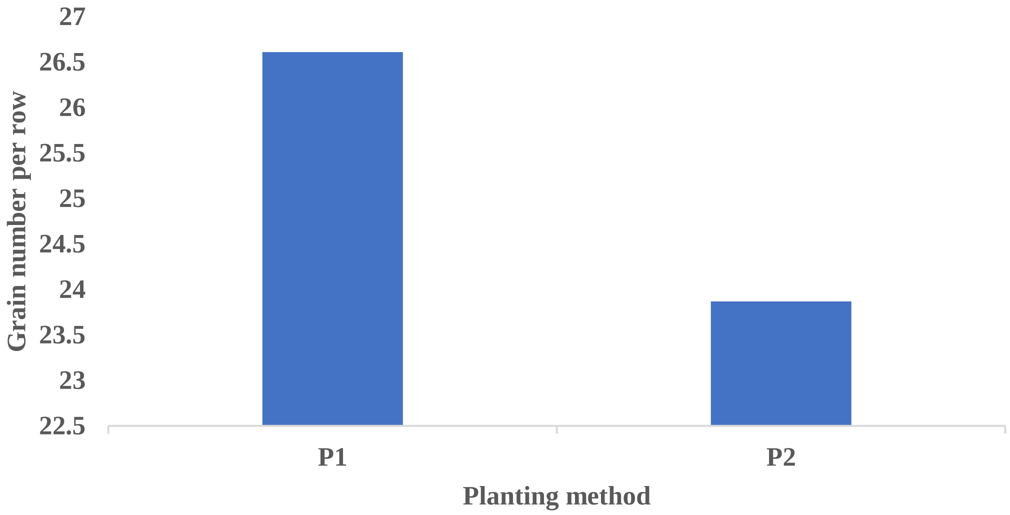
P_2C_1	15.24 c	13.23 d	8.67 b	14.34 c
P_2C_2	12.19 e	10.44 f	5.33 e	10.67 e
P_2C_3	13.48 d	11.08 e	6.67 d	13.33 d
P_2C_4	14.69 c	13.06 d	7.63 c	13.67 d
LSD $_{(0.05)}$	0.75	0.42	0.87	0.53
CV (%)	6.54	4.29	3.66	5.41

P_1 = Sowing, P_2 = Transplanting
C_1 = No leaf Clipping, C_2 = All leaf clipping, C_3 = Clipping of four leaves above cob, C_4 = Clipping of four leaves below cob

4.8 Number of grain row^{-1}

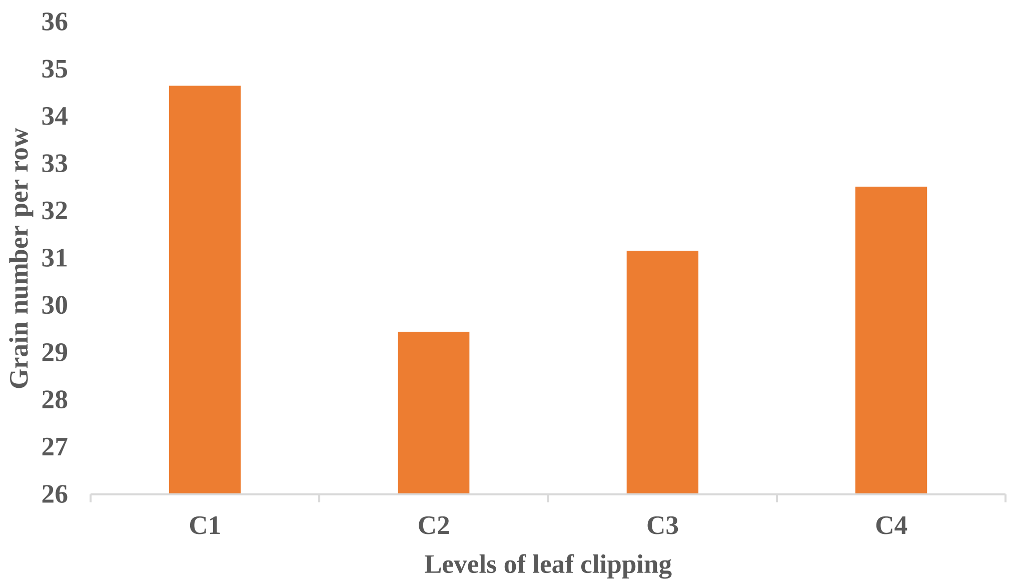
Significant variation was observed on number of grain row^{-1} due to differences in planting method (Figure 1 and Appendix VII). The results revealed that, the treatment P_1 produced the highest number of grain row^{-1} (26.61) and P_2 produced the lowest (23.87). This result supported the findings of Kumar *et al.* (2014) who reported that the enhanced number of grains per row and cob in transplanted maize.

Significant variation was observed on number of grain row^{-1} due to differences in leaf clipping (Figure 2 and Appendix VII). The results revealed that, the treatment C_1 produced the highest number of grain row^{-1} (34.65) and C_2 produced the lowest (29.44). Interaction effect of planting method and leaf clipping showed significant variation on number of grain row^{-1} (Table 5 and Appendix VII). The highest number of grain row^{-1} (36.89) was recorded from P_1C_1 and the lowest (24.37) from P_2C_2.



P_1 = Sowing, P_2 = Transplanting

Figure 1: Effect of planting method on number of grain row^{-1} of white maize



C_1 = No leaf Clipping, C_2 = All leaf clipping, C_3 = Clipping of four leaves above cob, C_4 = Clipping of four leaves below cob

Figure 2: Effect of leaf clipping on number of grain row^{-1} of white maize

Table 5: Interaction effect of planting method and leaf clipping on number of grain row^{-1}, grain yield and 100 seed weight of white maize

Treatments	Number of grain row^{-1}	Grain yield (t ha^{-1})	100 seed weight (g)
P_1C_1	36.89 a	8.70 a	29.45 a
P_1C_2	31.66 c	6.86 d	25.38 c
P_1C_3	33.85 b	7.46 c	27.12 b
P_1C_4	34.28 b	8.16 b	27.66 b
P_2C_1	29.72 d	6.81 d	25.19 c
P_2C_2	24.37 f	4.92 g	20.37 e
P_2C_3	26.19 e	5.51 f	22.96 d
P_2C_4	29.41 d	6.19 e	23.57 d
LSD $_{(0.05)}$	0.56	0.48	0.64
CV (%)	4.97	6.61	2.43

P_1 = Sowing, P_2 = Transplanting

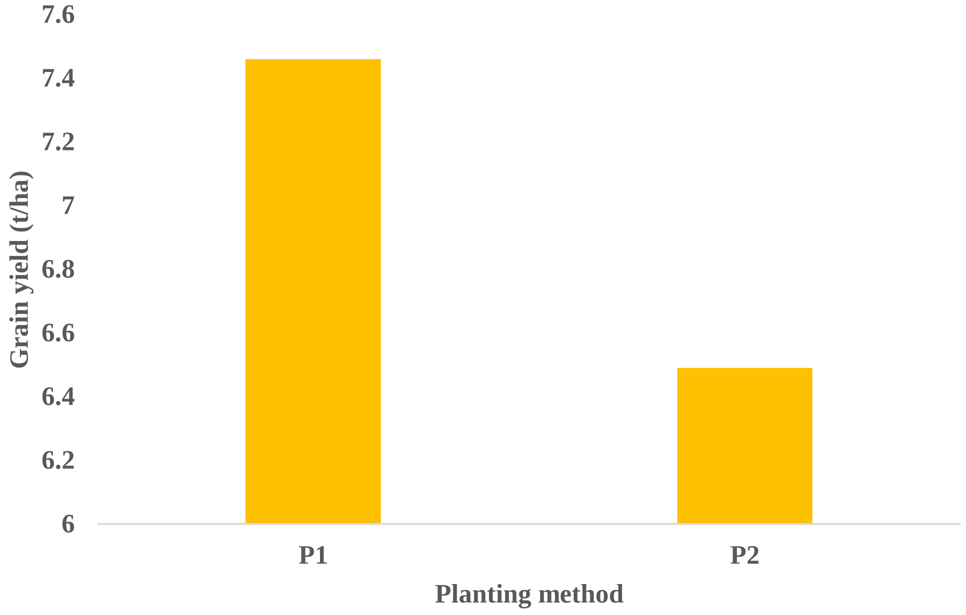
C_1 = No leaf Clipping, C_2 = All leaf clipping, C_3 = Clipping of four leaves above cob, C_4 = Clipping of four leaves below cob

4.9 Grain yield (t ha^{-1})

Significant variation was observed on grain yield due to differences in planting method (Figure 3 and Appendix VII). The results revealed that, the treatment P_1 produced the highest grain yield (7.46 t ha^{-1}) and P_2 produced the lowest (6.49 t ha^{-1}).

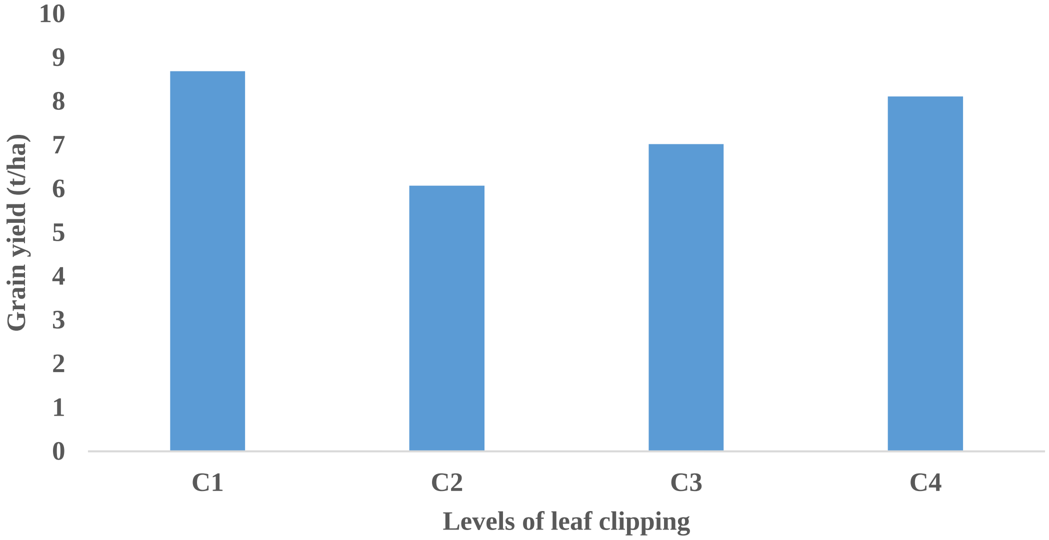
Significant variation was observed on grain yield due to differences in leaf clipping (Figure 4 and Appendix VII). The results revealed that, the treatment C_1 produced the highest grain yield (8.69 t ha^{-1}) and C_2 produced the lowest (6.07 t ha^{-1}). This result is supported by Cheema *et al.* (2010) who reported that maize leaf clipping caused the seed yield reduction because of the seed number decrease.

Interaction effect of planting method and leaf clipping showed significant variation on grain yield **(**Table 5 and Appendix VII). The highest grain yield (8.70 t ha^{-1}) was recorded from P_1C_1 and the lowest (4.92 t ha^{-1}) from P_2C_2.



P_1 = Sowing, P_2 = Transplanting

Figure 3: Effect of planting method on grain yield of white maize

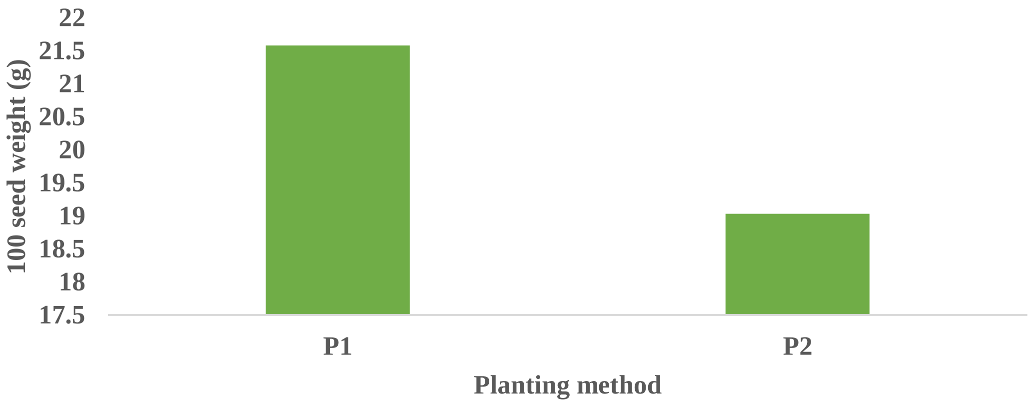


C_1 = No leaf Clipping, C_2 = All leaf clipping, C_3 = Clipping of four leaves above cob, C_4 = Clipping of four leaves below cob

Figure 4: Effect of leaf clipping on grain yield of white maize

4.10 100 seed weight (g)

Significant variation was observed on 100 seed weight due to differences in planting method (Figure 5 and Appendix VII). The results revealed that, the treatment P_1 produced the highest 100 seed weight (21.58 g) and P_2 produced the lowest (19.03 g).

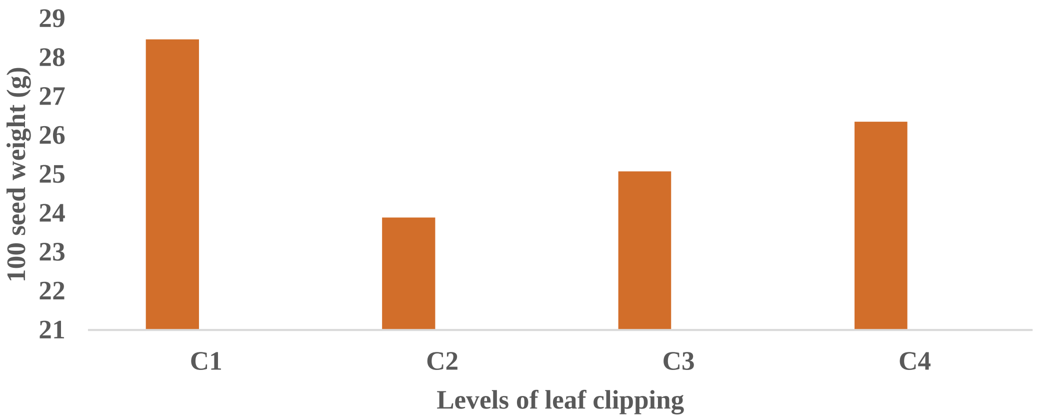


P_1 = Sowing, P_2 = Transplanting

Figure 5: Effect of planting method on 100 seed weight of white maize

Significant variation was observed on 100 seed weight due to differences in leaf clipping (Figure 6 and Appendix VII). The results revealed that, the treatment C_1 produced the highest 100 seed weight (28.47 g) which was statistically similar with C_4

(26.35 g) and C_2 produced the lowest (23.89 g). This results are in conformity with Ahmadi *et al.* (2009) who reported that clipping significantly affect remobilization of grain yield and 1000-grain weight.



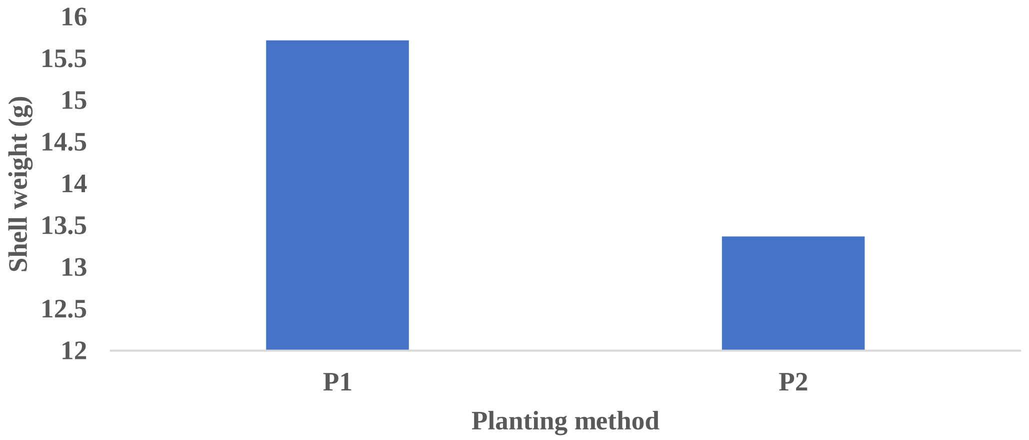
C_1 = No leaf Clipping, C_2 = All leaf clipping, C_3 = Clipping of four leaves above cob, C_4 = Clipping of four leaves below cob

Figure 6: Effect of leaf clipping on 100 seed weight of white maize

Interaction effect of planting method and leaf clipping showed significant variation on 100 seed weight **(**Table 5 and Appendix VII). The highest 100 seed weight (29.45 g) was recorded from P_1C_1 and the lowest (20.37 g) from P_2C_2.

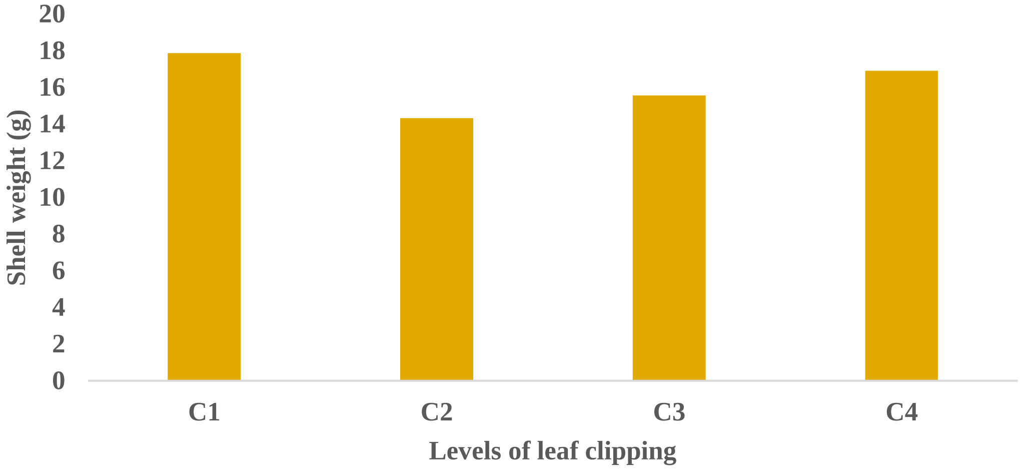
4.11 Shell weight (g)

Significant variation was observed on oven dried shell weight due to differences in planting method (Figure 7 and Appendix VIII). The results revealed that, the treatment P_1 produced the highest oven dried shell weight (15.72 g) and P_2 produced the lowest (13.37 g).



P_1 = Sowing, P_2 = Transplanting

Figure 7: Effect of planting method on oven dried shell weight of white maize



C_1 = No leaf Clipping, C_2 = All leaf clipping, C_3 = Clipping of four leaves above cob, C_4 = Clipping of four leaves below cob

Figure 8: Effect of leaf clipping on oven dried shell weight of white maize

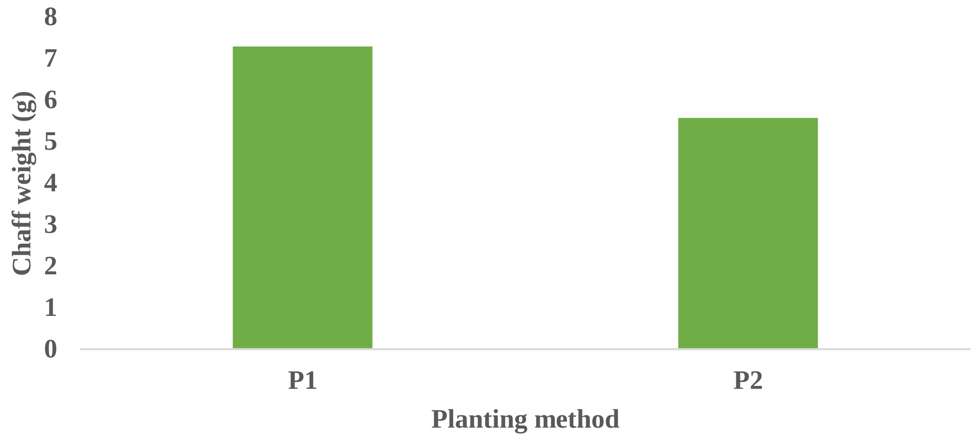
Significant variation was observed on oven dried shell weight due to differences in leaf clipping (Figure 8 and Appendix VIII). The results revealed that, the treatment C_1 produced the highest oven dried shell weight (17.87 g) which was statistically similar with C_4 (16.91 g) and C_2 produced the lowest (14.32 g).

Interaction effect of planting method and leaf clipping showed significant variation on oven dried shell weight **(**Table 6 and Appendix VIII). The highest oven dried shell weight (18.11 g) was recorded from P_1C_1 which was statistically similar with P_1C_4 (17.32 g) and the lowest (13.39 g) from P_2C_2.

4.12 Chaff weight (g)

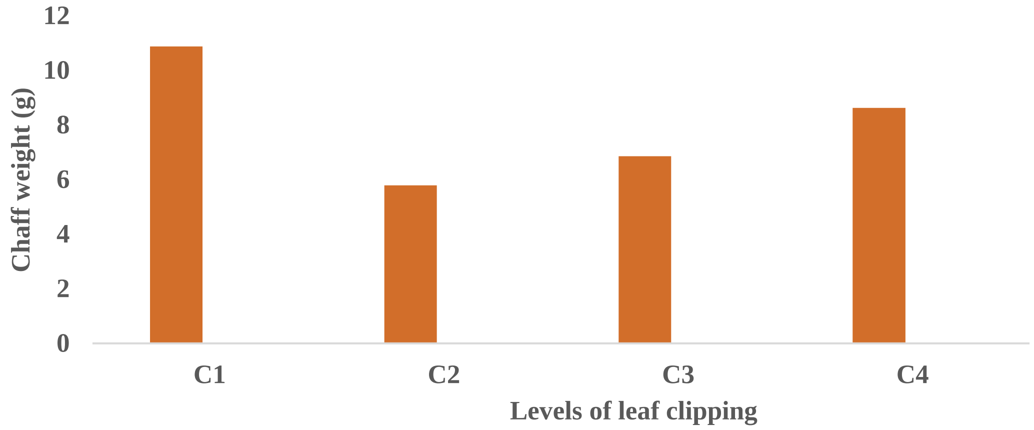
Significant variation was observed on oven dried chaff weight due to differences in planting method (Figure 9 and Appendix VIII). The results revealed that, the treatment P_1 produced the highest oven dried chaff weight (7.29 g) and P_2 produced the lowest (5.57 g).

Significant variation was observed on oven dried chaff weight due to differences in leaf clipping (Figure 10 and Appendix VIII). The results revealed that, the treatment C_1 produced the highest oven dried chaff weight (10.88 g) which was statistically similar with C_4 (8.62 g) and C_2 produced the lowest (5.79 g).



P_1 = Sowing, P_2 = Transplanting

Figure 9: Effect of planting method on oven dried chaff weight of white maize



C_1 = No leaf Clipping, C_2 = All leaf clipping, C_3 = Clipping of four leaves above cob, C_4 = Clipping of four leaves below cob

Figure 10: Effect of leaf clipping on oven dried chaff weight of white maize

Interaction effect of planting method and leaf clipping showed significant variation on oven dried chaff weight (Table 6 and Appendix VIII). The highest oven dried chaff weight (11.05 g) was recorded from P_1C_1 and the lowest (5.61 g) from P_2C_2.

Table 6: Interaction effect of planting method and leaf clipping on oven dried shell and chaff weight of white maize

Treatments	Shell weight (g)	Chaff weight (g)
P_1C_1	18.11 a	11.05 a
P_1C_2	15.72 b	6.65 d
P_1C_3	16.36 b	7.87 c
P_1C_4	17.32 a	9.22 b

P_2C_1	15.29 c	7.43 c
P_2C_2	13.39 e	5.61 e
P_2C_3	13.76 d	6.22 d
P_2C_4	14.64 c	6.51 d
LSD $_{(0.05)}$	0.83	0.65
CV (%)	5.39	4.12

P_1 = Sowing, P_2 = Transplanting

C_1 = No leaf Clipping, C_2 = All leaf clipping, C_3 = Clipping of four leaves above cob, C_4 = Clipping of four leaves below cob

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka from January 2018 to June 2018 to study the effect of planting methods and leaf clipping on yield performance of white maize. The experiment comprised of two factor viz. Factor A: Planting method - 2 types (P_1 = Sowing, P_2 = Transplanting) and Factor B: Leaf clipping - 4 levels (C_1 = No leaf clipping, C_2 = All leaf clipping, C_3 = Clipping of four leaves above cob, C_4 = Clipping of four leaves below cob). The experiment was laid out in split plot design with three replications.

Different growth and yield parameters varied significantly due to difference in planting method. At 40 DAP, 80 DAP and at harvest; the treatment P_1 produced the tallest plant (85.43, 163.56 and 212.34 cm) respectively and the treatment P_2 produced the shortest plant (82.87, 152.59 and 202.68 cm) respectively. The treatment P_1 produced the highest leaf length (39.87 cm) and P_2 produced the lowest (36.44 cm). The highest cob length (17.63 cm) recorded from P_1 and P_2 produced the lowest (14.08 cm). The highest cob breadth (12.45 cm) was recorded from P_1 and the lowest (10.79 cm) from the P_2. The highest number of cob bearing node (7.67) produced by P_1 and the lowest (5.33) by P_2. The maximum number of row cob^{-1} (13.67) produced by P_1 and the lowest (10.33) by P_2. The highest number of grain row^{-1} (26.61) produced by P_1 and P_2 produced the lowest (23.87). The treatment P_1 produced the highest grain yield (7.46 t ha^{-1}) and P_2 produced the lowest (6.49 t ha^{-1}). The highest 100 seed weight (21.58 g) produced by P_1 and P_2 produced the lowest (19.03 g). The highest oven dried shell weight (15.72 g) produced by P_1 and P_2 produced the lowest (13.37 g). The highest chaff weight after oven dry (7.29 g) produced by P_1 and P_2 produced the lowest (5.57 g).

Different growth and yield parameters varied significantly due to difference in leaf clipping. At 40 DAP, the highest plant height (89.31 cm) was recorded from C_1 and the lowest (74.12 cm) from C_2. At 80 DAP, the highest plant height (168.32 cm) was recorded from C_1 and the lowest (135.87 cm) from C_2. At harvest, the highest plant height (217.21 cm) was recorded from C_1 and the lowest (172.29 cm) from C_2. The treatment C_1 produced the highest leaf length (41.87 cm) and C_2 produced the lowest (33.82 cm). The highest cob length (19.77 cm) recorded from C_1 and C_2 produced the lowest (13.28 cm). The highest cob breadth (18.42 cm) was recorded from C_1 and the lowest (11.91 cm) from the C_2. The highest number of cob bearing node (9.33) produced by C_1 and the lowest (6.33) by C_2. The maximum number of row cob^{-1} (14.67) produced by C_1 and the lowest (11.33) by C_2. The highest number of grain row^{-1} (34.65) produced by C_1 and C_2 produced the lowest (29.44). The treatment C_1 produced the highest grain yield (8.69 t ha^{-1}) and C_2 produced the lowest (6.07 t ha^{-1}). The highest 100 seed weight (28.47 g) produced by C_1 and C_2 produced the lowest (23.89 g). The highest oven dried shell weight (17.87 g) produced by C_1 and C_2 produced the lowest (14.32 g). The highest oven dried chaff weight (10.88 g) produced by C_1 and C_2 produced the lowest (5.79 g).

At 40 DAP, the highest plant height (91.38 cm) was recorded from P_1C_1 and the lowest (74.21 cm) from P_2C_2. At 80 DAP, the highest plant height (172.34 cm) from P_1C_1 and the lowest (142.87 cm) from P_2C_2. At harvest, the highest plant height (219.36 cm) was recorded from P_1C_1 and the lowest (181.66 cm) from P_2C_2. The treatment P_1C_1 produced the highest leaf length (42.19 cm) and P_2C_2 produced the lowest (31.14 cm). The treatment P_1C_1 produced the highest leaf breadth (6.08 cm) and P_2C_2 produced the lowest (4.08 cm). The highest cob length (20.57 cm) recorded from P_1C_1 and P_2C_2 produced the lowest (12.79 cm). The highest cob breadth (18.79 cm) was recorded from P_1C_1 and the lowest (10.44 cm) from the P_2C_2. The highest number of cob bearing node (10.67) produced by P_1C_1 and the lowest (5.33) by P_2C_2. The maximum number of row cob^{-1} (16.33) produced by P_1C_1 and the lowest (10.67) by P_2C_2. The highest number of grain row^{-1} (36.89) produced by P_1C_1 and P_2C_2 produced the lowest (24.37). The treatment P_1C_1 produced the highest grain yield (8.70 t ha^{-1}) and P_2C_2 produced the lowest (4.92 t ha^{-1}). The highest 100 seed weight (29.45 g) produced by P_1C_1 and P_2C_2 produced the lowest (20.37 g). The highest oven dried shell weight (18.11 g) produced by P_1C_1 and P_2C_2 produced the lowest (13.39 g). The highest oven dried chaff weight (11.05 g) produced by P_1C_1 and P_2C_2 produced the lowest (5.61 g).

From the above results it can be concluded that,

- Leaf clipping adversely affects all the yield related attributes.
- P_1 (Sowing) showed better result in all aspects than P_2 (Transplanting).
- Treatment C_1 (No leaf clipping) produced better yield and yield contributing attributes than C_2 (All leaf clipped).
- P_1C_1 showed the best performance in terms of yield of white maize.

CHAPTER VI
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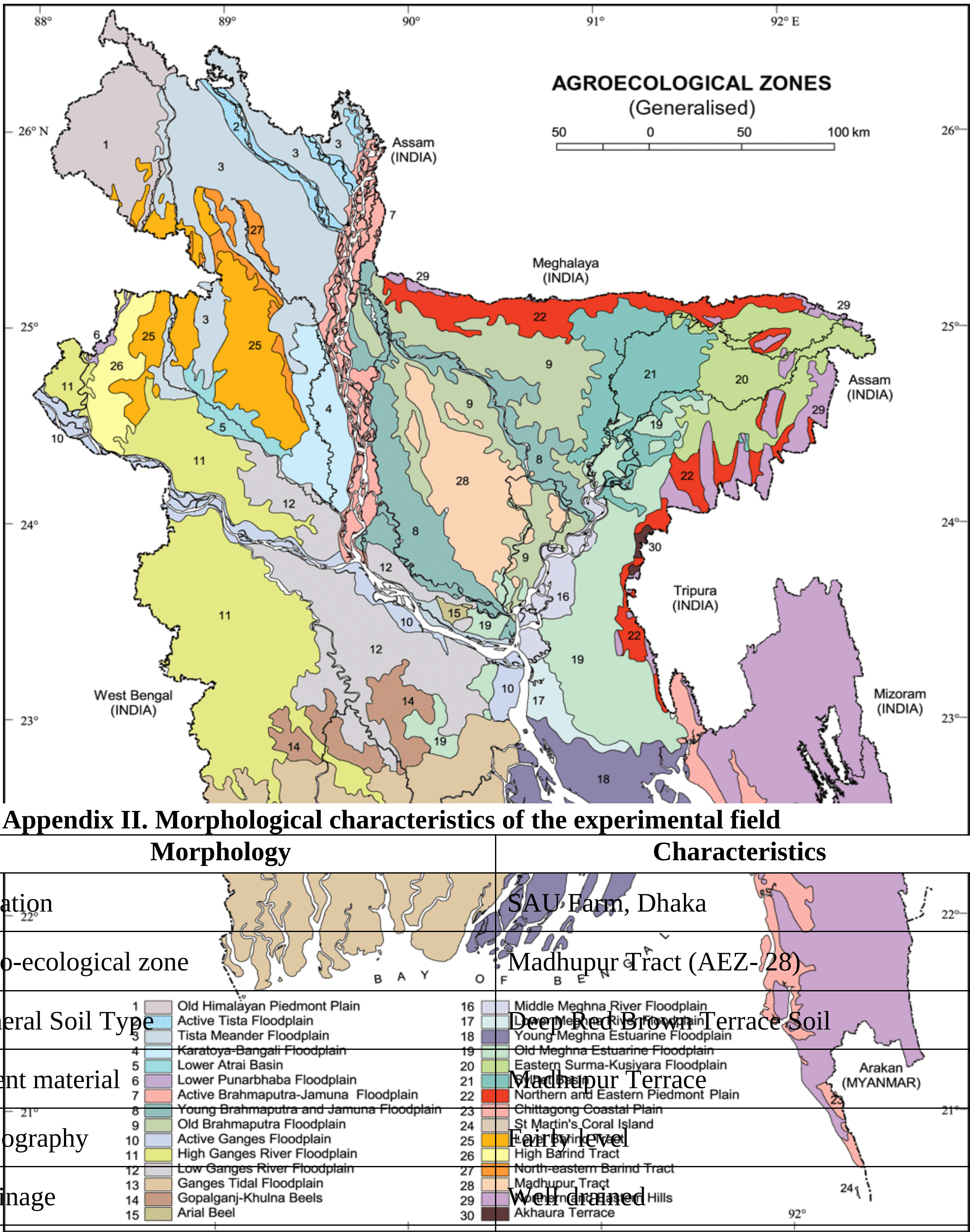
APPENDICES

Appendix I. Experimental location on the map of 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)

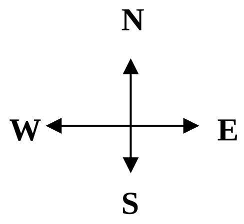
Appendix III. Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions: % Sand (2.0-0.02 mm) % Silt (0.02-0.002 mm) % Clay (<0.002 mm)	 22.26 56.72 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

B_1	B_2	B_3
P_2C_1	P_1C_2	P_2C_4
P_1C_3	P_2C_3	P_1C_2
P_2C_2	P_1C_1	P_2C_2
P_1C_4	P_2C_4	P_1C_4
P_2C_4	P_1C_3	P_2C_1
P_1C_1	P_2C_2	P_1C_1
P_2C_3	P_1C_4	P_2C_3
P_1C_2	P_2C_1	P_1C_3



Plot length = 3 m
Plot width = 1.4 m
Plot area = 3 × 1.4 = 4.2 m^2
P_1 = Sowing

P_2 = Transplanting

C_1 = No leaf clipping
C_2 = All leaf clipping
C_3 = Clipping of four leaves above cob

C_4 = Clipping of four leaves below cob

Appendix V. **Mean square value for plant height, leaf length and leaf breadth at different days after sowing and transplanting of white maize**

Source of variation	Degrees of freedom	Mean square				
		Plant height			Leaf length	Leaf breadth
		40 DAP	80 DAP	At harvest		
Replication	2	3.69	5.43	4.66	4.95	5.11
Factor A	1	353.79*	350.92*	226.48*	7.98**	6.45*
Error	2	6.52	2.72	3.78	3.19	4.22
Factor B	3	28.12**	15.67*	15.29*	5.41*	3.05*
A × B	3	0.51*	0.58**	0.89*	2.51*	1.30*
Error	12	1.81	1.68	3.97	0.47	0.97

*Significant at 5% level
**Significant at 1% level
NS - Non Significant

Appendix VI. **Mean square value for cob length, cob breadth, number of cob bearing node and number of row cob^{-1} of white maize**

Source of variation	Degrees of freedom	Mean square			
		Cob length	Cob breadth	Number of cob bearing node	Number of row cob^{-1}
Replication	2	2.79	6.24	3.67	3.53
Factor A	1	11.76^{NS}	13.43*	8.73*	22.93**
Error	2	5.14	3.96	4.68	5.49
Factor B	3	6.84*	17.47*	19.88**	92.42**
A × B	3	18.18*	2.03*	1.53*	11.45*
Error	12	4.64	1.47	0.78	0.75

*Significant at 5% level
**Significant at 1% level
NS - Non Significant

Appendix VII. **Mean square value for number of grain row^{-1}, grain yield and 100 seed weight of white maize**

Source of variation	Degrees of freedom	Mean square		
		Number of grain row $^{-1}$	Grain yield	100 seed weight
Replication	2	3.12	4.97	5.55
Factor A	1	12.59*	554.75*	4739.43*
Error	2	4.48	2.34	6.22
Factor B	3	39.94**	2897.26**	5576.15*
A × B	3	4.14*	49.62**	798.88*
Error	12	4.97	417.44	1087.25

*Significant at 5% level
**Significant at 1% level
NS - Non Significant

Appendix VIII. Mean square value for oven dried shell and chaff weight of white maize

Source of variation	Degrees of freedom	Mean square	
		Shell weight	Chaff weight
Replication	2	1.45	2.62
Factor A	1	22.49*	18.45**
Error	2	3.80	4.26
Factor B	3	924.03**	497.13**
A × B	3	9.62*	5.92*
Error	12	2.27	3.09

*Significant at 5% level
**Significant at 1% level
NS - Non Significant