INFLUENCE OF SEEDLING HEIGHT MANIPULATION AND LEAF REMOVAL ON GROWTH AND YIELD OF BRRI Dhan48

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INFLUENCE OF SEEDLING HEIGHT MANIPULATION AND LEAF REMOVAL ON GROWTH AND YIELD OF BRRRI Dhan48

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CERTIFICATE

*This is to certify that thesis entitled, "**INFLUENCE OF SEEDLING HEIGHT MANIPULATION AND LEAF REMOVAL ON GROWTH AND YIELD OF BRRI Dhan48**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **MD. NAJMUL ISLAM**, Registration no. **13-05693** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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INFLUENCE OF SEEDLING HEIGHT MANIPULATION AND LEAF REMOVAL ON GROWTH AND YIELD OF BRRI Dhan48

ABSTRACT

An experiment was conducted during the period from March to August 2019 at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to study the influence of leaf clipping on the growth and yield of *aus* rice. The experiment comprised two factors; Factors A: three different seedling clipping *viz.* S_0 = no seedling clipping (control), S_1 = 1/3rd height seedling clipping and S_2 = 1/2nd height seedling clipping and Factor B: five different leaf clipping before panicle initiation *viz*. L_0 = no leaf clipping (control), L_1 = Lower 1st + 2nd leaves clipping, L_2 = Lower 2nd + 3rd leaves clipping, L_3 = Lower 3rd + 4th leaves clipping and L_4 = Flag leaf clipping. The experiment was laid out in Randomized Complete Block design (RCBD) with three replications.Seedling clipping showed significant variations on all parameter except plant height. Leaf clipping treatment also showed same effect on different plant characters. Combine effect of seedling clipping and leaf clipping treatment varied growth and yield parameters significantly as well. The tallest plant (110.17 cm) was recorded from the combination of no seedling clipping and no leaf clipping. The highest number of effective tillers hill^{-1} (27.69) and longest panicle (35.81 cm) was obtained from the combination of 1/3rd height clipping with no leaf clipping of seedlings. The maximum number of filled grains panicle^{-1} (157.50), 1000-grain weight (28.00 g), grain yield (4.98 t ha^{-1}) and harvest index (48.54 %) was recorded from 1/3rd seedling clipping and no leaf clipping combination of treatment.

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LIST OF ABBREVIATIONS

AEZ	Agro-Ecological Zone
Anon.	Anonymous
AIS	Agriculture Information Service
BARC	Bangladesh Agricultural Research Council
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
BNNC	Bangladesh National Nutrition Council
BRRI	Bangladesh Rice Research Institute
CRRI	Central Rice Research Institute
CV %	Percent Coefficient of Variance
cv.	Cultivar (s)
DAT	Days After Transplanting
DRR	Directorate of Rice Research
eds.	Editors
et al.	and others
etc.	et cetera (and other similar things)
FAO	Food and Agriculture Organization
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
IRRI	International Rice Research Institute
L.	Linnaeus
LSD	Least Significant Difference
i.e.	id est (that is)
MoP	Muriate of Potash
NPTs	New Plant Types

SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resource and Development Institute
TDM	Total Dry Matter
TSP	Triple Super Phosphate
UNDP	United Nations Development Programme
var.	Variety
viz.	Namely

INTRODUCTION

Rice (*Oryza sativa* L) belongs to the Poaceae family is the staple food for more than three billion people of the world's total population. Rice is the staple food of about 135 million people of Bangladesh. It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average person in the country. Rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh. Rice is grown in 114 countries across the world on an area about 150 million hectares with annual production of over 525 million tones, constituting nearly 11 percent of the world's cultivated land (Rai, 2006). More than 90 per cent of the world's rice is produced and consumed in Asia where it is an integral part of culture and tradition. In Asia, it is the main item of the diet of 3.5 billion people. Therefore, increase in asian population will require 70 percent more rice in 2025 than is consumed today (Kim and Krishnan, 2002).

The demand of rice is constantly increasing in Bangladesh with nearly three million people are being added each year to the total population of the country (BBS, 2015). To meet the total food demand of growing population, *Aus* rice production needs to be increased more even to compensate the future strategy of closing *Boro* cultivation for giving space to other non-rice crops cultivation.

Aus, Aman and Boro are three distinct growing seasons for Rice in our country. According to the report of FAO (2016), the average yield of rice in Bangladesh is about 2.92 t ha^{-1} that is very low than the other rice growing countries of the world, such as China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and Korea (6.30 t ha^{-1}). In this condition, the crop production has to be increased at least 60% by 2020 so that we can meet up our food demand for the growing population

(Langfield *et al*., 1960). Overpopulation and their demand for the grain have been increasing day by day while crop cultivating area is showing negative trend. Now-a-days, soil fertility has been decreased with intensive cropping cropland with shortage of soil.

Economic implications include high consumer prices, problems for the balance of payments,and the burden of external debt. One of the important aims for the cultivation of rice is yield. However, grain yield which is a complex trait and the genetic control of grain yield is a series of biochemical and physiological processes that is also very complex (Ashraf *et al.,* 1994). The primary source of grain yield for rice is photosynthesis of carbohydrate. Grain filling that is sustained by current photosynthesis of the upper parts of the plant, i.e. the flag leaf, penultimate leaves and the ear (Tambussi *et al.,* 2007). Plant leaves are the main organ of photosynthesis that is considered as the important determinant and they are also characterized for higher photosynthetic capacities (Asana, 1968).

Leaf is an unique media for photosynthesis which influenced by many plant factors such as leaf age, leaf position, and mutual shading, as well as environmental factors such as light, temperature, nutrition, and water availability (Lieth and Pasian, 1990). The analysis of the regulation of assimilate allocation between shoot and root by means of partitioning control mechanism, which promotes the initiation of a compensatory adaptive response by the plant to changes in shoot and root dry matter partition (Gray, 1996). Thus leaf clipping in transplanted seedling may have option to translocate assimilate towards root zone for early establishing of seedling. Das *et al.* (2017) opinioned that leaf clipping either flag leaf or along with 2nd and 3rd leaves has no positive effect on grain production in modern variety was higher. Misra and Misra (1991) (pearl millet) and Mae (1997) (rice), stated that the top three leaves translocate towards grain filling but also provide proportion of remobilized nitrogen for grain development before crop maturity. By keeping eyes on those points, it is important to examine the response of leaf clipping on growth and yield of Aus rice when this type of experiment is very scanty at this time.

Flag leaves that play an important role in synthesis and also help for the translocation of photo-assimilates to the rice grains that affects grain yield. The uppermost leaf which is situated below the panicle is called flag leaf that provides the most important source of photosynthetic energy during reproduction. Flag leaf is assigned as an important role for the supply of photosynthates to the grains (Asana, 1968), for grain yield and for enhancing productivity (Padmaja and Rao, 1991). The yield of grain and yield related traits have positive relation to the area of flag leaf (Ashrafuzzaman *et al.,* 2009). However, research work on either seedling clipping and leaf clipping or combined management at house is scanty.

Under these circumstances, the present research work was undertaken to achieve the following objectives-

Objectives

1) To study the effect of seedling height manipulation and leaf clipping establishment.
2) To ascertain the position of leaf to be clipped down and
3) To find out the combined effect of seedling height and leaf clipping on the growth and yield of Aus rice.

CHAPTER II

REVIEW OF LITERATURE

Rice is widely adaptable crop in different environmental condition. The growth and development of rice may be influenced by systems of cultivation. Leaf is an important part of rice plant and major source of photosynthetic activity. Leaf clipping practice on either at seedling stage or after seedling transplanting stage can influence different growth and yield attributes of rice. Yield potentiality also depends on physiological parameters like leaf area index, dry matter accumulation, translocation and regulation of assimilate association between shoot and root by means of partitioning physiology. The work so far done in Bangladesh on leaf clipping is not adequate and conclusive. An attempt was made in this section to collect and study relevant information available in the country and abroad to gather knowledge helpful in conducting the present research work and subsequently writing up the result and discussion. Some of the important and informative works and research findings so far been done at home and abroad on leaf clipping on the growth and yield of rice have been reviewed in this chapter under the following headings and sub-headings:

2.1 Impact of Leaf Clipping on growth parameters

2.1.1 Plant height

A field experiment was conducted by Islam *et al.* (2005) during the 2001 T. aman (wet season) and 2002 Boro (dry season) to find out the effect of flag leaf clipping and gibberellic acid (GA_3) application on hybrid rice seed yield. IR58025A (female parent) and BR827R (male parent) were taken as experimental materials. Four treatments were applied: T_1 = control, T_2 = GA_3 application without flag leaf clipping, T_3 = flag leaf clipping without GA_3 application and T_4 = GA_3application with flag leaf clipping.When primary tillers were at booting stage in both seasons, half of the flag leaf of the A line was clipped using a sickle. In the time of T. aman season, plant height of the A line differed significantly among different treatments. The highest plant height (90 cm) in T. aman season was observed in T_2 treatment where GA_3 was applied without flag leaf clipping. No significant differences were observed in terms of seed yield among different treatments during T. aman.

An experiment was carried out by Ahmed *et al.* (2001) to asses the effect of pre-flowering leaf cutting on forage and seed yield of transplant aman rice. The experiment consisted of four varieties namely Latishail, BR10, BR11 and BRRI dhan 32 and four cttings viz, no leaf cutting (T_1), leaf cutting at 21 DAT (T_2), leaf cutting at 28 DAT (T_3), leaf cutting at 35 DAT (T_4). The effect of leaf cutting was significant on different growth parameters. No leaf clipping (control) has significant effect on plant height. The results revealed that among the varieties among the leaf cutting treatments, Latishail leaf cutting at 35 DAT gave the significant plant height as well as higher forage yield.

An experiment was conducted by Molla *et al.* (2002) to ascertain the feasibility of green fodder harvest without affecting the seed yield of transplant aman rice. Plant height, number of leaves hill^{-1}, number of tillers hill^{-1}, green fodder yield and seed yield were significantly differed due to different cultivar and leaf clipping height. Latishail produced the highest plant height, number of leaves hill^{-1}, number of tillers hill^{-1} at all growth stages where BR10 showed the lowest among cultivers. There are two factors of this experiment, (A) cultivar: (i) C_1 = Latishail (ii) C_2 = BR 10 (iii) C_3 = BR 11 and (iv) C_4 = BRRI dhan32 and (B) leaf clipping heights: (i) H_1 = clipping at 10 cm (ii) H_2 = clipping at 15 cm (iii) H_3= clipping at 20 cm and (iv) H_4 = control (no clipping). The height of the rice plants were significantly different because of different cultivars and leaf clipping heights. The highest plant height was obtained from control plot at all growth stages where the lowest plant was recorded from leaf clipping at 10 cm height.

Hossain (2017) carried out an experiment to assess the effect of leaf cutting on plant growth and yield of selected BRRI released Aman varieties. The experiment had two factors such as leaf cutting managements i.e. T_1 = Leaf cutting (except flag and penultimate leaves) T_2 = Control (no leaf cutting) and five BRRI rice varieties e.g. V_1 = BRRI dhan32, V_2 = BRRI dhan33, V_3 = BRRI dhan39, V_4 = BRRI dhan62 and V_5 = BRRI dhan56. Under the survey of all these irrespective varieties, the maximum plant height was obtained in no leaf cutting (control treatment).

An experiment was conducted by Ahmed *et al.* (2001) to study the effect of nitrogen rate and time of leaf cutting on green fodder as well as seed yield of rice. The experiment included two factors, (A) three Nitrogen levels (N_1 – 50 kg N ha^{-1}, N_2 –75 kg N ha^{-1}, N_3 – 100 kg N ha^{-1}, (B) four Times of leaf cutting – viz. i) No cutting (control) – C_0, ii) Cutting at 21 DAT – C_1, iii) Cutting at 35 DAT – C_2 and iv) Cutting at 49 DAT

– C_3. Plant height value was found to be the highest for no leaf cutting which was statistically similar to cutting at 21 DAT and the lowest for cutting at 49 DAT.

Usman *et al.* (2007) carried out an experiment to study the effect of detopping on grain yield of rice. The experiment has six treatments viz., Control (T_1), detopping at 22 DAT (T_2), 29 DAT (T_3), 36 DAT (T_4), 43 DAT (T_5), and 50 DAT (T_6). The effect of detopping was significant on all the yield and yield components of rice.Above all the six treatments, the highest plant height (125 cm) were obtained from control (no detopping). It was concluded that detopping at an early vegetative stage of crop growth could produce almost higher grain yield and reduce lodging in case of excessive vegetative growth. It is also evident that plant height decreased when detopping was done at later stages of crop growth and vice versa. Detopping can be practiced successfully up to 36 DAT having a little effect on grain yield. Moreover, it is the most economical way of increasing the yield,

A field experiment was conducted by Medhi *et al.* (2015) to study the effect of foliage pruning on vegetative growth and grain yield of two low land rice varieties, TTB-303−1-42 (Dhansiri) and TTB-303−1-23 (Difalu) under rain-fed low land situation (50–100 cm water depth) during wet season. The result of the experiment showed that two times removal of foliage significantly reduced the plant height and prevented lodging. Foliage pruning up to 100 days after germination (DAG) had no adverse impact on tillers of the crop. Foliage pruning up to 100 DAG produced grain yield comparable with that of no pruning but pruning there after (120 DAG) and to times pruning (80+100 DAG, 100+120 DAG and 80+120 DAG) reduced grain yield. Grain sterility was 5.89-8.27% higher at delayed pruning and two times pruning. Additionally foliage pruning provided considerable amount of green foliage which can serve as a nutritious feed for cattle at the time of its scarcity during wet season.

2.1.2 Number of effective tillers hill^{-1}

A field experiment was conducted by Daliri *et al.* (2009) in order to study the effect of cutting time and cutting height on yield and yield components of ratoon rice (*Oryza sativa* L.).A variety Tarom langrodi was carried out for the experiments and results showed that the effect of cutting time on number of effective tiller hill^{-1} was found statistically significant. Cutting height had a significant effect on number of tiller in hill^{-1} and number of effective tiller in hill^{-1}. Interaction among cutting time and cutting height on number of tiller hill^{-1} and number of effective tillers hill^{-1} were significant.

Hachiya (1989) conducted an experiment to study on the effect of artificial leaf cutting on growth and yield of rice plants. The highest value of number of total tillers hill-1 for observations at 28, 35, 42, 48 DAT and at maturity were obtained in control and the lowest at the same date of observations were obtained when leaf cutting was done at 21, 21, 28, 28 and 35 DAT, respectively. The study proved that increases in the percentages of productive tillers were observed in response to artificial leaf cutting.

Ahmed *et al.* (2001) carried out an experiment to study the effect of nitrogen rate and time of leaf cutting on green fodder as well as seed yield of rice. The experiment consist of two factors, (A) Nitrogen level – viz. i) N_1 – 50 kg N ha^{-1}, ii) N_2 –75 kg N ha^{-1} and iii) N_3 – 100 kg N ha^{-1}, (B) Time of leaf cutting – viz. i) No cutting (control) – C_0, ii) Cutting at 21 DAT – C_1, iii) Cutting at 35 DAT – C_2 and iv) Cutting at 49 DAT – C_3. Time of leaf cutting had significant influence on number of total tillers hill^{-1} and number of productive tillers hill^{-1}. It was found to be the highest from no leaf cutting treatment which was statistically similar to cutting at 21 DAT and the lowest from leaf cutting at 49 DAT.

Boonreund and Marsom (2015) conducted an experiments aimed at searching for the optimal length of cutting for Pathum Thani1 rice leaf for better yield. Length of rice leaf cutting was reported to have positive effecting on broadcasting Thai jasmine rice yield in Ponsai district, Roi Et province but not clarify in other variety .The experiments consist of 7 Treatments, cutting lengths (0, 5, 10, 15, 20, 25 and 30 cm from the leaf tip was performed by sickle after 60 days after planting and 6 replications. The results found that tiller numbers was not significantly increased after cutting. So cutting of leaves had no significant effect on tiller number plant^{-1}.

An experiment was conducted by Fatima *et al.* (2019) to study the effect of flag leaf clipping on growth yield, and yield attributes of hybrid rice varieties in Boro season. The experiment comprised of two factors. Factor A: Flag leaf clipping: T_1 = Flag leaf clipping at heading and T_2 = Control (without clipping). Factor B: Six hybrid rice varieties: V_1 = BRRI hybrid dhan1, V_2 = BRRI hybrid dhan2, V_3 = Heera 2, V_4 = Heera 4, V_5 = Nobin and V_6 =Moyna. All the studied parameters were exhibited superiority in control treatment regardless of all these six varieties .The highest number of effective tillers hill^{-1} was found from Heera 4 under control condition.

Effect of leaf clipping at two growth stages on grain yield of rice reported that some cultivars are more tolerant to leaf clipping than others are due to their genetic variability or genetic makeup, BRRI (1986).Another observation was found that leaf clipping at PI (panicle initiation) stage had more detrimental effect than that at active tillering stage.

2.1.3 Number of non-bearing tillers hill^{-1}

Ahmed *et al.* (2001) carried out an experiment to study the effect of nitrogen rate and time of leaf cutting on green fodder as well as seed yield of rice. The experiment consist of two factors, (A) Nitrogen level – viz. i) N_1 – 50 kg N ha^{-1}, ii) N_2 –75 kg N ha^{-1} and iii) N_3 – 100 kg N ha^{-1}, (B) Time of leaf cutting – viz. i) No cutting (control) – C_0, ii) Cutting at 21 DAT – C_1, iii) Cutting at 35 DAT – C_2 and iv) Cutting at 49 DAT – C_3. Highest number of non-bearing tillers hill^{-1} was founded in no leaf cutting treatment, which was statistically minimum to leaf cutting at 49 DAT and similar was observed in leaf cutting at 21 DAT.

2.1.4 Total dry matter weight

An experiment was carried out by Ros *et al.* (2003) to determine what plant attributes conferred vigor on the seedlings and the concept of seedling vigor of transplanted rice. Previous studies suggest that the positive response of transplanted rice (*Oryza sativa* L.) to nursery fertilizer application was due to increased seedling vigour or possibly to increased nutrient content. This paper presents results of two glasshouse experiments designed to test the hypothesis that seedling vigour was responsible for the response of transplanted seedlings to nursery treatments. The aim of the present study was to explore the concept of seedling vigour of transplanted rice and to determine what plant attributes conferred vigour on the seedlings. Seedling vigour treatments were established by subjecting seedlings to short-term submergence (0, 1 and 2 days/week) in one experiment and to leaf clipping or root pruning and water stress in another to determine their effect on plant growth after transplanting. Submerging seedlings increased plant height but depressed shoot and root dry matter and root:shoot ratio of the seedling at 28 days after sowing. After transplanting these seedlings, prior submergence depressed shoot dry matter at 40 days. Nursery nutrient application increased plant height, increased root and shoot dry matter, but generally decreased root:shoot ratio. Pruning up to 60% of the roots at transplanting decreased shoot and root dry matter, P concentration in leaves at panicle initiation (PI) and straw dry matter and grain yield at maturity. By contrast, pruning 30% of leaves depressed shoot and root dry matter by 30% at PI, and root dry matter and straw and grain yield by 20% at maturity. The combined effects of leaf clipping and root pruning on shoot, root and straw dry matter were largely additive. It is concluded that the response of rice yield to nursery treatments is largely due to increased seedling vigour and can be effected by a range of nutritional as well as non-nutritional treatments of seedlings that increase seedling dry matter, nutrient content, and nutrient concentration. Impairment of leaf growth and to a lesser extent root growth in the nursery depressed seedling vigour after transplanting. However, rather than increasing stress tolerance, seedling vigour was more beneficial when post-transplant growth was not limited by nutrient or water stresses.

2.1.5 Panicle length

Rahman *et al.* (2013) conducted an experiment in order to explore the relationship between grain yield and flag leaf parameters. Length and width of the flag leaf, Yield composition and panicle length were measured in some rice cultivars. Rice cultivars BR 3, BR 4, BR 11, BRRI dhan28, BRRI dhan29, BRRI dhan34 and BRRI dhan37 were used. Flag leaf was excised at the base during heading stage from the plants and let it grow to maturity. Length of panicle and flag leaf of two rice cultivars, BR 11 and BRRI dhan28 were measured and correlation between the characters was calculated. Plants with grater flag leaf length had elongated panicle length, thus producing increased number of primary and secondary rachis resulted in increased number of grain in the panicle that ultimately improved the yield. Statistical analysis showed that the worth of correlation coefficient was 0.79 and 0.97 for BR 11 and BRRI dhan28, respectively. The flag leaves were excised after the emergence of panicle from some of the selected plants of all the examined cultivars and let it to grow. Phenotypic observation indicated various defects existed in the leaf cut plants throughout maturation where panicle length and branching were reduced. It was noticed that when flag leaf length is high the panicle length is also high. In case of BR 11 when the average FL length was 21.33, 25.90, 28.19, 37.33, 18.28, 37.84, 37.59, 25.90, 24.13 and 35.50

cm, then the average panicle length was 18.03, 18.54, 20.32, 34.98, 17.52, 33.87, 33.36, 19.85, 22.60 and 31.65 cm, respectively and in case of correlation analysis, a significant correlation was found between them. Similar significant result was found in case of BRRI dhan28. Yield was significantly and positively associated with panicle length. They also found that flag leaf length was positively associated with panicle length, thereby indicating associated with grain yield.

An experiment was conducted by Rahman *et al.* (2013) about the correlation analysis of flag leaf with yield in several cultivars. The uppermost leaf below the panicle is the flag leaf that provides the most important source of photosynthetic energy during reproduction and grain filling, thereby has great impact in panicle development and grain yield in rice. In the present investigation in order to explore the relationship between grain yield and flag leaf parameters, yield composition, length and width of the flag leaf, and panicle length were measured in some rice cultivars. Statistical analysis indicated that flag leaf length was positively correlated with panicle length for the studied cultivars demonstrating higher grain yield. Chlorophyll measurement indicated that flag leaf contained more chlorophyll than penultimate leaf. Yield of all the cultivars upon excision of flag leaf was also compared. Removal of flag leaf led to a decline in the seed-setting rate which eventually reduced the grain yield. Besides this, variable pollen viability was also noticed in the different cultivars.

Fatima *et al.* (2019) carried out an experiment to study the effect of flag leaf clipping on growth yield, and yield attributes of hybrid rice varieties in Boro season. The experiment comprised of two factors. Factor A: Flag leaf clipping: T_1 = Flag leaf clipping at heading and T_2 = Control (without clipping). Factor B: Six hybrid rice varieties: V_1 = BRRI hybrid dhan1, V_2 = BRRI hybrid dhan2, V_3 = Heera2, V_4 = Heera4, V_5 = Nobin and V_6 = Moyna. Chlorophyll content (SPAD value) in penultimate leaf after 15 days after heading, grain filling duration, yield contributing characters and yield were investigated after cutting of flag leaf. Regardless of variety, all the studied parameters were exhibited superiority in control treatment. The highest weight of 1000-grains was recorded from Heera4 under control condition.

Boonreund and Marsom (2015) carried out experiments aimed to search for the optimal length of cutting for Pathum Thani1 rice leaf for better yield. The experimental design was randomized complete block design(RCBD).Treatment was 7 cutting lengths (0,5,10,15,20,25 and 30 cm from the leaf tip was performed by sickle after 60 days after planting and 6 replications. It was conducted in a research greenhouse and field of Agricultural Technology and Agro-industry, Rajamangala University of Technology Suvarnabhumi, PhraNakhon Si Ayutthaya during November 2012to February 2013. The results showed that no effect on plant height , tiller number per plant panicle length and yield but significantly higher number of grains per panicle and 1,000 grains weight. The optimal length of rice leaf cutting was15-30 cm.

2.2 Impact of leaf clipping on yield parameters

2.2.1 Number of filled grains panicle^{-1}

Fatima *et al.* (2019) carried out an experiment to study the effect of flag leaf clipping on growth yield, and yield attributes of hybrid rice varieties in Boro season. The experiment consist of Six hybrid rice varieties (viz. BRRI Hybrid dhan1, BRRI hybrid dhan2, Heera2, Heera4, Nobin and Moyna) were used for this study. All the test varieties exhibited superiority in control condition. The tallest plant (115.2) cm was recorded from Moyna at harvest stage and higher individual flag leaf area (81.61cm^2) was observed from Heera4. Penultimate leaf area and third leaf area (78.98 cm^2 and 46.95cm^2, respectively) were obtained from BRRI hybrid dhan2. The highest number of leaves (67.33) and spikelet panicle^{-1} (219) were observed from Heera4. Among test rice varieties, higher grain yield (6.01t ha^{-1}) and biological yield (13.45 t ha^{-1}) were also observed from Heera4. Days to maturity was significantly varied from 123 (Nobin) to 145 (BRRI Hybrid dhan1) among the studied varieties. Chlorophyll content (SPAD value) in penultimate leaf after 15 days after heading, grain filling duration, yield contributing characters and yield were collected after cutting of flag leaf. Regardless of variety, all the studied parameters were exhibited superiority in compared to control treatment. Chlorophyll and nitrogen content (1.35% to 17.27%) in penultimate and grain filling duration were increased (4.5 to 6.25 days) due to clipping of flag leaf. The highest number of effective tillers hill^{-1}, filled grains panicle^{-1}, weight of 1000 grains, grain yield, straw yield, biological yield were recorded from Heera4 under control condition. The clipping of the flag leaf reduced grain yield from 15.69 % to 29.43 % in the test hybrid rice varieties

Ghosh and Sharma (1998) reported higher number of grains panicle^{-1} from early leaf cutting than late leaf cutting. The lowest value for all crop characters were observed when the leaf was cut at 35 DAT. Ahmed (2001) also showed the effect of leaf cutting was found to be significant in respect of the crop characters except 1000-grain weight. The highest value of productive tillers hill^{-1} (9.19), panicle length (23.52 cm), sterile grains (18.68) grains panicle (92.69), 1000-grain weight (22.72 81, grain yield (4.71 t ha^{-1} , straw yield (5.60 t ha^{-1}), biological yield (10.31 t ha^{-1} and harvest index (45.59%) were found in control.

Daliri *et al.* (2009) carried out a field experiment in order to study the effect of cutting time and cutting height on yield and yield components of ratoon rice (*Oryza sativa* L.) Taromlangrodi variety. Results showed that the effect of cutting time on percent filled spikelet panicle^{-1} was found statistically significant. Cutting height had a significant effect on filled spikelet panicle percentage. Interaction among cutting time and cutting height on percent filled spikelet panicle^{-1} was significant. Some agronomical traits such as numbers of effective tiller hill^{-1}, panicle number m^{-2}, total spikelet panicle^{-1}, filled spikelets percentage, 1000 grains weight, grain and biological yield and harvest index were measured. Results showed that the effect of cutting time on number of effective tiller hill^{-1}, panicle m^{-2}, percent filled spikelet panicle^{-1}, grain yield and harvest index were found statistically significant. Cutting height had a significant effect on number of tiller in hill, number of effective tiller in hill, number of panicle m^{-2}, filled spikelet panicle^{-1} percentage, grain yield and harvest index. Interaction among cutting time and cutting height on number of tiller hill^{-1}, number of effective tillers hill^{-1}, number of panicle m^{-2} percent filled spikelet panicle^{-1} were significant. According to results cutting time at physiological maturity and also cutting in 40 cm cutting height from soil surface for the best grain yield of ratoon rice were recommended.

Ali *et al.* (2017) conducted pot experiments to evaluate the impact of five different types of leaf clipping on the yield attributes of modern (Binadhan-8) and local (Terebaile) rice variety. Following leaf clipping treatments were applied for both the experiments: L_0 - Control (without leaf cutting), L_1 - Flag leaf cut, L_2- 2nd leaf cut, L_3 - 3rd leaf cut, L_4 - Both flag leaf and 2nd leaf cut and L_5 - Flag leaf with 2nd and 3rd leaves cut together. Impact of five different types of leaf clipping on the yield attributes of modern (Binadhan-8) and local (Terebaile) rice variety was evaluated on pot experiments following a completely randomized design (CRD) with three replications.

Leaves were cut according to the treatment. Data were collected on panicle length (cm), filled grain panicle-1, unfilled grain panicle^{-1}, thousand grain weight (g), grain weight panicle^{-1} (g). In Binadhan-8, flag leaf alone or flag leaf with 2nd leaf and 2nd and 3rd leaves cutting showed profound reduction in grain number panicle-1 (35.14, 62.62, and 51.83%, respectively) and grain weight panicle^{-1} (29.18, 58.37 and 48.93%, respectively) while, cutting of 2nd leaf and 3rd leaf alone exert no significant impact compared to control. Number of unfilled grain increased with higher intensity of leaf cutting. In Terebaile, only flag leaf cut showed non-significant impact on grain number panicle^{-1} and grain weight panicle-1. Profound impact was observed by cutting flag leaf with 2nd leaf (55.47 and 48.98%, respectively) and flag leaf with 2nd and 3rd leaf (58.96 and 63.13%, respectively). Leaf clipping had non-significant effect on thousand grain weight of modern variety Binadhan-8 while, it had significant effect in Terebaile.

Nagato and Chaudhry (1970) carried out several studies to understand the influence of panicle clipping, flag leaf cutting on ripening of *japonica* and *indica* rice. In the experiments of flag leaf cutting, six varieties that is, Dular, Karalath, Te-Tep, Bluebonnet (*indica*), Kinmaze and Towada (*japonica*) were used as experimental planting materials.In flag leaf cutting trial, entire flag leaf and half of the flag leaf were cut at two growth stages in the following way: (C) Control (no cut), (1) 1 cut - entire flag leaf was cut before heading, (2) ½ cut - half of the flag leaf was cut before heading, (3) 1 cut - entire flag leaf was cut at heading stage and (4) ½ cut - half of the flag leaf was cut at heading stage. In leaf cutting trial, secondary branches were influenced to a greater degree compared to primary branches. Entire leaf cutting treatment exerted greater negative influence on the ripening as compared to ½ leaf cutting treatment. In case of cutting one week before heading treatment, some of the inferior florets especially on secondary branches appeared as "White-husk”, florets which stopped growth in the early stage and appeared as white, papery structures. In this way, the number of spikelets per panicle particularly on secondary branches was decreased and the supply of carbohydrates for the remaining spikelets was increased and hence re-sulted in better ripening. Again, an increasing trend of sterile, abortive and opaque kernels were recorded in cutting before heading treatment. This increasing trend was expected to be more in the cutting after heading treatment but in reality, it was less. This was because in cutting before heading treatment, number of spikelets per panicle were decreased (which in return will result in the decrease of sterile, abortive and opaque kernels). This was true in case of Dular and Karalath in which number of spikelets per panicle especially on secondary branches decreased considerably. In case of Towada and Kinmaze, sterile, abortive and opaque kernels increased because number of spikelets per panicle on secondary branches did not decreased as much. Te-Tep and Bluebonnet behaved intermediately in reduction of number of spikelets per panicle and occurrence of sterility etc. Cutting at heading treatment showed an increase in sterile, abortive and opaque kernels. Occurrence of milky-white kernels ranges from small to large degree depending upon the variety and generally, an increasing trend was found in all the tested varieties. However, when the sterile, abortive and opaque kernels occurred abnormally as in case of secondary branches of Dular, Towada, Karalath and Te-Tep, the competition for nutrients among the spikelets was ameliorated in the remaining kernels and as a result, milky-white kernels were decreased. White-belly kernels generally increased in treated plots but in case the number of spikelets per panicle decreased and sterile, abortive and opaque kernels occur numerously in cutting before heading treatment (Dular and Bluebonnet), the competition in later stage of ripening was decreased and consequently the white-belly kernels were also decreased.

2.2.2 Number of unfilled grains panicle^{-1}

Moballeghi *et al.* (2016) conducted a field experiment in order to study the effect of source-sink limitations on agronomic traits and grain yield of different lines of rice. Treatments of source-sink limitation in four levels (including cutting of flag leaf, cutting of one third the end of panicle, cutting of other leaves except flag leaf and control or without limitation) and lines of rice in four levels (line of No. 3, line of No. 6, line of No. 7 and line of No. 8) were the treatments. Among different source sink limitation treatments, increase in unfilled grain number per panicle and decrease in panicle fertility percentage were recorded when all leaves except flag leaf removed.

Imam (1967) conducted an experiment with three varieties of rice to investigate the effects of removing of panicle bearing culms and removing photosynthesizing leaves after flowering on the fertility of different varieties. The highest percentage of sterility of spikelets was found in IR 8 following by Latishail and IR 5 when some of the panicle bearing culms were removed. Again, the highest percentage of sterility of spikelets was in IR 8 followed by IR 5 and Latishail when some of the photosynthesizing leaves were removed.

Muduli *et al.* (1995) set up a field experiment to study the effect of flag leaf on spikelet sterility and grain yield in rice. The flag leaf of semi-dwarf high yielding rice cv. IR 36, Lalat and Bhuban and the local tall cv. Khandasagar was removed at panicle emergence, 7 or 14 days later in field trials. Spikelet sterilities in the three semi-dwarf cultivars were 14.7–18.2%, 12.1–15.8% and 11.7–14.9% with flag leaf removal at 0, 7 and 14 days after panicle emergence, respectively and 10.1–12.8% where the flag leaf was not removed. The corresponding values for the local cultivar were 75.3%, 70.7%, 62.6% and 59.7%, respectively.

2.2.3. 1000-grains weight

Aktar-uz-zaman (2006) conducted an experiment to study on source-sink manipulation and their effect on grain yield in rice of rainfed varieties. There were nine treatments in source-sink manipulation: T_0 = Control, T_1 = Defoliation of flag leaf, T_2 = Defoliation of penultimate leaf, T_3 = Defoliation of tertiary leaf (Third leaf), T_4 = Defoliation of flag leaf & penultimate leaf, T_5 = Defoliation of flag leaf, penultimate leaf & tertiary leaf, T_6 = Defoliation of all leaves, T_7 = Defoliation of all leaves without flag leaf, T_8 = Removal of 50% Spikelets. Significant variation was observed for all the characters among the varieties and treatments but interaction (genotypes × treatments interactions) was not significant. Effect of source-sink manipulations on grain yield and different sink characters were analyzed. It was observed that the defoliation of flag leaf caused significant reduction on 1000-grain weight by 10.69%. Similarly, the removal of penultimate leaf caused reduction of 6.45% for 1000-grain weight. Likewise, the defoliation of third leaf caused reduction of 3.59% for 1000-grain weight. Similarly, the defoliation of flag leaf, penultimate leaf and third leaf at a time caused reduction of 15.67% for 1000-grain weight. On the other hand, there was 6.33% increase in 1000-grain weight by sink manipulation (removal of 50% spikelets).

Alejar *et al.* (1995) carried out an experiment to study the effect of source-sink imbalance on rice leaf senescence and yield. The planting materials for the experiment used were a slow senescing rice cultivar, Hankang and a rapid senescing cultivar, IR66; which were grown in waterlogged soil and at heading half the lamina of the flag, penultimate and 3^{rd} leaves were cut transversely, half of the spikelets panicle^{-1} were removed or leaves and panicles were left intact. The slow senescing Hankang gave heavier 1000-grain weights compared with that of rapid senescing IR66.

Hachiya (1989) carried out a field experiment to study on the effect of artificial leaf cutting on growth and yield of rice plants. The study revealed that compensatory response in rice growth, such as increases in the 1,000-grains weight, was observed.

2.3 Impact of leaf clipping on yield

2.3.1 Grain yield

Moballeghi *et al.* (2016) carried out a field experiment in order to study the effect of source-sink limitations on agronomic traits and grain yield of different lines of rice. Treatments of source-sink limitation in four levels (including cutting of flag leaf, cutting of one third the end of panicle, cutting of other leaves except flag leaf and control or without limitation) and lines of rice in four levels (line of No. 3, line of No. 6, line of No. 7 and line of No. 8) were the treatments. Interaction effect of two factor showed that the highest grain yield (6531 kg ha^{-1}) was obtained in line of No.7 and control treatment. The lowest grain yield (4166.3 kg ha^{-1}) was observed in line of No.6 and cutting of leaves except flag leaf.

Medhi *et al.* (2015) set up a field trial to study the effect of foliage pruning on growth and yield of two low land rice varieties, TTB-303−1-42 (Dhansiri) and TTB-303−1-23 (Difalu) under rain-fed low land situation (50–100 cm water depth) during wet season. Foliage pruning up to 100 DAG produced grain yield comparable with that of no pruning but pruning there after (120 DAG) and two times pruning (80 + 100 DAG, 100 + 120 DAG and 80 + 120 DAG) reduced grain yield. The responses of both the varieties to leaf pruning were similar.

Asli *et al.* (2011) conducted a field experiment to evaluate the sink and source relationship in different rice (*Oryza sativa* L.) cultivars. Treatments consisted of combination of three cultivars included beejar, khazar and binam and four sink and source manipulations treatments comprising: (i) control, (ii) flag leaf blade removed, (iii) thinning consisted of cutting rows 2, 4 and 6 to ground level and (iv) thinning and cutting flag leaf blade. Removal of the flag leaf blade at anthesis resulted in a decrease of 12 % in grain yield. This more considerable decrease in grain yield showed that flag leaf has an important role in grain filling. The comparison between control and defoliated plants indicated that cultivars differed in the ability to remobilize reserves from the stems to the grains. In khazar, beejar and binam cultivars, removal of flag leaf resulted in a decrease of 10%, 18% and 6.5% grain yield, respectively. The results represent the possibility of remobilization of assimilates from secondary sources to grains in khazar and binam are more than beejar. One of the reasons for more decreased yield in beejar related to other cultivars is the large flag leaf area in this cultivar as compared to others as one of the most important factors in photosynthesis rate and supply assimilate to ear from flag leaf area. There were significant effects between thinning treatments and cutting of flag leaf blade. Whenever these two treatments occurred synchronized, grain yield increased about 9%. The study of components of yield revealed that thinning and removal of flag leaf blade treatments had no significant effects on number of panicle per unit area, which is because of the time of treatments application. Cutting flag leaf resulted in decrease of grain weight by 7% and represents the importance of flag leaf supplied material for grain growth. In three cultivars of khazar, beejar and binam with removed flag leaf, grain weight decreased by 4%, 12% and 4%, respectively. In general, grains weight is more under photo-assimilate stress than number of grain.

Abou-khalifa *et al.* (2008) conducted field experiments during two summer seasons i.e. 2003 and 2004 to study the effect of leaf cutting on physiological traits and yield of two rice cultivars *viz.* hybrid rice cultivar H5 (IR 70368 A /G 178) and traditional inbred Egyptian local rice cultivar Sakha 103. The leaf cutting was followed from flag leaf as follows: i) L - Control = without leaf cutting, ii) L_1 - flag leaf cut, iii) L_2 - second leaf cut, iv) L_3 - third leaf cut, v) L_4 - both flag leaf and second leaf cut and vi) L_5 - flag leaf, second leaf and third leaf removed all together. Grain yield was severely affected by L_5, followed by L_4, L_1, L_3 and L_2 in sequence. However, as a single component affecting grain yield is the removal of flag leaf. The flag leaf contributed maximum to the yield of rice grains. In L_5, L_4, L_1, L_2 and L_3 treatments, the loss of grain yield was 59.87, 94.92, 44.89, 29.58 and 19.98 % (relative % of control) respectively. Flag leaf contributed to 45% of grain yield and it was the single most component responsible for yield loss. The contribution of leaf removal 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.

Sardana *et al.* (2006) conducted a field experiment to study the effect of extent and stage of foliage clipping on the grain yield of basmati rice (Basmati 386). The treatments were as follows: i) ⅓ of leaf clipping from top of the plant at 30 days after transplanting (DAT), ii) ½ of leaf clipping from top of the plant at 30 DAT, iii) ⅓ of leaf clipping from top of the plant at 45 DAT, iv) ½ of leaf clipping from top of the plant at 45 DAT, v) ⅓ of leaf clipping from top of the plant at 60 DAT, vi) ½ of leaf clipping from top of the plant at 60 DAT, vii) ⅓ of leaf clipping from top of the plant at 30 and 60 DAT, viii) ½ of leaf clipping from top of the plant at 30 and 60 DAT, ix) clipping of leaf just above growing point at the time of seedling transplanting and x) No leaf clipping. The extent (⅓ or ½) and stage (30, 45 or 30 and 60 DAT) of foliage clipping significantly influenced the grain yield through their marked influence on yield attributes. The maximum grain yield (2.90 t ha^{-1}) was registered in case of clipping of ⅓ foliage from the top at 30 DAT followed by clipping at the time of transplanting just above the growing point (2.50 t ha^{-1}). Grain yield linearly decreased with each successive delay in clipping from 30 to 60 DAT and the difference between 30 (2.60 t ha^{-1}) and 60 DAT (1.90 t ha^{-1}) was significant (mean of ⅓ and ½ foliage clipping). Similarly, foliage clipping only once (irrespective of the stage and extent of clipping) produced higher grain yield (1.90–2.90 t ha^{-1}) than clipping twice at 30 and 60 DAT (1.50–1.70 t ha^{-1}). Such reduction was significant as compared to clipping once at 30 (2.60 t ha^{-1}) or 45 DAT (2.30 t ha^{-1}). Similarly, foliage clipping of ⅓ portion from the top produced higher grain yield (2.20 t ha^{-1}) than clipping ½ foliage from top (2.0 t ha^{-1}). Clipping once at 60 DAT or twice at 30 and 60 DAT resulted in lower grain yield as compared to control where no foliage clipping was done. Lower yield in case of clipping made at time of transplanting of seedlings as compared to that of 30 DAT might be due to lesser ability of plants to withstand clipping shock because the seedlings at this stage were also under transplanting shock. On the other hand, foliage clipping at 45 and 60 DAT might have adversely influenced the subsequent growth and possibly took more time to recover from such shock leading to reduced grain yield. Clipping of only ⅓ of foliage from the top was found to be better than clipping to ½. It was concluded that partial foliage clipping up to ⅓ portion from top at 30 DAT has beneficial effect on traditional tall basmati rice.

Molla *et al.* (2002) conducted an experiment to ascertain the feasibility of green fodder harvest without affecting the seed yield of transplant aman rice. The experiment consists of two factors, (A) cultivar (i) C_1 = Latishail (ii) C_2 = BR 10 (iii) C_3 = BR 11 and (iv) C_4 = BRRI dhan32 and (B) leaf clipping heights (i) H_1 = clipping at 10 cm (ii) H_2 = clipping at 15 cm (iii) H_3= clipping at 20 cm and (iv) H_4 = control (no clipping). Seed yield was significantly differed due to different cultivar and leaf clipping height.

The highest value of all parameters except seed yield were obtained from control plot at all growth stage where the lowest were recorded from clipping at 10 cm height. The plants, which were clipped at 20 cm height, produced an average green fodder yield in addition to higher seed yield, which was statistically similar to control. Therefore, it is possible to get green fodder by leaf clipping without seriously affecting the rice seed yield.

Sharma and De (1994) conducted an experiment to study the effect of foliage cutting on growth and yield of different rice cultivars under semi-deep water conditions (0–80 cm). In 1990 and 1991, four rice cultivars – Utkalprabha, Panidhan, CN573-321-7−1 and Jaladhi−1 were sown in dry soil and grown thereafter under semi-deep water conditions (0–80 cm). These crops were subjected to foliage cutting at the collar of the uppermost leaf. The grain yield of CN573-321-7−1 was the highest and the effect of foliage cutting was the least pronounced; whereas Jaladhi−1 gave the lowest grain yield which further decreased significantly when foliage was removed. Cutting in September had no effect on the yield of CN573-321-7−1, Panidhan and Utkalprabha, but the later cut in October had a detrimental effect, particularly when cutting was done a second time. Nevertheless, a single late cutting in October was not found to be harmful to the yield of the tall cultivar CN573-321-7−1 and the long-duration semi-tall Panidhan. The results suggest that foliage could be harvested for feeding cattle from the long-duration, tall and photosensitive rice cultivars without any adverse effect on grain yield under semi-deep lowland conditions.

Kupkanchanakul *et al.* (1990) conducted an experiment to observe the effect of leaf cutting for rice herbage on grain yield of deep-water rice. Leaf cutting for forage at 40, 70, 100 and 40 + 100 days after emergence gave grain yields of 2.13, 2.20, 2.24 and 1.94 ton ha^{-1} respectively, compared with 2.02 ton ha^{-1} without cutting.

Rao (1991) conducted greenhouse trials to study the effects of defoliation, defoliation + shading or removal of parts of the panicle on yield and grain quality in rice cv. Tulasi and Rasi. In defoliation experiments, removal of the flag leaf had the most effect on grain yield while removal of the 4^{th} leaf had little effect on yield. Percentage high density (HD) grain was decreased the most by removing the flag leaf or removing all except the top 4 leaves. Experiments, which combined defoliation with shading of different plant organs, showed that the leaves were the most important organs governing grain filling.

Owen (1968) investigated the relation between leaf area duration and grain yield of two tropical rice varieties. Different Leaf area index (LAI) regimes during growth were imposed on two tropical rice, Sirona and HD34, by partial defoliation at different growth stages. In addition, part of the plant was completely defoliated after panicle emergence. Grain yield showed the least association with leaf area duration (treatment) after panicle emergence, but were the most influenced by leaf area duration before panicle emergence. From this observation, it was concluded that the partial removal of some leaves only before panicle emergence reduced the grain yield but the treatment did not have same effect after the panicle emergence.

2.3.2 Straw yield

Hossain (2017) carried out an experiment to assess the effect of leaf cutting on plant growth and yield of selected BRRI released Aman varieties. The experiment consisted of two factors: Factor A: five varieties, V_1 = BRRI dhan32, V_2 = BRRI dhan33, V_3 = BRRI dhan39, V_4 = BRRI dhan62 and V_5 = BRRI dhan56 and Factor B: two leaf cutting, T_1 = Leaf cutting (except flag and penultimate leaves) T_2 = Control (no leaf cutting). Irrespective of all the varieties under study, the highest straw yield was obtained in no leaf cutting (control).

2.3.3 Biological Yield

Ahmed *et al.* (2001 a) carried out a field trial to study the effect of pre-flowering leaf cutting on forage and seed yield of transplant aman rice. The possibility of extent usage of rice for human and livestock simultaneously was studied. The experiment consisted of four varieties namely Latishail, BR 10, BR 11 and BRRI dhan32 and four leaf cuttings *viz.*, no leaf cutting (T_1), leaf cutting at 21 DAT (T_2), leaf cutting at 28 DAT (T_3) and leaf cutting at 35 DAT (T_4). The results revealed that among the varieties and the different leaf cutting treatments, Latishail variety with leaf cutting at 35 DAT gave the significantly higher forage yield. The highest value of straw yield (5.60 t ha^{-1}) was found in control. The yield and yield contributing characters decreased by leaf cutting as compared to control. The lowest value for all crop characters were observed when the leaf was cut at 35 DAT. Leaf cutting at early stage (leaf cutting at 28 DAT for studied modern varieties and 35 DAT for Latishail) of crop growth could produce almost similar grain or seed yield of control crops with the additional forage yield.

Usman *et al.* (2007) conducted an experiment to study the effect of detopping on forage and grain yield of rice. The experiment consisted of six treatments viz., Control (T_1, no detopping), detopping at 22 DAT (T_2), detopping at 29 DAT (T_3), detopping at 36 DAT (T_4), detopping at 43 DAT (T_5), and detopping at 50 DAT (T_6). In respect of all the six treatments, the highest biological yield (9.6 t ha^{-1}) was obtained from control (no detopping).

2.3.4 Harvest Index

Daliri *et al.* (2009) conducted an field experiment in order to study the effect of cutting time and cutting height on yield and yield components of ratoon rice (*Oryza sativa* L.) Taromlangrodi variety. Results showed that the effect of cutting time on harvest index was found statistically significant. Cutting height had a significant effect on harvest index.

Mapfumo *et al.* (2007) conducted an experiment to study the effect of cultivar, seedling age and leaf clipping on establishment, growth and yield of pearl millet (*Pennisetumglaucum*) and sorghum (*Sorghum bicolor*) transplants. This study 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 carried out over two seasons, the 1999/2000 and 2000/2001 seasons in the southeastern 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. In case of pearl millet, clipped seedlings yielded 932 kg ha^{-1} compared to 797 kg ha^{-1} for non-clipped seedlings for cultivar PMV2 while cultivar PMV3 yielded 902 kg ha^{-1} compared to 820 kg ha^{-1} for non-clipped seedlings. In case of sorghum, 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 might enhance sorghum and pearl millet yields in the semi-arid tropics.

Páez and González (1995) conducted a study to determine the short-term interacting effects of clipping management and water stress on photosynthesis and water relations of guineagrass (*Panicum maximum* Jacq.). The experiments were conducted outdoors in pots in Maracaibo, Venezuela. After seedling emergence and establishment, plants were clipped at four frequencies and three heights for 3 mo, followed by exposure to water stress. After a stress cycle of 15 d, a group of plants was reirrigated for 21 d, to observe recovery. Photosynthesis and transpiration rates, stomatal conductance, leaf water potential, and water use efficiency (WUE) were measured. During the stress period, the most closely clipped plants had greater photosynthesis, but not increased stomatal conductance. Photosynthesis was also greater in more frequently clipped plants, and both photosynthesis and conductance were reduced by water stress. Upon rewatering, photosynthesis increased sharply. Leaf transpiration rates were not affected by clipping height or frequency during water stress. A linear decrease in WUE occurred as cutting height increased, but clipping frequency did not alter WUE. Water stress reduced leaf water potential, and this effect occurred sooner in plants clipped less frequently and to greater heights. After reirrigation, the highest photosynthesis in closely clipped plants was associated with increased stomatal conductance; leaf transpiration rate, WUE, and water potential were not altered by clipping height or frequency. Partial defoliation may relieve water stress to some degree. The increase in photosynthesis caused by close clipping is not fully related to higher stomatal conductance as previously reported, so other factors must also be involved.

Khan (2002 and 2003) and Khan and Lone (2005) reported that mustard leaves on lower layers con-tribute to the development of supra-optimal leaf area indices with accompanying self-shading and shading by other leaves within the plant axis. These shaded leave receive reduced irradiation and thus are less photo synthetically active. Earlier research has shown that removal of shaded leaves of mustard improves assimilate balance, growth and photosynthetic potential of the rest of the leaves.

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

Ali *et al.* (2008) conducted an experiment where five spring wheat varieties were utilized to study the contribution of flag leaf and awns on grain yield and its attributes. The characters associated with the photosynthetic activity were examined in relation to the grain yield and its attributes. The study revealed significant variation among different varieties, treatments and varieties × treatment. The treatments (removal of flag leaf, awns & both) caused considerable reduction in grain yield and its related characters. Removal of flag leaf had less effect on yield and related components than awns detachment. Nonetheless the detachment of flag leaf + awns revealed greater 10 effects than individual treatment. Flag leaf area, awn length, number of grains spike^{-1} and 1000 grain weight demonstrated positive and significant association with grain yield plant^{-1} . Number of grains spike^{-1} , grain weight spike^{-1} and 1000 grain weight exhibited the maximum heritability and genetic advance over different treatments. The study investigated the presence of strong source-sink association of both flag leaf and awns with grain yield hence these traits could be used as morphological markers for selection of wheat genotypes having superior photosynthetic activity and higher grain yield.

Davidson (1965) stated that the effects on variety olympic wheat of maintaining the leaf area index (LAI), once attained, at approximately 3 and 1, and of removing whole leaves or half of each leaf at ear emergence, were assessed by comparison with an uncut crop (maximum LAI= 12). Leaf clipping at ear emergence had no significant impact on grain yield. Leaf area maintenance at LAI values of 3 and 1 greatly reduced grain yield by decreasing both grain number spike-1 and mean grain weight by about 50%. These effects followed earlier reductions in the rate of development of the shoot 11 apex. The results were discussed in relation to the yields obtained and conclusions reached by English workers, and to possible scope for yield improvement.

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

Hamzi *et al.* (2018) carried out a field experiment to study the relationship between sink and source in corn plants, experiment was conducted as a factorial experiment in a Randomized Complete Block Design with three replications. A total of 3 cultivars (301, 604 and 700) and four leaf clippings (without leaf clipping, ear leaf clipping, above ear leaf clipping, and below ear leaf clipping) were used during 2007 crop season. Results showed that oil, grain yield, globulin, glutamine, and carbohydrates were different among cultivars and treatment compositions. Leaf clipping did not affect oil, globulin and carbohydrates but yield and other quality traits were influenced by leaf clipping. Ear leaf clipping and below ear leaf defoliation were ranked second for yield production. The lowest yield was observed in above ear leaf clipping treatment. Overall, all leaf clipping treatments produced similar amounts of oil, globulin and carbohydrates. The highest glutamine was obtained in above ear leaf clipping that was similar with ear leaf clipping treatment. Control treatment had the 12 lowest glutamine similar to ear leaf clipping and below ear leaf clipping treatments. Above ear leaf clipping strongly increased grain prolamine and albumin. The lowest prolamine was obtained from below ear leaf clipping and without leaf clipping treatments. But the minimum grain albumin was belonged to ear leaf clipping. Leaf clipping treatments were ranked in four different groups with aspect to grain albumin concentration whereas control and below leaf clipping treatments had no difference in grain prolamine.

Khalifa *et al.* (2008) impemented several field experiments during two summer seasons of 2003 and 2004 to study the effect of leaf cutting on physiological traits and yield of two rice cultivars hybrid (H5) (IR 70368 A /G 178) and inbred rice. The leaf cutting was followed from flag leaf as follows: 1.) L; Control = without leaf cutting, 2.) L1;

flag leaf cut, 3.) L2; second leaf cut, 4.) L3; third leaf cut, 5.) L4; both flag leaf and second leaf cut. 6.) L5; flag leaf, second leaf and third leaf cut together. A split plot design with four replications was used; the main plots were devoted to the cutting of leaves, while the sub-plots were assigned to the two rice cultivars. Chlorophyll, sugar, starch and grain yield parameters were severely affected by L5, followed by L4, L1, L3 and L2 in sequence. However, as a single component affecting maximum to these parameters is the removal of flag leaf. The flag leaf contributed maximum to the yield of rice grains. L5, L4, L1, L2 and L3 treatments grain yield (relative % of control) by 59.87, 94.92, 44.89, 29.58 and 19.98 % respectively. Flag leaf contributed to 45% of grain yield and is the single most component for yield loss. The contribution of removal of leaf in hybrid rice was minimum, suggesting the probability of maximum translocation of photosynthesis from stem to the grain during grain feeling stage of hybrid rice after leaf removal.

Mahmood and Chowdhury (1997) conducted some studies to investigate the impact of the removal of green photosynthetic structures including flag leaf, 3rd nodal leaf and awns, on yield and some yield related parameters in two local wheat cultivars (Pasban 90 and Inqalab 91). The experiment was conducted in a triplicated randomized complete block design in split-plot fashion. The two varieties differed significantly for flag leaf area, 3^{rd} nodal leaf area, seed set percentage, grains per spike and grain weight per spike. Effect of removing flag leaf (T_2), 3^{rd} 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.

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

CHAPTER III

MATERIALS AND METHODS

The experiment was undertaken during March 2019 to July 2019 to study the growth and yield of transplanted aus rice as influenced by leaf clipping. The materials used and the methodologies followed are described in this chapter.

3.1. Experimental Site

The present experiment was conducted in the Agronomy field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is 23074/N latitude and 90035/E longitude and at an elevation of 8.2 m from sea level.

3.2 Soil of the experimental field

Soil of the experimental site was silty clay loam in texture belonging to Tejgaon series (Anon., 1988 a). The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) with pH 5.8–6.5, ECE-25–28 (Anon., 1988 b) Appendix I. The analytical data of the soil sample collected from the experimental area were analyzed in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix II.

3.3 Climate

The experimental area was under the subtropical climate and was characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds during the period from March to August, but scanty rainfall associated with moderately low temperature prevailed during the period from March to August .The detailed meteorological data in respect of air temperature, relative humidity, rainfall and sunshine hour recorded by the meteorology centre, Dhaka for the period of experimentation have been presented in Appendix III.

3.4 Plant materials and features

The improved variety of rice cv. BRRI dhan48 was used as planting material for the present study. The variety is recommended for *aus* season. It is modern transplanted *aus* rice released by BRRI in 2008 (BRRI, 2008). The feature of the variety is presented below:

Name of Variety : BRRI dhan48

Height : 102-105 cm

Maturity : 105-110 days

Number of Grains panicle^{-1} : 130-160

1000 grains weight : 25-28 g

Yield : 4.98 t ha^{-1}

3.5 Experimental details

Sowing Date **:** 5 March, 2019

Transplanting Date **:** 1 April, 2019

Harvesting Date **:** 25 June, 2019

Fertilizer Applied **:** Urea, TSP, MoP, Gypsum and Zinc sulphate

Spacing **:** 25 cm × 20 cm

3.6 Experimental treatments

The experiment consisted of two factors as mentioned below:

Factor A: Seedling clipping (3)

S_0 – No seedling clipping (Control)

S_1 – 1/3rd height clipping and

S_2 – 1/2nd height clipping.

Factor B: Leaf clipping before panicle emergence (4)

L_0 – No leaf clipping (Control),

L_1 – Lower 1st + 2nd leaves clipping,

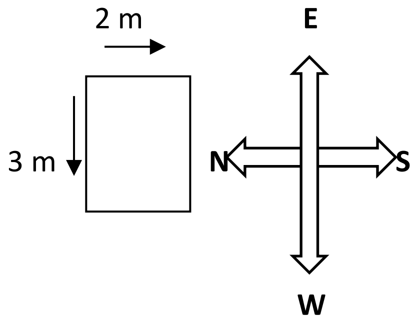
L_2 – Lower 2nd + 3rd leaves clipping

L_3 – Lower 3rd + 4th leaves clipping and

L_4 – Flag leaf clipping.

3.6.2 Experimental design and layout

The experiment was laid out in Randomized Complete Block design (RCBD) with three replications. The size of the individual plot was 4.0 m × 2.5 m and total numbers of plots were 45. There were 15 treatment combinations. Lay out of the experiment was done on 20 March, 2019 with inter plot spacing of 0.25 m and inter block spacing of 1.0 m (Figure 1).



R_1	R_2	R_3
S_1L_3	S_2L_3	S_1L_4
S_0L_3	S_2L_2	S_0L_0
S_1L_0	S_0L_3	S_2L_1
S_1L_1	S_0L_2	S_0L_2
S_2L_0	S_0L_4	S_1L_2
S_2L_4	S_0L_0	S_0L_1
S_1L_4	S_1L_2	S_1L_0
S_2L_3	S_1L_0	S_0L_3
S_2L_1	S_2L_0	S_1L_1
S_1L_2	S_1L_1	S_2L_4
S_0L_1	S_0L_1	S_2L_3
S_0L_4	S_1L_3	S_0L_4
S_0L_0	S_2L_4	S_2L_0
S_0L_2	S_2L_1	S_2L_2
S_2L_2	S_1L_4	S_1L_3

3.7 Cultivation procedure

3.7.1 Growing of Crop

3.7.1.1 Plant materials collection

Healthy and vigorous seeds of *aus* rice cv. BRRI dhan48 was collected from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur. The seeds were collected just 20 days ahead of the sowing of seeds in seedbed.

3.7.1.2 Seed sprouting

Healthy seeds were selected by specific gravity method. Seeds were then immersed in water in bucket for 24 hours. Then seeds were taken out of water and kept thickly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours.

3.7.1.3 Seed bed preparation and seedling raising

A piece of high land was selected in the Agronomy Field Laboratory, Sher-e-Bangla Agricultural University, Dhaka for raising seedlings. The land was puddled well with country plough followed by levelling with a ladder. Seed were sown in the seedbed @ 70 g m^{-2} on 1 March 2019. Proper care was taken to raise the healthy seedlings in the nursery bed. Weeds were removed and irrigation was given in the nursery bed as and when necessary.

3.7.1.4 Final land preparation

The land was first opened with a tractor drawn disc plough on 27 March 2019. The land was then puddled thoroughly by repeated ploughing and cross ploughing with a country plough and subsequently levelled by laddering. The field layout was made on 20March 2019 according to experimental specification immediately after final land preparation. Weeds and stubbles were cleared off from individual plots and finally plots were levelled properly by wooden plank so that no water pocket could remain in the field.

3.7.1.5 Fertilizer application

The following doses of manure and fertilizers (BRRI, 2008) were used.

Urea	: 120 kgha^{-1}
TSP	: 70 kgha^{-1}
MoP	: 50 kgha^{-1}
Gypsum	: 40 kgha^{-1}
Zinc	: 10 kgha^{-1}

Whole amount of TSP, MoP, Gypsum and Zinc and one third of urea were applied at the time of final land preparation. Half of the rest two third of urea was applied at 20 DAT and the rest amount of urea was applied at 40 DAT.

3.7.1.6 Uprooting of seedlings

The seedbed was made wet by application of water in the morning and evening on the previous day before uprooting. The seedlings were uprooted without causing any mechanical injury to the roots and were kept in the soft mud in shade. The age of seedling on the day of uprooting was 26 days.

3.7.1.7 Transplanting

35 days older rice seedlings were transplanted on 1 April, 2019 in 45 experimental plots which were puddled further with spade on the day of transplanting. Transplanting was done by using two seedlings hill^{-1} with 25 cm × 20 cm spacing between the rows and hills, respectively.

3.7.2 Intercultural operation

3.7.2.1 Gap filling

Seedlings in some hills were died off and those were replaced by healthy seedling within 10 days of transplantation.

3.7.2.2 Weeding

First weeding was done from each plot at 15 DAT and second weeding was done from each plot at 30 DAT. Mainly hand weeding was done from each plot.

3.7.2.3 Irrigation and drainage

Flood irrigation was given to respective plots to maintain a constant level of moisture into the soil to enhance tillering. The field was finally dried out at 15 days before harvesting. Proper drainage channels were made to drain out theexcess water from the field.

3.7.2.4 Herbicide application

Spraying were done by a hand crop sprayer (model - AM S021, capacity - 20 Litre, Brand name- AGROS, Made in- Zhejiang, China, Working Pressure: 0.2–0.3 Mpa) at 5 days after transplanting.

3.7.2.5 Plant protection measures

The crop was attacked by yellow rice stem borer (*Scirpopagaincertulas*) at the panicle initiation stage which was successfully controlled with Sumithion @ 1.5 L ha^{-1}. Yet to keep the crop growth in normal, Basudin was applied at tillering stage @ 17 kg ha^{-1} while Diazinon 60 EC @ 850 ml ha^{-1}were applied to control rice bug.

3.7.2.6 General observations of the experimental field

Regular observations were made to see the growth stages of the crop. In general, the field looked nice with normal green plants, which were vigorous and luxuriant in the treatment plots than that of control plots.

3.8 Harvesting, threshing and cleaning

The rice plant was harvested depending upon the maturity of grains and harvesting was done manually from each plot. Maturity of crop was determined when 80–90% of the grains become golden yellow in colour. Three (3) pre-selected hills per plot from which different data were collected and 1.00 m^2 areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor. Enough care was taken for harvesting, threshing and cleaning of rice seed.

Fresh weight of grain and straw were recorded plot wise. Finally, the grain weight was adjusted to a moisture content of 13%. The straw was sun dried and the yields of grain and straw $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.9 Recording of plant data

The growth and yield parameters were taken at harvest from pre-demarcated area.

3.9.1 Crop growth parameters

a) Plant height (cm)
b) Effective tillers hill^{-1} (no.)
c) Non-effective tillers hill^{-1} (no.)
d) Above ground dry mater weight hill^{-1} (g)

3.9.2 Yield contributing parameters

a) Panicle length (cm)
b) Filled grains panicle^{-1} (no.)
c) Unfilled grains panicle^{-1} (no.)
d) Weight of 1000-grains (g)

3.9.3 Yield parameters

a) Grain yield (t ha^{-1})
b) Straw yield (t ha^{-1})
c) Biological yield (t ha^{-1})
d) Harvest index (%)

3.10 Procedure of recording data

3.10.1 Plant height (cm)

The height of plant was measured at the time harvest for all the entries on 5 randomly selected plants from the middle rows. The height was measured from the base of the plant to the tip of the longest leaf or tip of the longest ear head, whichever was longer and the average was recorded in centimetres.

3.10.2 Number of leaves hill^{-1}

The number of leaves hill^{-1} was recorded at 20, 40 and 60 DAS by counting total number of leaves as the average of same 3 hills pre selected at random from the inner rows of each plot.

3.10.3 Dry matter weight hill^{-1} (g)

Total above ground dry matter hill-1 was recorded at the time of 20, 40, 60 DAS and at harvest by drying plant sample. Data were recorded as the average of 3 sample hill plot^{-1} selected at random from the outer rows of each plot leaving the boarder line and expressed in gram.

3.10.4 Effective tillers hill^{-1}

The total number of effective tillers hill^{-1} was counted as the number of panicle bearing tillers hill^{-1}. Data on effective tiller hill^{-1} were recorded from 3 randomly selected hill at harvesting time and average value was recorded.

3.10.5 Non-effective tillers hill^{-1}

The total number of non-effective tillers hill^{-1} was counted as the number of non panicle bearing tillers plant^{-1}. Data on non-effective tiller hill^{-1} were counted from 3 selected hills at harvest and average value was recorded.

3.10.6 Length of panicle

The length of panicle was measured with a meter scale from 3 selected panicles and the average value was recorded.

3.10.7 Filled grains panicle^{-1}

The total number of filled grains was collected randomly from selected 3 plants of a plot and then average number of filled grains panicle^{-1} was recorded.

3.10.8 Unfilled grains panicle^{-1}

The total number of unfilled grains was collected randomly from selected 3 plants of a plot and then average number of unfilled grains panicle^{-1} was recorded.

3.10.9 Total grains panicle^{-1}

The total number of grains was calculated by adding filled and unfilled grains and then average number of grains panicle^{-1} was recorded.

3.10.10 Weight of 1000 grains

One thousand seeds were counted randomly from the total cleaned harvested seeds of each individual plot and then weighed in grams and recorded.

3.10.11 Grain yield

Final grain yield was adjusted at 13% moisture. The grain yield t ha^{-1} was measured by the following formula:

$$\text{Grain yield (t ha}^{-1}\text{)} = \frac{\text{Grain yield per unit plot (kg)} \times 10000}{\text{Area of unit plot in square meter} \times 1000}$$

3.10.12 Straw yield (t ha^{-1})

The straw yield t ha^{-1} was measured by the following formula:

$$\text{Straw yield (t ha}^{-1}\text{)} = \frac{\text{Straw yield per unit plot (kg)} \times 10000}{\text{Area of unit plot in square meter} \times 1000}$$

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

Grain yield together with straw yield was regarded as biological yield and calculated with the following formula:

$$\text{Biological yield (t ha}^{-1}\text{)} = \text{Grain yield (t ha}^{-1}\text{)} + \text{Straw yield (t ha}^{-1}\text{)}$$

3.10.12 Harvest Index (%)

Harvest Index denotes the ratio of economic yield to biological yield and was calculated with the following formula:

$$\text{Harvest Index (\%)} = \frac{\text{Economic Yield (Grain weight)}}{\text{Biological Yield (Total dry weight)}} \times 100$$

3.10.13 Statistical Analysis

The recorded data were compiled and subjected to statistical analysis. Analysis of variance was done following STATISTIX 10 software. The mean differences were adjudged by Least Significant Difference (LSD) at 5% levels of probability.

CHAPTER IV

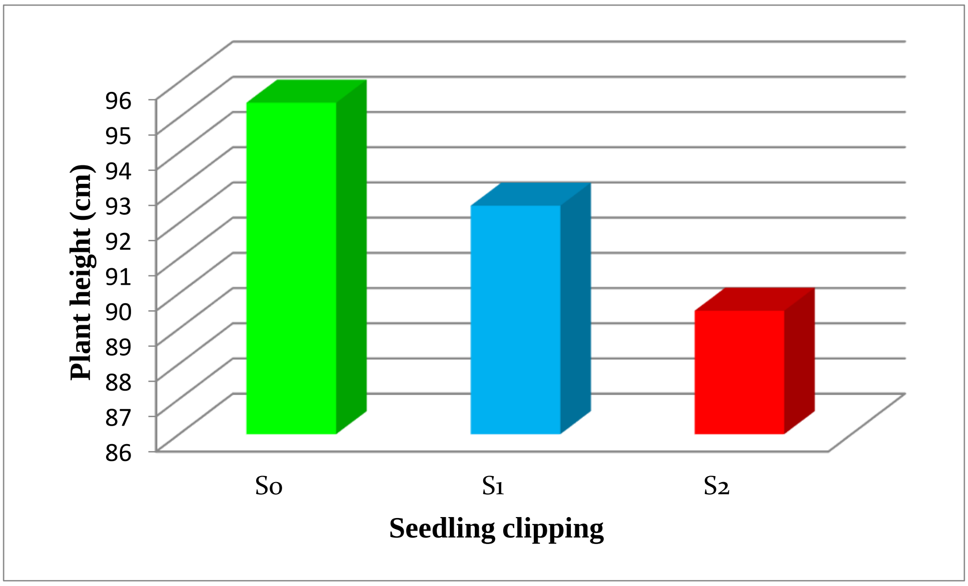
RESULTS AND DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter with a view to study the growth and yield of aus rice variety as influenced by seedling and leaf clipping. The data are given in different tables and figures. The results have been discussed, and possible interpretations are given under the following headings.

4.1 Plant height (cm)

4.1.1 Effect of seedling clipping

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its approach. Seedling clipping of Aus rice (At harvest) showed significant effect on plant height (Fig 2). From this experiment, result revealed that maximum plant height (95.41 cm) was observed from S_0 treatment which was statistically similar (92.49 cm) with S_1 treatment whereas minimum plant height (89.51 cm) was observed from S_2 treatment. Boonreund and Marsom (2015) reported that cutting of seedling had no significant effect on plant height.

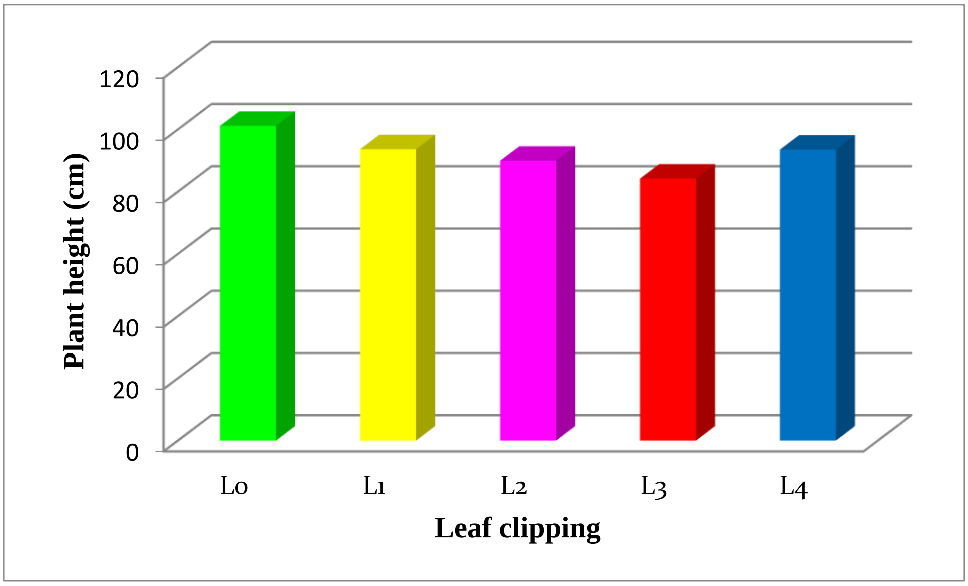


S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping

Figure 2: Effect of seedling clipping on plant height (cm) of aus rice at harvest ($LSD_{0.05}$=3.82)

4.1.2 Effect of leaf clipping

Leaf clipping showed significant effect on plant height (at harvest) of aus rice. From this experiment, result revealed that maximum plant height (101.13 cm) was observed from L_0 treatment whereas minimum plant height (84.18 cm) was observed from L_3 treatment. Similar result was found in Medhi *et al.* (2015) and Ahmed *et al.* (2001 b). Hossain (2017) and Molla *et al.* (2002) reported that the maximum plant height was obtained in no leaf cutting (control treatment). Sardana *et al.* (2006) also found the extent (one-third or ½) and stage (30, 45 or 30 and 60 days after transplanting) of foliage clipping significantly influenced the plant height of Basmati 386 rice variety.



L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

Figure 3: Effect of leaf clipping on plant height (cm) of aus rice at harvest ($LSD_{0.05}$=4.94)

4.1.3 Combined effect of seedling clipping and leaf clipping

Combined effect of seedling and leaf clipping showed significant variations on plant height (At harvest) of Aus rice. From this experiment, result revealed that maximum plant height (110.17 cm) was observed from the treatment combination of S_0L_0 whereas minimum plant height (80.75 cm) was observed from S_2L_3 treatment combination which was statistically similar with S_1L_3 (84.72 cm) treatment combination followed by S_0L_3 (87.07 cm) and S_2L_3 (80.75 cm) treatment combination.

Table 1 : Combined effect of height manipulation and leaf clipping on plant height (cm) of aus rice at harvest

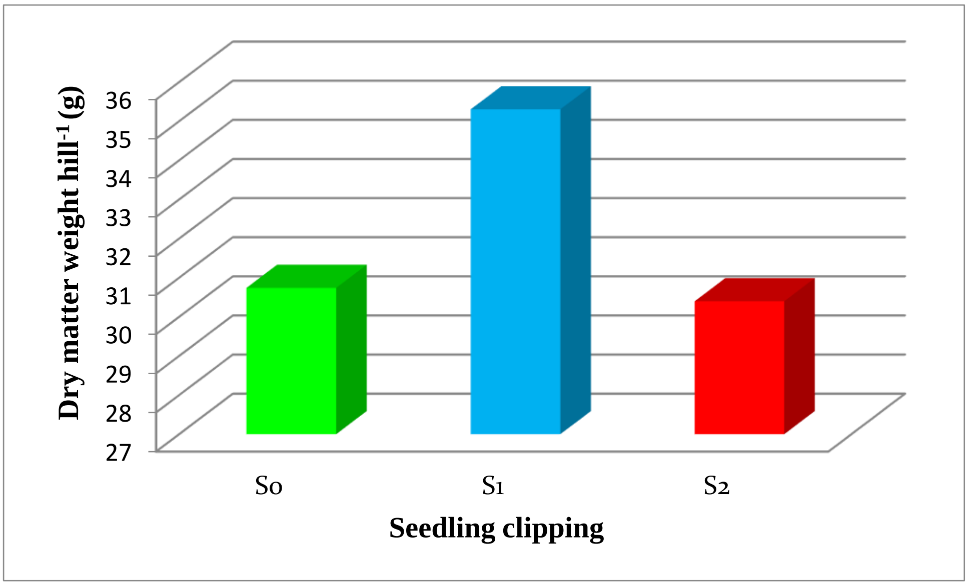
Treatment combinations	Plant height (cm)
S_0L_0	110.17a
S_0L_1	94.61b-d
S_0L_2	90.20b-e
S_0L_3	87.07d-f
S_0L_4	95.02b-d
S_1L_0	97.01b
S_1L_1	93.00b-e
S_1L_2	91.80b-e
S_1L_3	84.72ef
S_1L_4	95.91bc
S_2L_0	96.20bc
S_2L_1	93.26b-e
S_2L_2	87.75c-f
S_2L_3	80.75f
S_2L_4	89.57b-e
$LSD_{(0.05)}$	8.563
CV(%)	5.54

S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

4.2 Above ground dry matter weight hill^{-1} (g)

4.2.1 Effect of seedling clipping

Significant variation was found in above ground dry matter hill^{-1} (g) due to the seedling clipping in the *aus* rice field. The maximum dry matter (35.304 g) hill^{-1} was recorded from 1/3rd seedling clipping (S_1) treatment. On the other hand, the minimum dry matter (30.398 g) hill^{-1} was obtained from 1/2nd seedling clipping (S_2) treatment. Ros *et al.* (2003) conducted an experiment to explore the concept of seedling vigor of transplanted rice and to determine what plant attributes conferred vigor on the seedlings. He was shown that the combined effects of leaf dipping and root pruning on shoot, root and straw dry matter were largely additive. It was concluded that the response of rice yield to nursery treatments is largely due to increased seedling vigor and can be effected by a range of nutritional as well as non-nutritional treatments of seedlings that increase seedling dry matter, nutrient content and nutrient concentration. Impairment of leaf growth and to a lesser extent root growth in the nursery depressed seedling vigor after transplanting. However, rather than increasing stress tolerance, seedling vigor was more beneficial when post-transplant growth was not limited by nutrient or water stresses.

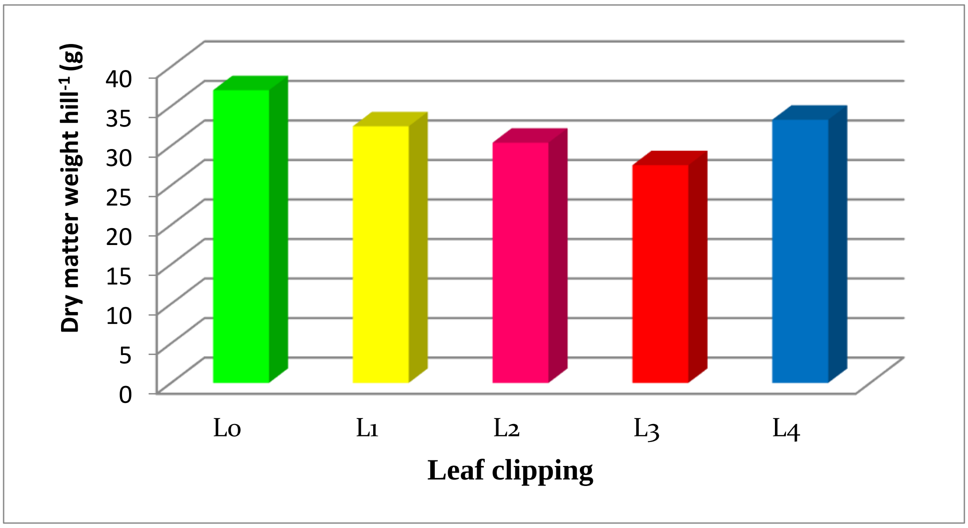


S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping

Figure 4: Effect of seedling clipping on dry matter weight hill^{-1} of aus rice at harvest ($LSD_{0.05}$=1.41)

4.2.2 Effect of leaf clipping

The leaf clipping had significant effect on dry matter hill^{-1} in aus rice field. No leaf clipping (L_0) produced maximum dry matter (37.027 g) hill^{-1}. On the other hand, the lower 3+4 (L_3) produced minimum dry matter (27.550 g) hill^{-1}



L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

Figure 5: Effect of leaf clipping on dry matter weight hill^{-1} of aus rice at harvest ($LSD_{0.05}$=1.83)

4.2.3 Combined effect of seedling clipping and leaf clipping

Significant variation was found in dry matter hill^{-1} (g) due to the seedling clipping with leaf clipping in the *aus* rice field. The maximum dry matter (43.360 g) hill^{-1} was recorded from the combined effect of 1/3rd seedling clipping with no leaf clipping (S_1L_0) treatment. On the other hand, the minimum dry matter (26.740 g) hill^{-1} was obtained from the combination of 1/2nd seedling clipping with lower 3+4 leaves clipping (S_2L_3) treatment.

Table 2: Combined effect of seedling clipping and leaf clipping on dry matter hill^{-1} of aus rice at harvest

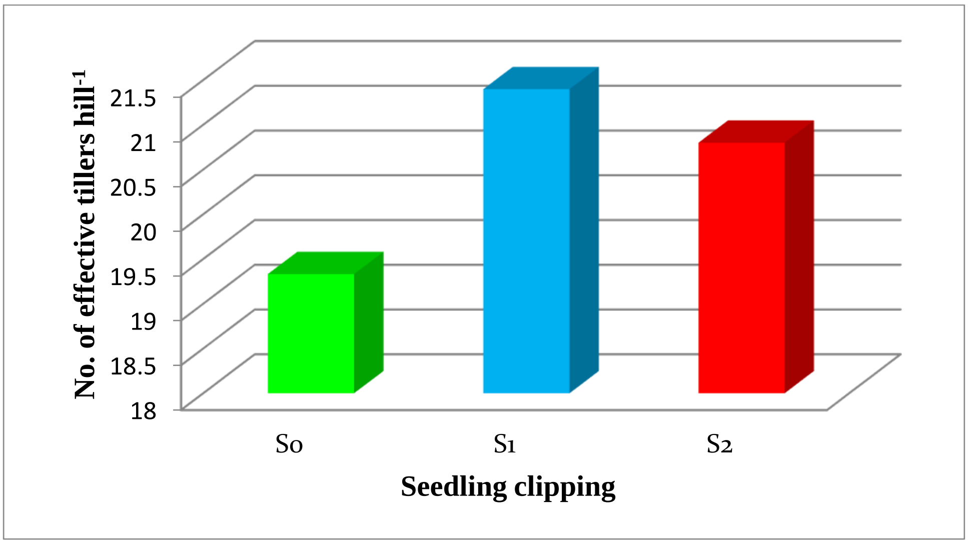
Treatment Combinations	Dry mater weight hill^{-1} (g)
S_0L_0	34.310bc
S_0L_1	30.440d-f
S_0L_2	29.970e-g
S_0L_3	26.740h
S_0L_4	32.240c-e
S_1L_0	43.360a
S_1L_1	36.770b
S_1L_2	32.330c-e
S_1L_3	28.800f-h
S_1L_4	35.260bc
S_2L_0	33.410cd
S_2L_1	30.200e-g
S_2L_2	28.880f-h
S_2L_3	27.110gh
S_2L_4	32.390c-e
$LSD_{(0.05)}$	3.1650
CV(%)	5.89

S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

4.3 Number of effective tillers hill^{-1}

4.3.1 Effect of seedling clipping

Productive tillers unit area^{-1} determined the final yield of rice. The number of effective tillers hill^{-1} was significantly influenced by seedling clipping in *aus* rice (Figure 6 and Appendix IV). 1/3rdheight seedling clipping (S_1) gave the highest effective tiller (23.42) and no seedling clipping (S_0) treatment in the field gave the lowest effective tiller (16.73).

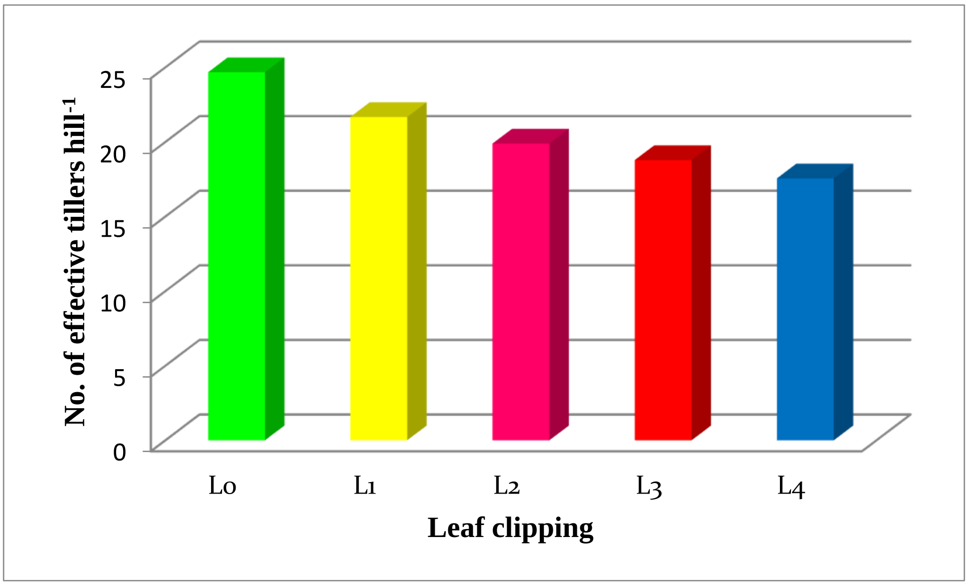


S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping

Figure 6: Effect of seedling clipping on number of effective tillers hill^{-1} of aus rice at harvest ($LSD_{0.05}$=0.87)

4.3.2 Effect of leaf clipping

Leaf clipping had significant effect on numbers of effective tillers hill^{-1} (Figure 7 and Appendix IV). No leaf clipping (L_0) produced higher number (24.667) and flag leaf clipping (L_4) produced lower number (17.553) of productive tiller. Similar results were observed by Daliri *et al.* (2009), Ahmed *et al.* (2001 a) and Ahmed *et al.* (2001 b). The same result was reported by Hossain (2017). He found the highest numbers of tillers hill^{-1} was obtained from no leaf cutting (control). Tiller numbers was not significantly increased after cutting. Molla *et al.* (2002) found that number of tillers hill^{-1} was significantly differed due to different cultivar and leaf clipping height. The highest number of tillers hill^{-1} was obtained from control plot at all growth stage whereas the lowest was recorded from clipping at 10 cm height. On the other hand, the dissimilar result was reported by Boonreund and Marsom (2015). He found that cutting of leaves had no significant effect on tiller number plant^{-1}. Hachiya (1989) also found the dissimilar result and observed increases in the percentages of productive tillers in response to artificial leaf cutting.



L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

Figure 7: Effect of leaf clipping on number of effective tillers hill^{-1} of aus rice at harvest ($LSD_{0.05}$=1.13).

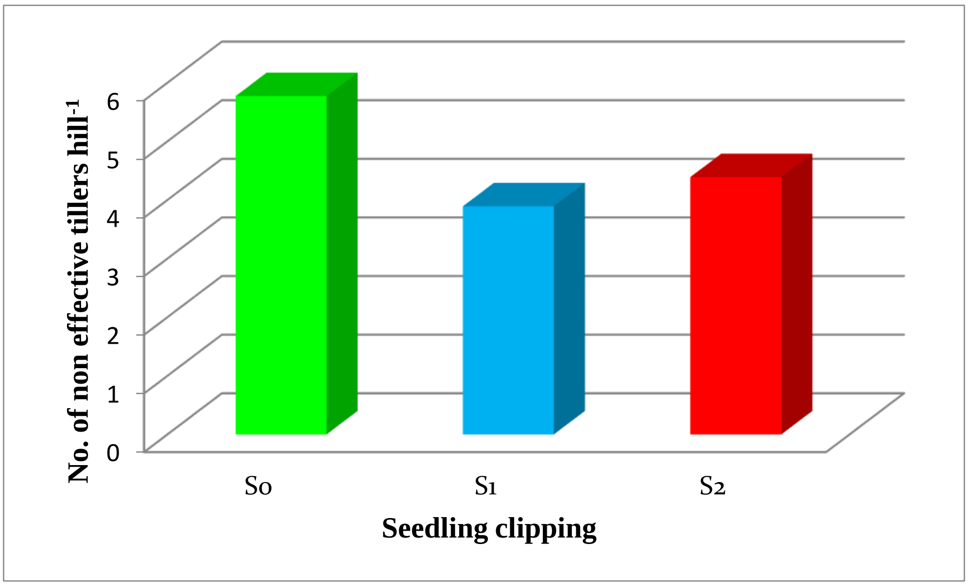
4.3.3 Combined effect of seedling clipping and leaf clipping

Effective tiller hill^{-1} was significantly affected by the interaction of seedling clipping with leaf clipping (Table 3 and Appendix IV). The highest effective tiller (27.69) was obtained from the combination of 1/3rd seedling clipping with no leaf clipping (S_1L_0) treatment. The second highest effective tiller (24.33) was obtained from the combination of Control (no clipping) with no leaf clipping (S_0L_0) treatment which was statistically similar (24.) to 1/2nd seedling clipping with no leaf clipping (S_2L_0) treatment. On the other hand, the lowest effective tiller (16) was found from the combination of no seedlling clipping with flag leaf clipping (S_0L_4) treatment.

4.4 Number of non-effective tillers hill^{-1}

4.4.1 Effect of seedling clipping

The number of non-effective tillers hill^{-1} varied significantly due to the seedling clipping in *aus* rice (Figure 8 and Appendix IV). The maximum number of non-effective tillers hill^{-1} (5.772) was obtained from no seedling clipping (S_0) treatment. The minimum number of non-effective tillers hill^{-1} (3.892) was obtained from 1/3rd seedling clipping (S_1) treatment. Seedling clipping facilitated the crop for absorption of greater amount plant nutrient, moisture and solar radiation for growth, perhaps lower plant competition among leaves resulted in lower number of non-effective tillers hill^{-1}.

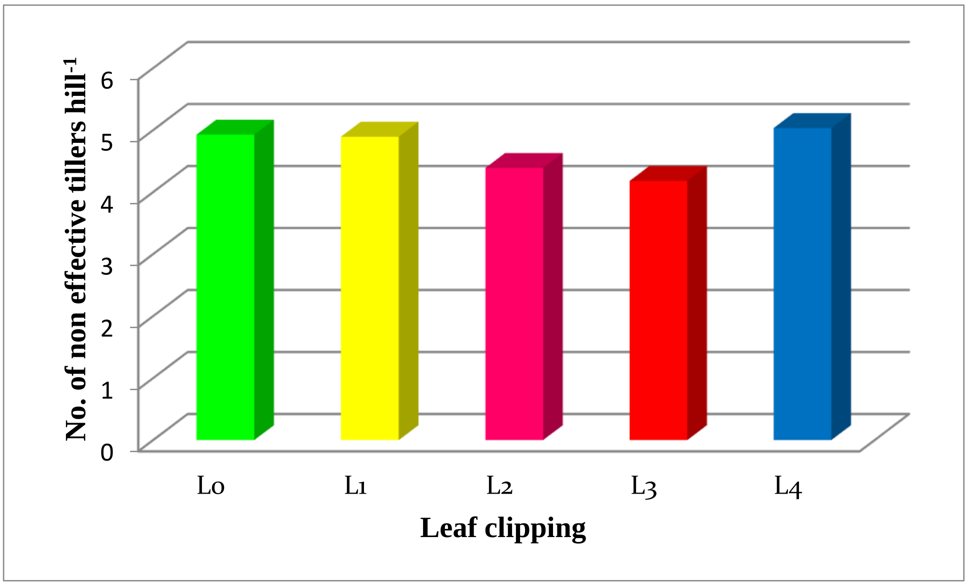


S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2= 1/2nd height clipping

Figure 8: Effect of seedling clipping on number of non-effective tillers hill^{-1} of aus rice at harvest ($LSD_{0.05}$=0.28).

4.4.2 Effect of leaf clipping

It was evident from that leaf clipping had significant effect on numbers of non-effective tiller hill^{-1} (Figure 9 and Appendix IV). Flag leaf clipping (L_4) produced higher number (5.03) which was statistically similar(4.92) with no leaf clipping (L_0) followed by (4.89) Lower 1+2 leaves clipping (L_1) and Lower 3+4 leaves clipping (L_3) produced lower number (4.18) of productive tiller which was statistically similar(4.39) with Lower 2 +3 leaves clipping(L_2). The dissimilar result was recorded in Ahmed *et al.* (2001 b) who that the maximum number of non-bearing tillers hill^{-1} was recorded from no leaf cutting treatment.



L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

Figure 9: Effect of leaf clipping on number of non-effective tillers hill^{-1} of aus rice at harvest ($LSD_{0.05}$=0.35)

4.4.3 Combined effect of seedling clipping and leaf clipping

Non-effective tiller hill^{-1} was significantly affected by the interaction of seedling clipping and leaf clipping treatment (Table 3 and Appendix IV). The highest non-effective tiller (6.99) was obtained from the combination of no seedling clipping with flag leaf clipping (S_0L_4) treatment. The lowest (3.12) was found from the combination of 1/3rd seedling clipping with no leaf clipping (S_1L_0) treatment which was statistically similar with S_2L_3 (3.420), and S_2L_4 (3.68) treatment.

Table 3: Combined effect of seedling clipping and leaf clipping on no. of effective tillers hill^{-1} and no. of non-effective tillers hill^{-1} of aus rice at harvest

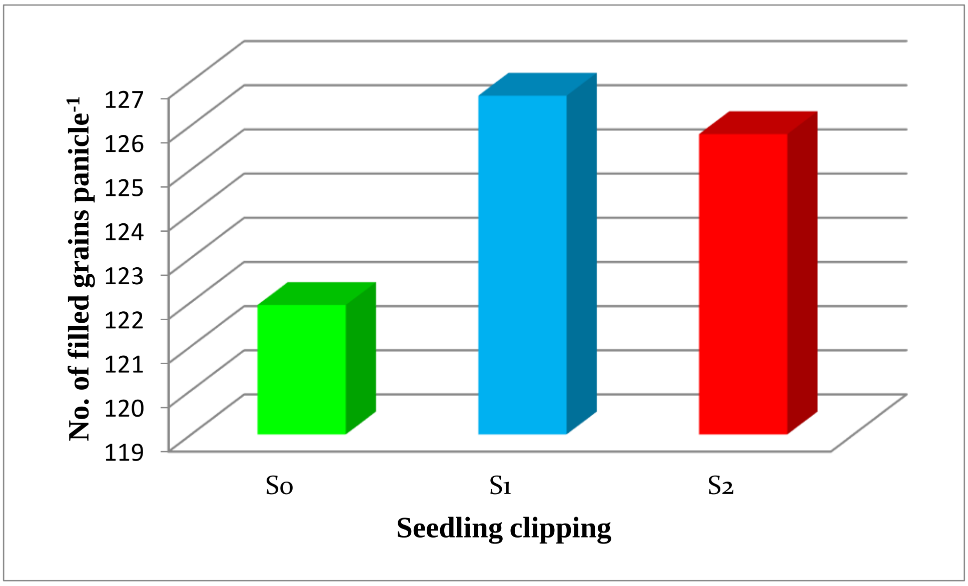
Treatment Combinations	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)
S_0L_0	24.330ab	6.0300b
S_0L_1	19.670ef	5.8100b
S_0L_2	19.330ef	5.0300cd
S_0L_3	17.330gh	5.0000d
S_0L_4	16.000h	6.9900a
S_1L_0	25.670a	3.1200h
S_1L_1	23.330bc	3.8700e-g
S_1L_2	20.330de	3.9200e-g
S_1L_3	19.330ef	4.1200ef
S_1L_4	18.330fg	4.4300de
S_2L_0	24.000ab	5.6300bc
S_2L_1	22.000cd	5.0000d
S_2L_2	20.000ef	4.2200ef
S_2L_3	19.670ef	3.4200gh
S_2L_4	18.330fg	3.6800f-h
$LSD_{(0.05)}$	1.959	0.622
CV(%)	5.71	7.93

S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

4.5 Number of filled grains panicle^{-1}

4.5.1 Effect of seedling clipping

Significant variation was found in filled grains panicle^{-1} due to the seedling clipping in the *aus* rice field (Figure 10 and Appendix IV). The maximum number of filled grains panicle^{-1} (126.67) was recorded from 1/3rd seedling clipping (S_1) treatment which was statistically similar(125.80) with 1/2nd seedling clipping (S_2) treatment and the minimum (121.93) was obtained from no seedling clipping (S_0) treatment.

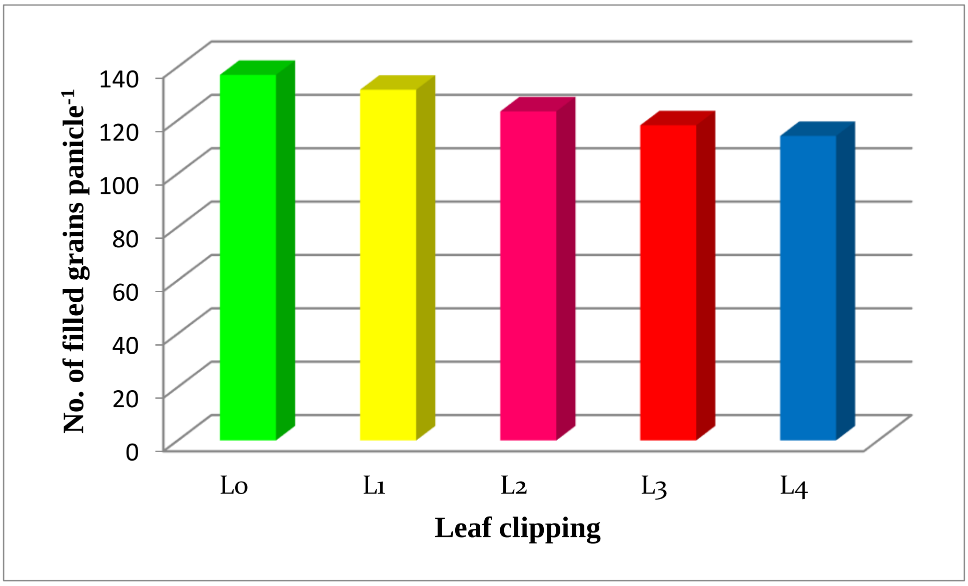


S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping

Figure 10: Effect of seedling clipping on number of filled grains panicle^{-1} of aus rice at harvest ($LSD_{0.05}$=3.76)

4.5.2 Effect of leaf clipping

Significant variation was found in filled grains panicle^{-1} due to the *aus* rice leaf clipping (Figure 11 and Appendix IV). The maximum number of filled grains panicle^{-1} (137) was recorded from no leaf clipping (L_0) treatment and the minimum (114.11) was obtained from Flag leaf Clipping (L_4) treatment which was statistically similar(118.11) with Lower 3+4 leaves Clipping (L_3). These results were in agreement with Fatima *et al.* (2019) who reported that the highest number of filled grains panicle^{-1} was recorded from Heera 4 under control condition. Hossain (2017) also found that the highest number of grains panicle^{-1} was obtained in no leaf cutting (control) treatment. Dissimilar result was found from Boonreund and Marsom (2015) who recorded increased grains panicle^{-1} with cutting of rice leaf. Daliri *et al.* (2009) opined that the effect of leaf cutting time on percent filled grains panicle^{-1} was found statistically significant. Usman *et al.* (2007) recorded that the number of grains panicle^{-1} was obtained from control (no detopping) treatment. These results were in agreement with Ahmed *et al.* (2001 a) who reported that the yield and yield contributing characters decreased by leaf cutting as compared to control.



L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

Figure11: Effect of leaf clipping on number of filled grains panicle^{-1} of aus rice at harvest ($LSD_{0.05}$=4.85).

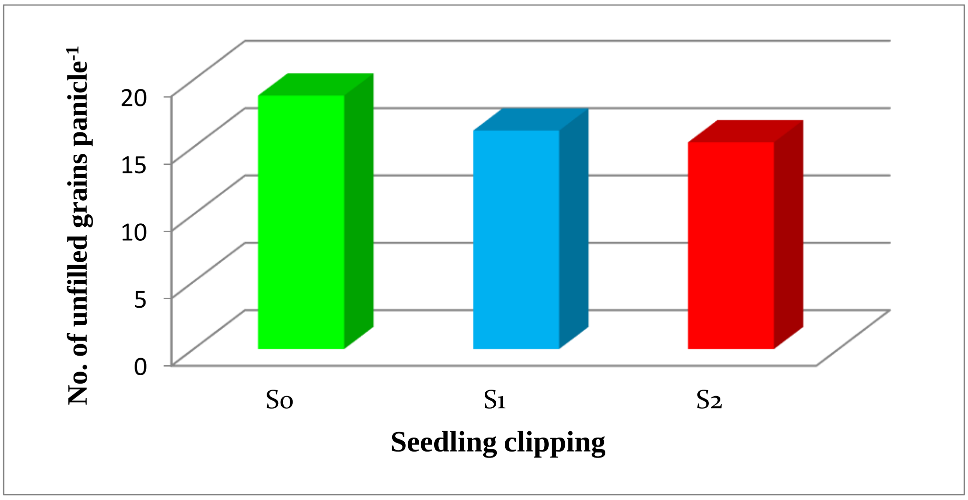
4.5.3 Combined effect of seedling clipping and leaf clipping

Significant variation was found in filled grains panicle^{-1} due to the seedling clipping with leaf clipping in the *aus* rice field (Table 4 and Appendix IV). The maximum number of filled grain panicle^{-1} (157.50) was recorded from the combined effect of 1/3rd seedling clipping with no leaf clipping (S_1L_0) treatment. The minimum number of filled grain panicle^{-1} (127.20) was obtained from the combination of 1/2nd seedling clipping with lower 2+3 leaves clipping (S_2L_2) treatment.

4.6 Number of unfilled grains panicle^{-1}

4.6.1 Effect of seedling clipping

Unfilled grains panicle^{-1} varied significantly due to the seedling clipping (Figure 12 and Appendix IV). The maximum number of unfilled grains panicle^{-1} (16.55) was recorded from no seedling clipping (S_0) treatment. On the other hand, the minimum number of unfilled grain panicle^{-1} (15.354) was obtained from 1/2nd seedling clipping (S_2) treatment which was statistically similar (16.22) with 1/3rd seedling clipping (S_1) treatment.

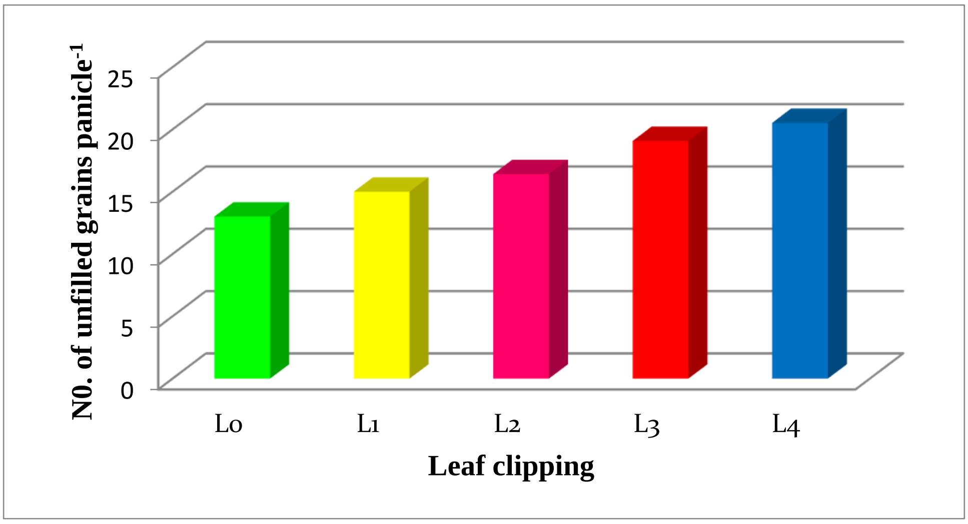


S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping

Figure 12: Effect of seedling clipping on number of unfilled grains panicle^{-1} of aus rice at harvest ($LSD_{0.05}$=0.87).

4.6.2 Effect of leaf clipping

Significant variation was obtained in unfilled grain due to the effect of leaf clipping (Figure 13 and Appendix IV). Flag leaf clipping (L_4) produced highest unfilled grain (20.52) and the lowest unfilled grain (13.003) from no leaf clipping (L_0). Rahman *et al.* (2013) was shown that removal of flag leaf led to a decline in the seed-setting rate, which eventually reduced the grain yield. Ahmed *et al.* (2001 b) was also found that the number of sterile spikelets panicle^{-1} was found to be the highest for no leaf cutting treatment.



L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

Figure13: Effect of leaf clipping on number of unfilled grains panicle^{-1} of aus rice at harvest ($LSD_{0.05}$=1.13).

4.6.3 Interaction effect of seedling clipping and leaf clipping

Significant variation was obtained in unfilled grains due to the combined effect of seedling clipping and leaf clipping in *aus* rice shown in (Table 4 and Appendix IV). Combined effect of no seedling clipping with Flag leaf Clipping (S_0L_4) gave highest unfilled grain (22.89) which was statistically similar(22.56) with no seedling clipping with Lower 3+4 leaves clipping (S_0L_3) . On the other hand, the lowest unfilled grain (11.56) was found from the combined effect of 1/3rd seedling clipping with no leaf clipping (S_1L_0) treatment which was statistically similar(13.44) with1/2nd seedling clipping with Lower 1+ 2 leaves clipping(S_2L_1).

Table 4: Combined effect of seedling clipping and leaf clipping on no. of filled grains panicle^{-1} and no. of unfilled grains panicle^{-1} of aus rice at harvest

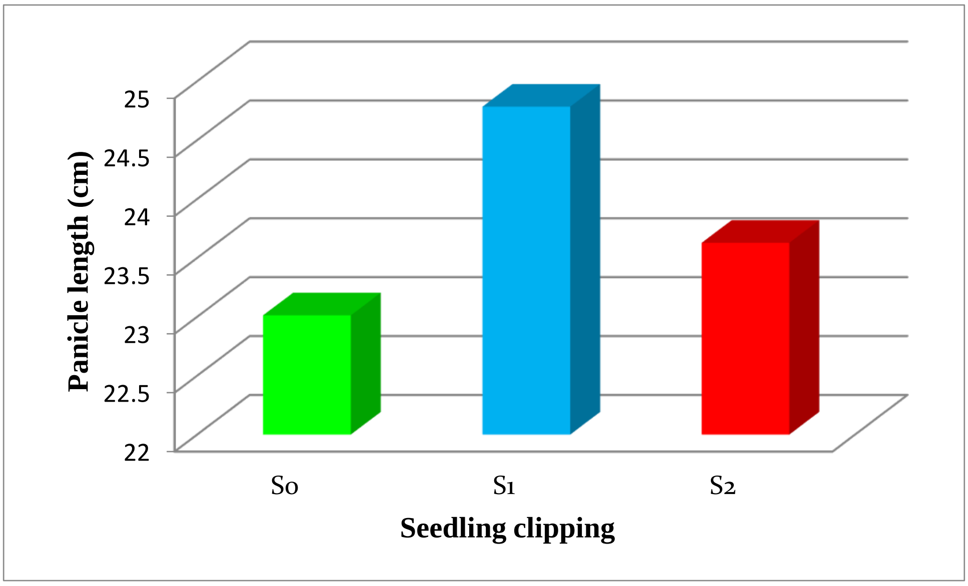
Treatment Combinations	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)
S_0L_0	137.67a	13.780de
S_0L_1	133.67ab	16.440c
S_0L_2	115.00ef	18.440b
S_0L_3	112.00f	22.560a
S_0L_4	111.33f	22.890a
S_1L_0	138.33a	11.560f
S_1L_1	134.00ab	15.110c-e
S_1L_2	127.33b-d	15.560cd
S_1L_3	121.67c-e	19.220b
S_1L_4	112.00f	19.670b
S_2L_0	135.00ab	13.670de
S_2L_1	126.67b-d	13.440ef
S_2L_2	127.67bc	15.220c-e
S_2L_3	120.67c-e	15.440cd
S_2L_4	119.00d-f	19.000b
$LSD_{(0.05)}$	8.415	1.959
CV(%)	4.03	6.97

S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

4.7 Panicle length (cm)

4.7.1 Effect of seedling clipping

The panicle length varied significantly due to seedling clipping treatments shown in (Table 5 and Appendix V). It was observed that the longest panicle (33.48 cm) was observed from the treatment of 1/3rd seedling clipping (S_1). The shortest (25.92 cm) panicle length was observed from no seedling clipping treatment (S_0) which was statistically similar (23.628cm) with the treatment of 1/2nd clipping (S2). This confirms the report of Boonreund and Marsom (2015) who observed that panicle length was differed due to different seedling clipping treatments.

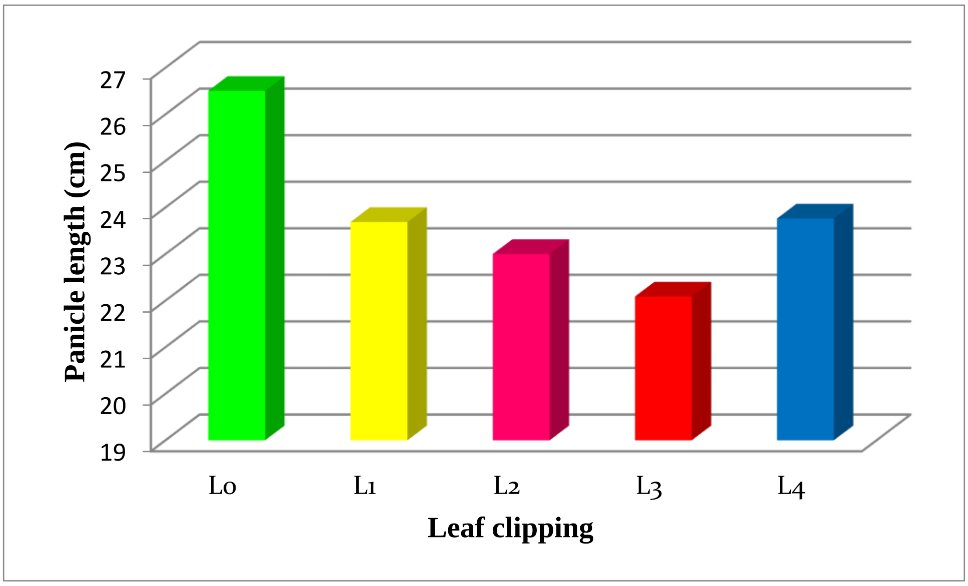


S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping

Figure 14: Effect of seedling clipping on panicle length of aus rice at harvest ($LSD_{0.05}$=0.99).

4.7.2 Effect of leaf clipping

The panicle length varied significantly due to leaf clipping shown in (Table 5 and Appendix V) . It was observed that no leaf clipping (L_0) produced significantly longer (26.503 cm) panicle. On the other hand, the shortest panicle length (22.087 cm) was measured from Lower 3+4 leaves clipping (L_3) which was statistically similar (23cm) with the treatment of Lower 2 +3 leaves clipping (L_2). This confirms the report of Boonreund and Marsom (2015) who showed that cutting of leaves had no significant effect on panicle length. Similar result was found by Usman *et al.* (2007) who shown in the tallest length of panicle (23.4 cm) was obtained from control (no detopping).



L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

Figure15: Effect of leaf clipping on panicle length of aus rice at harvest ($LSD_{0.05}$=1.28).

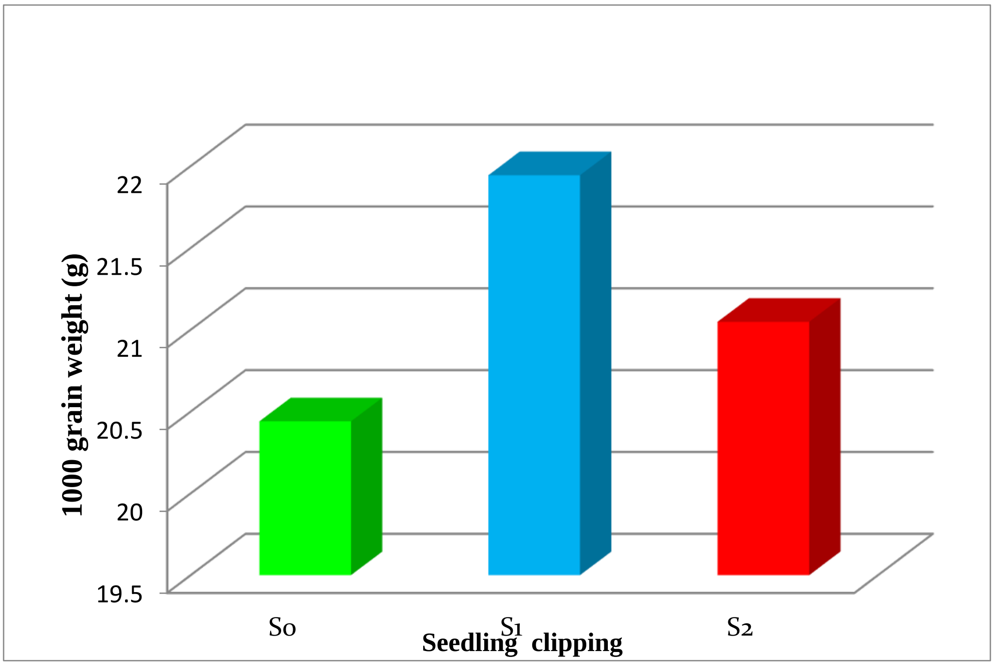
4.7.3 Combined effect of seedling clipping and leaf clipping

Panicle length was significantly affected by the interaction of seedling clipping and leaf clipping (Table 5 and Appendix V). The longest (35.81 cm) panicle was observed from the combination of 1/3rd seedling clipping and no leaf clipping (S_1L_0) treatment. On the other hand, the shorter panicle length (21.240cm) was found from the combination of no seedling clipping and Lower 3+4 leavesclipping (S_0L_3) treatment which was statistically similar with the treatment combination of S_2L_3 followed by S_0L_3 , S_2L_2, S_0L_4 and S_2L_1 treatment combination.

4.8 1000-grains weight (g)

4.8.1 Effect of seedling clipping

Effect of seedling clipping showed significant variation in 1000 grains weight (Table 5 and Appendix V). 1/3rd seedling clipping (S_1) gave the highest 1000 grains weight (21.944 g) which was statistically similar (21.048 gm) with 1/2nd clipping (S_2) treatment. The lowest 1000 grains weight (18.30 g) was found from no seedling clipping (S_0) treatment. This finding was in agreement with Fatima *et al.* (2019) who showed that seedling clipping regime had significant effect on 1000-grains weight.

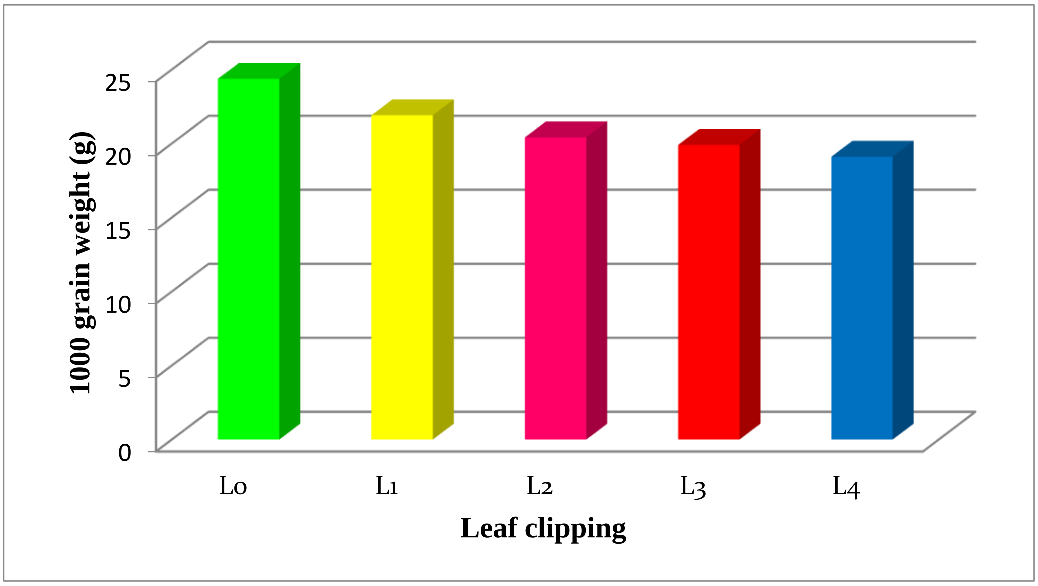


S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping

Figure 16: Effect of seedling clipping on 1000 grains weight (g) of aus rice at harvest

4.8.2 Effect of leaf clipping

Weight of 1000 grains showed significant variation among the different leaf clipping (Table 5 and Appendix V). No leaf clipping (L_0) produced highest 1000 grains weight (24.370 g). The lowest 1000 grains weight (19.11 g) was obtained from Flag leaf Clipping (L_4) treatment which was statistically similar (19.910 g) with Lower 3+4 leaves Clipping (L_3) . Similar findings were reported by Hossain (2017). He was recorded that the 1000-grains weight was significantly reduced in plants those had the leaves cut compared with the plant in control treatment. Dissimilar findings were reported by Ali *et al.* (2017) who shown that the leaf clipping had non-significant effect on 1000-grains weight of modern variety Bina dhan8. Rahman *et al.* (2013) was shown that the weight of 1000-grains of BR 3 was 27.5 g and 14 g for control and treated, respectively. Similarly, 1000-grains weight of BR 4 had 26 g and 17 g, BR 11 had 25.7 g and 18 g, BRRI dhan34 had 31 g and 16.5 g, BRRI dhan37 had 23.1 g and 15 g for control and treated, respectively. Ahmed *et al.* (2001 a) recorded that the highest value of 1000-grain weight (22.72 g) was recorded from control treatment.



L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

Figure 17: Effect of leaf clipping on 1000 grains weight (g) of aus rice at harvest

4.8.3 Combined effect of seedling clipping and leaf clipping

Interaction effect of seedling clipping and leaf clipping showed significant variation in 1000-grains weight (g) shown in (Table 5 and Appendix V) . The highest grain weight (28.00 g) was found from the combined effect of 1/3rd seedling clipping and no leaf clipping (S_1L_0) treatment . On the other hand, the lowest grain weight (18.37 g) was found with the combined effect of no seedling clipping with flag leaf clipping (S_0L_4) treatment which was statistically similar with the all others treatments combination excepts S_2L_1 followed by S_0L_1, S_1L_2, S_1L_1 and S_2L_0 treatments combination.

Table 5: Combined effect of seedling clipping and leaf clipping on panicle length (cm) and 1000-grains weight (g) of aus rice at harvest

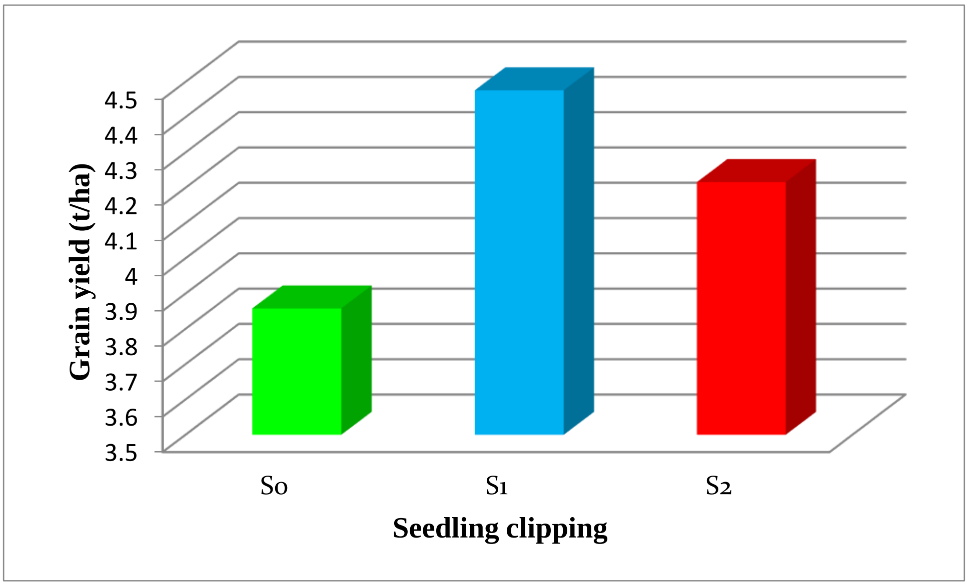
Treatment Combinations	Panicle length (cm)	Weight of 1000-grains (g)
S_0L_0	25.510bc	23.570b
S_0L_1	22.580ef	21.500cd
S_0L_2	22.530ef	19.430ef
S_0L_3	21.240f	19.330f
S_0L_4	23.200d-f	18.370f
S_1L_0	28.000a	25.970a
S_1L_1	25.050b-d	22.800bc
S_1L_2	23.690c-e	21.530cd
S_1L_3	22.680ef	20.330d-f
S_1L_4	24.500b-e	19.09f
S_1L_0	26.000ab	23.570b
S_1L_1	23.430c-f	21.430c-e
S_1L_2	22.780ef	20.300d-f
S_1L_3	22.340ef	20.070d-f
S_1L_4	23.590c-e	19.870d-f
$LSD_{(0.05)}$	2.217	2.035
CV(%)	5.57	5.76

S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

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

4.9.1 Effect of seedling clipping

Rice grain yield varied significantly due to the different seedling clipping in the *aus* rice field (Table 6 and Appendix VI). The maximum grain yield (4.4760 t ha^{-1}) was recorded from $1/3^{rd}$ seedling clipping (S_1) treatment. On the other hand, the minimum grain yield (3.86 t ha^{-1}) was obtained from no seedling clipping treatment. These might be due to the fact that the seedling clipping kept the rice field well aerated which facilitated the crop for absorption of greater amount of plant nutrients, moisture and greater reception of solar radiation for better growth. Ros *et al.* (2003) found that the response of rice yield to nursery treatments is largely due to increased seedling vigor and can be effected by a range of nutritional as well as non-nutritional treatments of seedlings that increase seedling dry matter, nutrient content and nutrient concentration. Das and Mukherjee (1992) from their research work on the effect of seedling removal on grain and straw yields of rainy season rice reported that late seedling cutting reduced the grain yield.

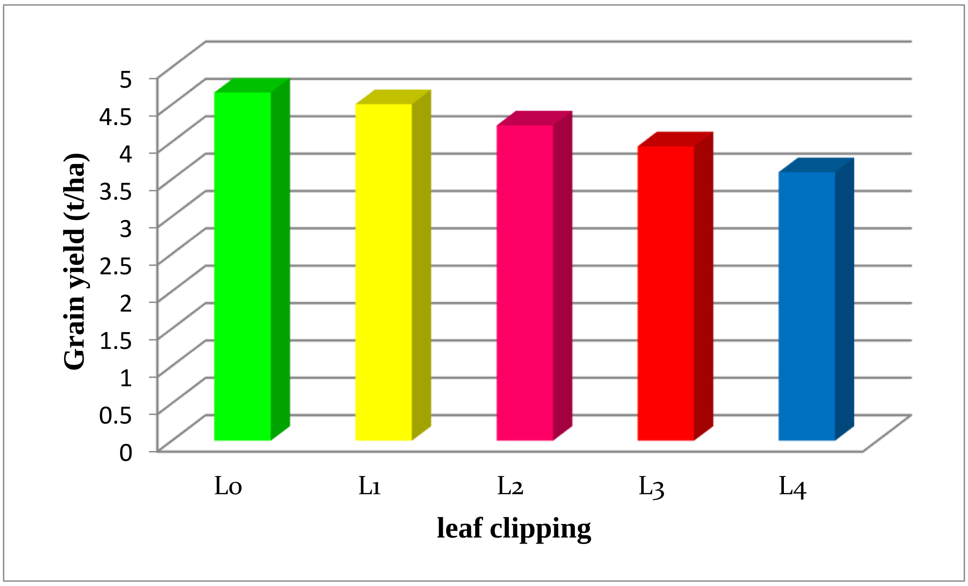


S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping

Figure 18: Effect of seedling clipping on grain yield of aus rice at harvest

4.9.2 Effect of leaf clipping

Rice grain yield varied significantly for different leaf clipping shown in (Fig.19 and Appendix VI) . The maximum grain yield (4.66 t ha^{-1}) was recorded by no leaf clipping (L_0) treatment. The second highest grain yield (4.5033 t ha^{-1}) was recorded from lower 1+2 leaves clipping (L_1) treatment. On the other hand, the lowest grain yield (4.24 t ha^{-1}) was recorded from flag leaf clipping (L_4) treatment. Fatima (2019) recorded significant variation was found for grain yield due to leaf removal. The highest grain yield (5.70 t ha^{-1}) was observed from no clipping, whereas the lowest (4.73 t ha^{-1}) was recorded from flag leaf clipping. These results are in agreement with earlier reports on the contribution of flag leaf and top three leaves to grain yield (Misra, 1986; Misra, 1987; Misra and Misra, 1991). Tambussi *et al.* (2007) also found the similar result and stated that Grains filling is sustained by current photosynthesis of the upper parts of the plant, i.e. the flag leaf and penultimate leaves and the ear. Fatima *et al.* (2019) opined that yield contributing characters and yield were investigated after cutting of flag leaf. Hossain (2017) recorded highest grain yield (6.75 t ha^{-1}) in BRRI dhan33 with no leaf cutting. Angrish (2000) from his experiment on lodging control in the tall statured Taraori basmati (*Oryza sativa* L.) by foliage pruning reported that cutting of excessive foliage of tall statured varieties of rice did not cause any adverse effect on grain yield. Muduli *et al.* (1995) found decreased grain yield when the flag leaf was removed at panicle emergence. Das and Mukherjee (1992) reported that late leaf cutting reduce the grain yield and this was true for present experiment.



L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

Figure 19: Effect of leaf clipping on grain yield of aus rice at harvest.

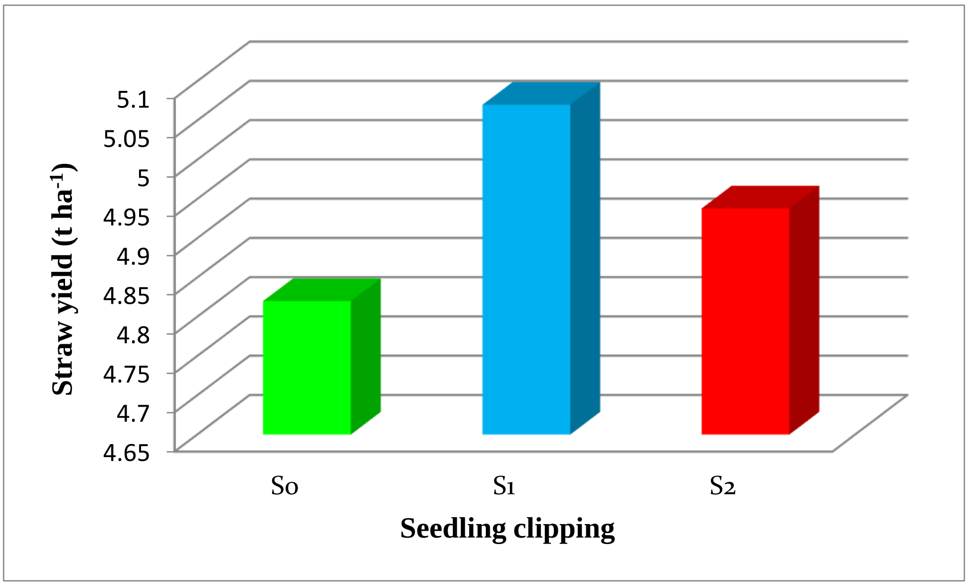
4.9.3 Combined effect of seedling clipping and leaf clipping

Rice grain yield varied significantly due to different seedling clipping and leaf clipping combinations (Table 6 and Appendix VI). The maximum grain yield (4.98 t ha^{-1}) was recorded from 1/3rd seedling clipping and no leaf clipping (S_1L_0) combination treatment which was statistically similar with the treatment combination of S_2L_0 (4.74 t ha^{-1}) followed by S_1L_1 (4.70 t ha^{-1}), S_2L_1 (4.63 t ha^{-1}) and S_1L_2 (4.52 t ha^{-1}treatment combination. On the other hand, the minimum grain yield (3.32 t ha^{-1}) was recorded from the no seedling clipping and flag leaf clipping (S_0L_4) treatment combination which was statistically similar with the treatment combination of S_0L_3 (3.48 t ha^{-1}) followed by S_2L_4 (3.55 t ha^{-1})

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

4.10.1 Effect of seedling clipping

Rice straw yield varied significantly due to the different seedling clipping in the *aus* rice field (Table 6 and Appendix VI). The maximum straw yield (5.07 t ha^{-1}) was recorded from 1/3rd seedling clipping (S_1) treatment which was similar(4.9380 t ha^{-1})with1/2nd clipping (S_2) The minimum straw yield (4.8200 t ha^{-1}) was obtained from no seedling clipping (S_0) treatment.

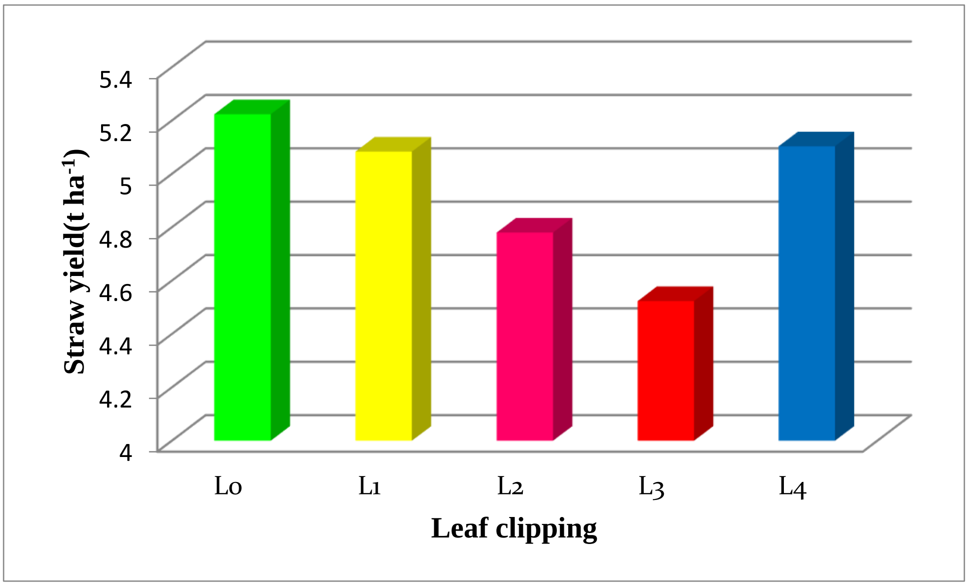


S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping

Figure 20: Effect of seedling clipping on straw yield (t ha^{-1}) of aus rice at harvest

4.10.2 Effect of leaf clipping

Significant variation in straw yield due to leaf clipping was evident (Fig 21 and Appendix VI). No leaf clipping (L_0) recorded the maximum straw yield (5.22 t ha^{-1}). with was statistically similar with L_4 (5.10 t ha^{-1}) followed by L_1 (5.08 t ha^{-1}) treatment. On the other hand, Lower 3+4 leaves clipping (L_3) recorded the minimum straw yield (4.52 t ha^{-1}). Fatima *et al.* (2019), Hossain (2017) and Usman *et al.* (2007) observed that the highest straw yield was obtained in no leaf cutting (control). Fatima (2019) recorded that the statistically significant variation was recorded for dry straw yield due to flag leaf clipping in Boro rice. The highest dry straw yield (7.29 t ha^{-1}) was recorded from no leaf clipping (control), whereas the lowest (5.84 t ha−1) was recorded from flag leaf clipping.



L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

Figure 21: Effect of leaf clipping on straw yield of aus rice at harvest

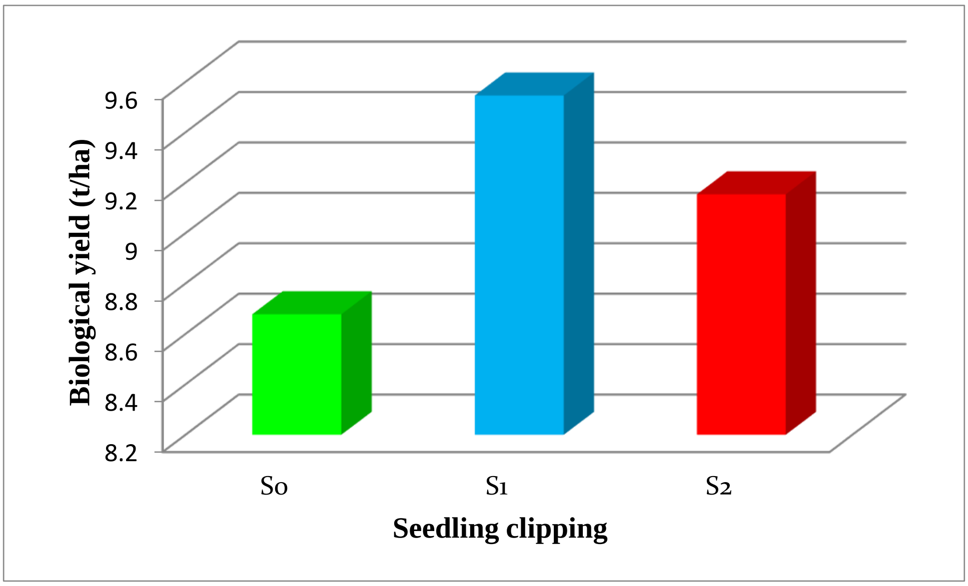
4.10.3 Combined effect of seedling clipping and leaf clipping

The straw yield varied significantly due to different seedling clipping and leaf clipping treatment combinations (Table 6 and Appendix VI). The maximum straw yield (5.28 t ha^{-1}) was obtained from the combination of 1/3rd seedling clipping and f no leaf clipping (S_0L_0) treatment which was statistically similar with all others treatment except S_0L_0, S_0L_0, S_0L_0, S_0L_0 and S_0L_0 treatment combination .The minimum straw yield (4.33 t ha^{-1}) was found from the combination of no seedling clipping and Lower 3+4 leaf clipping (S_0L_3) treatment which was statistically similar with the treatment combination of S_0L_2 (4.54 t ha^{-1}) followed by S_2L_3 (4.61 t ha^{-1}) and S_1L_3 (4.63 t ha^{-1}) treatment combination.

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

4.11.1 Effect of seedling clipping

The biological yield varied significantly due to different seedling clipping treatments shown in (Table 6 and Appendix VI). 1/3rdheight seedling clipping (S_1) gave the highest biological yield (9.546 t ha^{-1}). On the other hand, no seedling clipping (S_0) treatment gave the lowest biological yield (8.6780 t ha^{-1}).

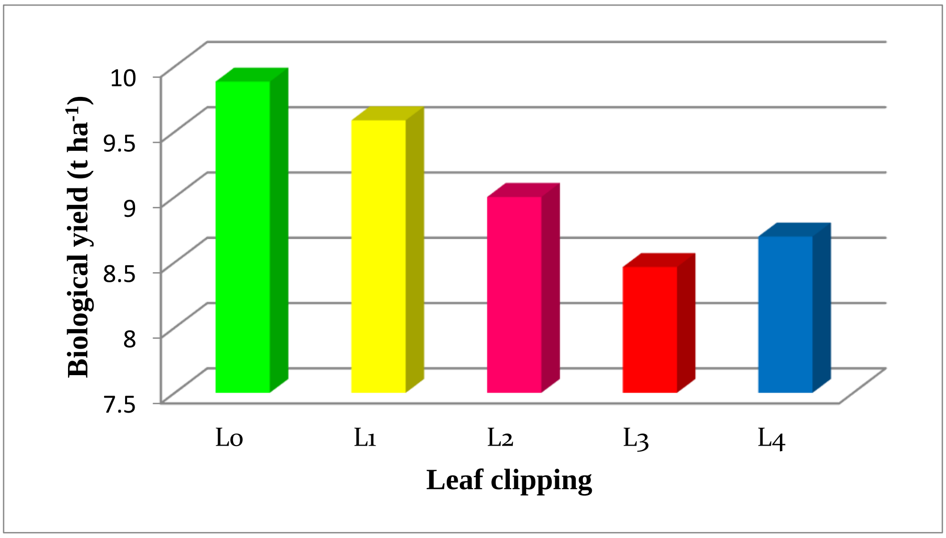


S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping

Figure 22: Effect of seedling clipping on biological yield (t/ha) of aus rice at harvest

4.11.2 Effect of leaf clipping

The biological yield varied significantly due to the leaf clipping shown in (Fig 23 and Appendix VI). It was observed that no leaf clipping (L_0) produced significantly highest biological yield (9.88 t ha^{-1}) which was statistically similar (9.58 t ha^{-1}) with lower 1+2 leaves clipping (L_1). On the other hand, the lowest biological yield (8.46 t ha^{-1}) was recorded from the Lower 3+4 leaves clipping (L_3) treatment which was statistically similar (8.69 t ha^{-1}) with Flag leaf Clipping (L_4).



L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3 =Lower 3rd+4th leaves; L_4 = Flag leaf Clipping

Figure 23: Effect of leaf clipping on biological yield of aus rice at harvest.

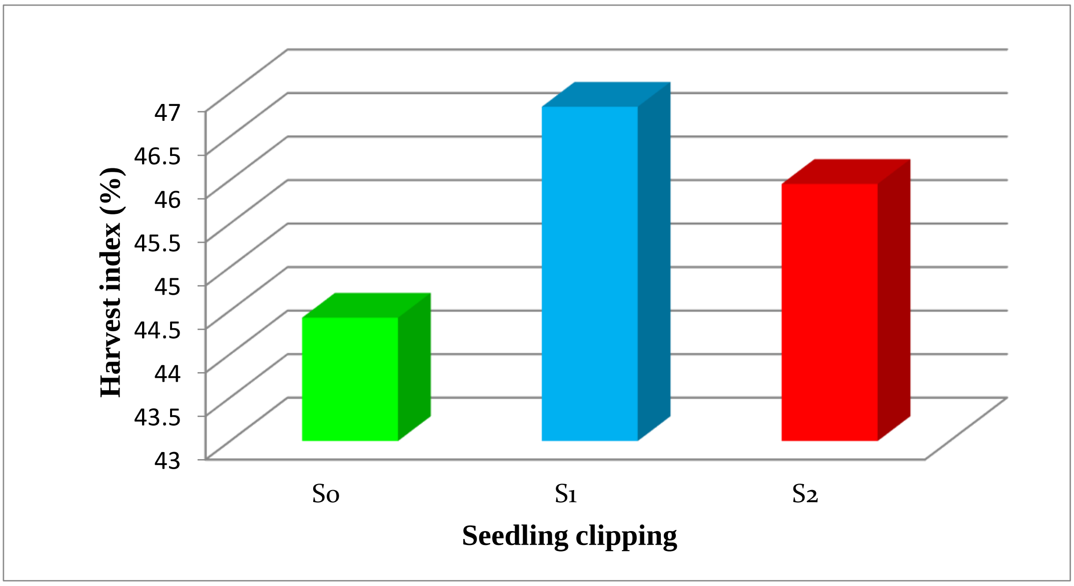
4.11.3 Combined effect of seedling clipping and leaf clipping

Biological yield was significantly affected by the combined of different seedling clipping and leaf clipping treatment in *aus* rice field (Table 6 and Appendix VI). The highest biological yield (10.26 t ha^{-1}) was obtained from the combination of 1/3rd height seedling clipping with no leaves clipping (S_1L_0) which was statistically similar (10.01 t ha^{-1}) with 1/2nd height seedling clipping and no leaf clipping (S_0L_3) followed by S_0L_3 (9.89 t ha^{-1}), S_0L_3 (9.65 t ha^{-1}) treatment. On the other hand, the lowest biological yield (7.88 t ha^{-1}) was found from the combination no seedling clipping with Lower 3+4 leaves (S_1L_3) treatment which was statistically similar (8.39 t ha^{-1}) with the S_1L_3 treatment combination.

4.12 Harvest Index (%)

4.12.1 Effect of seedling clipping

Harvest index (%) of rice varied significantly due to the different seedling clipping in the *aus* rice field (Table 6 and Appendix VI). The height harvest index (46.84%) was recorded from 1/3rd height seedling clipping (S_1) treatment which was statistically similar (45.95%) with 1/2nd seedling clipping (S_2). On the other hand, the lowest harvest index (44.42%) was obtained from no seedling clipping (S_0) treatment. This result was in agreement with the findings of Ros *et al.* (2003) who argued that the combined effects of seedling pruning was given the highest value of harvest index of rice.

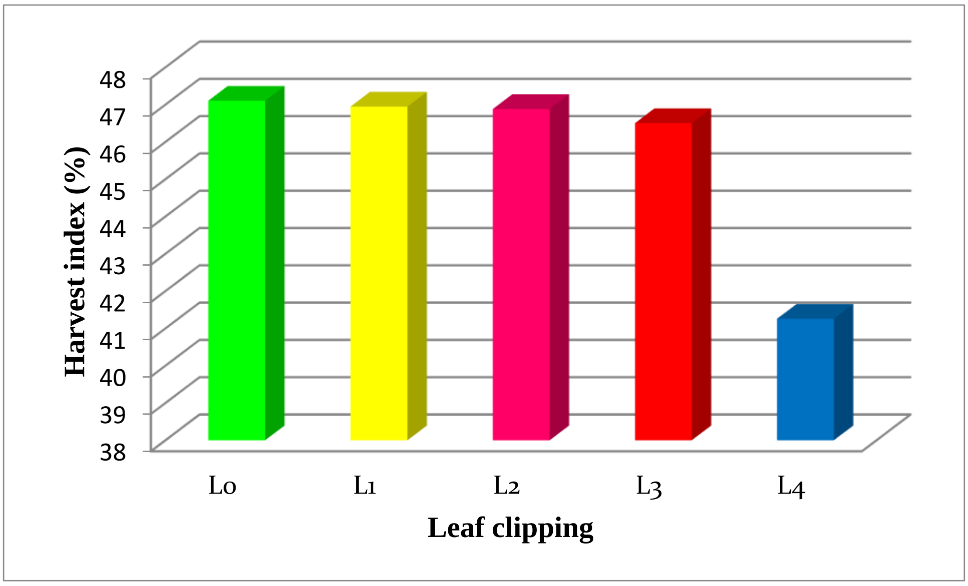


S_0= Control (no clipping); S_1= 1/3[rd] height clipping; S_2=1/2[nd] height clipping

Figure 24: Effect of seedling clipping on harvest index of aus rice at harvest

4.12.2 Effect of leaf clipping

Leaf clipping showed significant variation in harvest index (Table 6 and Appendix VI). No leaf clipping (L_0) showed the highest harvest index (47.10 %) was statistically similar with all other treatments except flag leaf clipping ((L_4) whereas lowest harvest index (41.26 %) in flag leaf clipping (L_4) treatment. These findings are being supported from the work of Hossain (2017), Daliri *et al.* (2009), Usman *et al.* (2007) and Ahmed *et al.* (2001 a), who obtained that the highest harvest index was obtained in no leaf cutting (control).



L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

Figure 25: Effect of leaf clipping on harvest index of aus rice at harvest

4.12.3 Combined effect of seedling clipping and leaf clipping

Interaction effect of seedling clipping and leaf clipping showed significant variation in harvest index of *aus* rice field (Table 6 and Appendix VI). The highest harvest index (48.54 %) was observed from the combined effect of 1/3rd seedling clipping with no leaf clipping (S_1L_0) treatment which was statistically similar with all others treatment combinations except S_0L_4 followed by S_2L_4, S_1L_4 and S_0L_3 treatment combinations. On the other hand, the lowest harvest index (39.57%) was obtained from the combined of no seedling clipping with flag leaf clipping (S_0L_4) treatment statistically similar with 1/2nd seedling clipping with flag leaf clipping.

Table 6: Combined effect of seedling clipping and leaf clipping on grain yield, straw yield, biological yield and harvest index of aus rice at harvest

Treatment Combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index %
S_0L_0	4.2600b-e	5.1200a	9.380c-e	45.416a-c
S_0L_1	4.1800c-e	5.0400ab	9.220d-f	45.336a-c
S_0L_2	3.9800ef	4.5400cd	8.520h	46.714a-c
S_0L_3	3.5500fg	4.3300d	7.880i	45.051bc
S_0L_4	3.3200g	5.0700a	8.390hi	39.571e
S_1L_0	4.9800a	5.2800a	10.260a	48.538a
S_1L_1	4.7000ab	5.1900a	9.890a-c	47.523ab
S_1L_2	4.5200a-d	5.0800a	9.600b-d	47.083ab
S_1L_3	4.2000c-e	4.6300cd	8.830e-h	47.565ab
S_1L_4	3.9800ef	5.1700a	9.150d-g	43.497cd
S_2L_0	4.7400a	5.2700a	10.010ab	47.353ab
S_2L_1	4.6300a-c	5.0200ab	9.650a-d	47.979ab
S_2L_2	4.1600c-e	4.7200bc	8.880e-h	46.847ab
S_2L_3	4.0700de	4.6100cd	8.680f-h	46.889ab
S_2L_4	3.4800g	5.0700a	8.550gh	40.702de
$LSD_{(0.05)}$	0.471	0.336	0.622	3.297
CV(%)	6.73	4.06	4.07	4.31

S_0= Control (no clipping); S_1= 1/3rd height clipping; S_2=1/2nd height clipping L_0= Control (No Clipping); L_1 =Lower 1st+ 2nd leaves; L_2 =Lower 2nd +3rd leaves; L_3=Lower 3rd+4th leaves; L_4= Flag leaf Clipping

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the period from March to August 2019 at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to study the influence of seedling and leaf clipping on the growth and yield of *aus* rice. The experiment comprised two factors; Factors A: three different seedling clipping *viz.* S_0 = no seedling clipping (control), S_1 = 1/3rd height seedling clipping and S_2 = 1/2nd height seedling clipping and Factor B: four different leaf clipping before panicle initiation *viz*. L_0 = no leaf clipping (control), L_1 = Lower 1st+2nd leaves clipping, L_2 = Lower 2nd+3rd leaves clipping, L_3 = Lower 3rd + 4th leaves and L_4 = Flag leaf clipping.

The experiment was laid out in Randomized Complete Block design (RCBD) with three replications. The size of the individual plot was 4.0 m × 2.5 m and total numbers of plots were 45. The data were collected on plant height (cm), number of effective tillers hill^{-1}, number of non-effective tillers plant^{-1}, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, above ground dry matter hill^{-1}, panicle length, 1000-grains weight, grain yield, straw yield, biological yield and harvest index.

Collected data were compiled and the mean separations were tested following least significant difference (LSD) test at 5% level of significance.

Seedling and leaf clipping either individually or combined showed significant variations in some parameters.

In respect of seedling clipping, the tallest plant (95.41 cm) was obtained from the no seedling clipping and the dwarf (89.51 cm) was from 1/2nd height clipping treatment. While for leaf clipping, the tallest (101.13 cm) plant was recorded from the no leaf clipping and the dwarf (97.58 cm) plant was at lower 2 + 3 leaf clipping treatment. Combination treatment showed that the tallest plant (110.17 cm) was observed from no seedling clipping with no leaf clipping (control) and the shortest (80.75 cm) from 1/2nd height seedling clipping with lower 2 + 3 leaves clipping.

1/3rd seedling clipping gave the highest effective tiller (23.42) and no seedling clipping treatment gave the lowest effective tiller (16.73). No leaf clipping produced higher number (24.17) and flag leaf clipping produced lower number (17.55) of productive tiller. The highest effective tiller (27.69) was obtained from the combination of 1/3rd height seedling clipping with no leaf clipping treatment and the lowest effective tiller (16.00) was found from the combination of no seedlling clipping with flag leaf clipping treatment.

The maximum number of non-effective tillers hill^{-1} (5.77) was obtained from no seedling clipping and the minimum (3.89) was obtained from 1/3rd height seedling clipping treatment. Flag leaf clipping produced higher number (5.03) and no leaf clipping produced lower number (4.18) of productive tiller. The highest non-effective tiller (6.99) was obtained from the combination of no seedling clipping with flag leaf clipping and the lowest (3.12) was 1/3rd height seedling clipping with no leaf clipping.

The maximum number of filled grains panicle^{-1} (126.67) was recorded from 1/3rdheight seedling clipping and the minimum (125.28) was obtained from no seedling clipping treatment. The maximum number of filled grains panicle^{-1} (137.00) was recorded from no leaf clipping and the minimum (114.11) was obtained from lower 2+3 leaves clipping (L_2) treatment. The maximum number of filled grain panicle^{-1} (157.50) was recorded from the combined effect of 1/3rd height seedling clipping with no leaf clipping and the minimum (127.20) was obtained from 1/2nd height seedling clipping with lower 2+3 leaves clipping.

The maximum number of unfilled grains panicle^{-1} (16.55) was recorded from no seedling clipping and the minimum number of unfilled grain panicle^{-1} (15.22) was obtained from 1/3rd height seedling clipping treatment. Flag leaf clipping produced highest unfilled grain (20.52) and the lowest (13.003) from no leaf clipping treatment. Combined effect of no seedling clipping with lower 2+3 leaves clipping gave highest unfilled grain (22.89) and the lowest unfilled grain (11.56) was found from the combined effect of 1/3rd seedling clipping with no leaf clipping.

The maximum above ground dry matter (35.30 g) hill^{-1} was recorded from 1/3rd height seedling clipping and the minimum (30.40 g) was obtained from 1/2nd height seedling clipping treatment. No leaf clipping produced maximum above ground dry matter (37.03 g) hill^{-1} and the lower 2+3 leaves clipping produced minimum (27.55 g). The maximum above ground dry matter (43.36 g) hill^{-1} was recorded from the combined effect of 1/3rd height seedling clipping with no leaf clipping and the minimum (26.74 g) was obtained from the combination of 1/2nd height seedling clipping with lower 2+3 leaves clipping.

The longest panicle (33.48 cm) was observed from the treatment of 1/3rd height seedling clipping and the shortest (25.92 cm) was observed from no seedling clipping treatment. No leaf clipping produced longer (26.50 cm) panicle and the shortest (22.09 cm) one was measured from lower 1+2 leaves clipping treatment. The longest (35.81 cm) panicle was observed from the combination of 1/3rd height seedling clipping and no leaf clipping treatment and the shortest panicle length (21.24 cm) was found from the combination of no seedling clipping and lower 1+2 leaves clipping treatment.

1/3rd height seedling clipping gave the highest 1000-grains weight (21.94 g) and the lowest (18.30 g) was found from no seedling clipping treatment. No leaf clipping produced highest 1000 grains weight (24.37 g) and the lowest (19.11 g) was obtained from lower 2+3 leaves clipping treatment. The highest 1000-grain weight (28.00 g) was found from the combined effect of 1/3rd seedling clipping and no leaf clipping and the lowest grain weight (18.37 g) was found with the combined effect of no seedling clipping with flag leaf clipping treatment.

Based on the results of the present experiment, the following conclusion can be drawn:

1. The maximum grain yield (4.98 t ha^{-1}) was recorded from treatment combination of 1/3rd height seedling clipping and no leaf clipping treatment and the minimum (3.32 t ha^{-1}) was recorded from the no seedling clipping and flag leaf clipping treatment combination.

2. The maximum straw yield (5.28 tha^{-1}) was obtained from the combination of no seedling clipping and flag leaf clipping and the minimum (4.33 t ha^{-1}) was found from the combination of 1/3rd height seedling clipping and no leaf clipping treatment.

3. The highest biological yield (10.26 t ha^{-1}) was obtained from the combination of 1/3rd height seedling clipping with lower 1+2 leaves clipping and the lowest (7.88 t ha^{-1}) was found from the combination 1/3rd height seedling clipping with no leaf clipping treatment.

4. The highest harvest index (48.54 %) was observed from the combined effect of 1/3rd height seedling clipping with no leaf clipping and the lowest (39.57 %) was obtained from no seedling clipping with flag leaf clipping treatment.

However, to reach a specific conclusion and recommendation, more research work with different height of seedling clipping and position leaf clipping on rice may be done over different Agro-ecological zones of the country.

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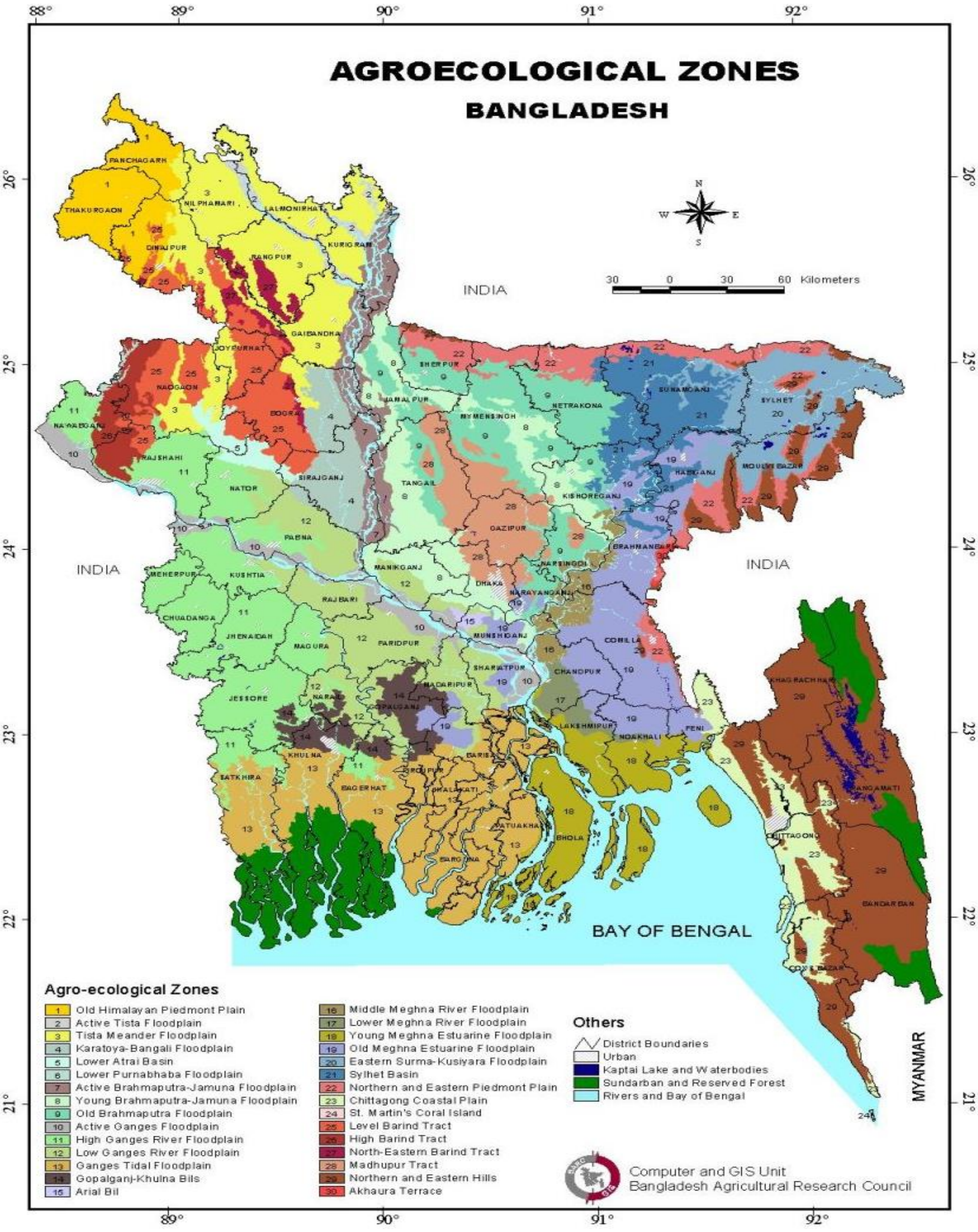
APPENDICES

Appendix I. Map showing the experimental sites under study



Appendix II. Characteristics of Agronomy Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping Pattern	Potato-Aus rice-Aman rice

Physical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30

Chemical properties of the initial soil

Characteristics	Value
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.08
Available P (ppm)	20.00
Exchangeable K (mel 100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix III. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from March, 2019 to August, 2019

Year	Month	Air Temperature (°C)			Relative Humidity (%)	Total Rainfall (mm)	Sunshine (Hour)
		Max	Min	Mean			
2019	March	34	24	30	44	57.6	301.5
	April	37	28	33	54	225.1	294
	May	39	29	35	61	259.3	294.5
	June	36	29	33	67	273.6	226.5
	July	34	28	31	74	380.6	194
	August	34	27	31	73	254.8	203.5

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka.

Appendix IV. Analysis of variance and mean square data on plant height, no. of effective tillers hill^{-1}, no. of non-effective tillers hill^{-1}, no. of filled grains panicle^{-1} and no. of unfilled grains panicle^{-1}

Source of variation	df	Plant height	No. of effective tillers hill^{-1}	No. of non-effective tillers	No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}
Replication	2	29.067	0.8000	0.0667	38.600	0.8000
Seedling	2	130.896*	16.9525*	14.2308*	95.249*	48.8338*
Leaf clipping	4	343.288*	69.1889*	1.2717*	796.853*	82.8627*
A × B	8	33.572*	1.6736*	1.9968*	65.203*	5.7686*
Error	28	26.210	1.3714	0.1381	25.314	1.3714
Total	44					

*Significant at 5% level of probability

Appendix V. Analysis of variance and mean square data on dry matter hill^{-1}, panicle length and 1000-seeds weight

Source of variation	Df	Dry matter hill^{-1}	Panicle length	1000-seeds weight
Replication	2	1.867	1.4000	1.2667
Seedling clipping (A)	2	112.540*	12.1394*	8.5862*
Leaf clipping (B)	4	111.251*	24.5191*	38.6503*
A×B	8	10.400*	0.4893*	1.1989*
Error	28	3.581	1.7571	1.4810
Total	44			

*Significant at 5% level of probability

Appendix VI. Analysis of variance and mean square data on grain yield, straw yield, biological yield and harvest index

Source of variation	df	Grain yield	Straw yield	Biological yield	Harvest Index (%)
Replication	2	0.05067	0.06667	0.06667	8.6000
Seedling clipping (A)	2	1.44422*	0.23462*	2.83416*	22.5580*
Leaf clipping (B)	4	1.66110*	0.73502*	3.20647*	56.9099*
A×B	8	0.03379*	0.03415*	0.07493*	2.0804*
Error	28	0.07924	0.04024	0.13810	3.8857
Total	44				

*Significant at 5% level of probability