GROWTH AND YIELD OF SCENTED RICE AS AFFECTED BY CLIPPING MANAGEMENT

MUSFIKA BINTE ZAMAN

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JUNE, 2021

GROWTH AND YIELD OF SCENTED RICE AS AFFECTED BY CLIPPING MANAGEMENT

By

MUSFIKA BINTE ZAMAN

REGISTRATION NO. 14-06211

A Thesis
submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka-1207,
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE (MS)

IN

AGRONOMY

SEMESTER: JANUARY-JUNE, 2021

APPROVED BY:

Prof. Dr. Md. Fazlul Karim
Supervisor

Assoc. Prof. Dr. Md. Hasanuzzaman
Co-Supervisor

Prof. Dr. Tuhin Suvra Roy
Chairman
Examination Committee

DEPARTMENT OF AGRONOMY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled 'GROWTH AND YIELD OF SCENTED RICE AS AFFECTED BY CLIPPING MANAGEMENT' 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 (MS) in AGRONOMY, embodies the result of a piece of bona fide research work carried out by MUSFIKA BINTE ZAMAN, Registration number: 14-06211, under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Place: Dhaka, Bangladesh

Prof. Dr. Md. Fazlul Karim
Supervisor
Department of Agronomy

Dedicated to My

Beloved Parents

ACKNOWLEDGEMENTS

Alhamdulillah, all praises are due to The Almighty Allah Rabbul Al-Amin for His gracious kindness and infinite mercy in all the endeavors the author to let her successfully completing the research work and the thesis leading to Master of Science degree.

The author would like to express her heartfelt gratitude and most sincere appreciations to her Supervisor Prof. Dr. Md. Fazlul Karim, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his valuable guidance, advice, immense help, encouragement and support throughout the study. Likewise grateful appreciation is conveyed to Co-Supervisor Assoc. Prof. Dr. Md. Hasanuzzaman, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his constant encouragement, given suggestions, constructive criticisms and valuable advice to complete the thesis.

It is highly appreciating words for Prof. Dr. Tuhin Suvra Roy, Chairman along with faculties, Department of Agronomy, Sher-e-Bangla Agricultural University for their rendered novel services towards me as their student. The author would like to express her deepest respect and boundless gratitude to them for their valuable teaching, sympathetic cooperation, and inspirations throughout the course of this study and research work.

The author wishes to extend her special thanks to her class mates and friends for their keen help as well as heartiest co-operation and encouragement during experimentation.

The author is deeply indebted and grateful to her parents, sister and relatives; without whose love, affection, inspiration and sacrifice this work would have not been completed.

Finally the author appreciates the assistance rendered by the staff of the Department of Agronomy, Sher-e-Bangla Agricultural University Farm staff, Dhaka, who has helped her during the period of study.

GROWTH AND YIELD OF SCENTED RICE AS AFFECTED BY CLIPPING MANAGEMENT

ABSTRACT

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during the period from July to December 2019 to investigate the growth and yield of scented rice as affected by clipping management. The experiment consisted of two factors, Factor A: Seedling top clipping (3) *viz:* S_0= Control (no clipping), S_1=1/3rd clipping and S_2= 1/2nd clipping and Factor B: Leaf clipping before panicle initiation (5) *viz:* L_0= Control (no clipping), L_1= Lower 1st & 2nd leaves, L_2= Lower 2nd & 3rd leaves, L_3= Lower 3rd & 4th leaves and L_4= Flag leaf. The experiment was laid out in split plot design with three replications. The test crop variety was BRRI dhan80. Data were recorded on growth, yield attributes and yield of aromatic rice and significant variation either individually or combined was observed for most of the studied characters. Results revealed that in respect of seedling top clipping the maximum effective tillers hill^{-1} (12.68), panicle length (25.31 cm), filled grains panicle^{-1} (176.58), total grains panicle^{-1} (200.39), 1000 grains weight (23.89 g), grain yield (4.07 t ha^{-1}), straw yield (7.76 t ha^{-1}), biological yield (11.83 t ha^{-1}) and harvest index (34.34 %) were recorded from S_1 (1/3rd seedling clipping) treatment. In respect of leaf clipping the maximum effective tillers hill^{-1} (13.43), panicle length (26.12 cm), filled grains panicle^{-1} (190.95), total grains panicle^{-1} (208.73), 1000 grains weight (25.21 g), grain yield (4.08 t ha^{-1}), straw yield (7.89 t ha^{-1}), biological yield (11.97 t ha^{-1}) and harvest index (34.04 %) were recorded from L_0 (No leaf clipping) treatment. In case of combined effect, 1/3rd seedling clipping (S_1) along with no leaf clipping (L_0) treatment combination (S_1L_0) had maximum effective tillers hill^{-1} (14.68), panicle length (27.19 cm), filled grains panicle^{-1} (206.07), total grains panicle^{-1} (221.42), 1000 grains weight (26.24 g), grain yield (4.52 t ha^{-1}), biological yield (12.56 t ha^{-1}) and harvest index (36.11 %) from S_1L_0 treatment combination. The corresponding lowest grain yield (3.28 t ha^{-1}) was recorded from 1/2nd seedling clipping (S_2) along with flag leaf clipping (L_4) treatment combination (S_2L_0).

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)

LIST OF APPENDICES

LIST OF ACRONYMS

Acronym		**Full meanings**
AEZ	=	Agro-Ecological Zone
%	=	Percent
^{0}C	=	Degree Celsius
BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAT	=	Days after transplanting
et al.	=	And others
FAO	=	Food and Agriculture Organization
g	=	Gram
ha-1	=	Per hectare
kg	=	Kilogram
LSD	=	Least Significant Difference
MoP	=	Muriate of Potash
N	=	Nitrogen
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
t	=	Ton
TSP	=	Triple Super Phosphate
viz.	=	Videlicet (namely)
Wt.	=	Weight

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the Poaceae family of cereal crops. After wheat in the world cereal crops, rice ranked second. In addition, Bangladesh is the 3rd largest country in the world based on the cultivation of rice (BBS, 2019). In Bangladesh, the area and production of total rice are approximately 11.52 million hectares and 36.28 million metric tons, respectively (BBS, 2019; FAO, 2019). Rice is used as a staple food by almost half of the world's population. In Asia, over 90% of the rice in the world is grown (BBS, 2013). Rice alone occupies about 77% of the total cultivated area among the 150 different crops grown in Bangladesh (BBS, 2017). In Bangladesh, annual per capita rice intake is the world's highest (Nasiruddin, 1993). It accounts for 76% of the caloric intake and 66% of the protein intake (BNNC, 2008). Its share of agricultural GDP is about 70%, whereas its share of national income is less than 17%. Bangladesh's population is still growing and will require about 47.26 million tons of rice by 2020 (BBS, 2016). To keep pace with population growth, global rice demand is expected to rise by 25% from 2001 to 2025 (Maclean *et al.*, 2002), making meeting this ever-increasing demand with shrinking natural resources a major challenge. Rice accounts for the majority of food grains in Bangladesh. Rice has a huge impact on the country's agrarian economy. According to the USDA, rice production in Bangladesh is predicted to climb to 36.3 million tons in the 2020-21 marketing year as more hybrid and high yield variety crops are planted. In the 2020-21 marketing year, the government is anticipated to import 200,000 tons of rice to alleviate food security concerns caused by the COVID-19 pandemic (USDA, 2021).

Rice has three distinct growing seasons in Bangladesh, which is determined by changes in seasonal conditions such as *Aus*, *Aman*, and *Boro*. More than half of the entire production (55.50 percent) is acquired in the *Boro* season (December–May), the second greatest production (37.90 percent) in the *Aman* season (July–November), and only a small contribution from the *Aus* season (6.60 percent) in April–June (APCAS, 2016). Among three growing seasons (*Aus*, *Aman* and *Boro*) aman rice occupies the highest area coverage. The aman rice crop occupies 67 per cent of the cropped area. There are two types of transplant aman rice: coarse and fine rice, with certain aromatic fine rice. Aromatic rice is a kind of rice that contains a natural component called 2-acetyl-1-pyrroline, which gives its scent, flavor, and aroma (Gnanavel and Anbhazhagan, 2010). Sriseadka *et al.* (2006) discovered 2-AP as the most important molecule contributing to aromatic characteristics of scented rice, with 15 times greater 2-acetyl-1-pyrroline concentration than that in non-aromatic rice (ranges 0.14-0.009 ppm). There are roughly 100 additional volatile compounds associated with rice aroma production, including 13 hydrocarbons, 14 acids, 13 alcohols, 16 aldehydes, 14 ketones, 8 esters, 5 phenols, and other substances (Singh, 2000).

Most of the aromatic rice varieties in Bangladesh are of traditional type,which are sensitive to photoperiods and are grown during the *aman* season in lowland rainfall (Das and Baqui, 2000). Thirty per cent of the rice land in northern Bangladesh districts was occupied by aromatic rice cultivars during the *aman* season. In the international rice trade, aromatic rice plays an important role. As well as other varieties, such as Kataribhog, Bansful and Chinigura, Bangladesh mainly exports Kalizira, a highly aromatic variety. Bangladesh has a promising prospect of earning foreign exchange for exporting fine rice (Islam *et al.*, 2012). Aromatic rice is the most highly valued rice commodity in Bangladesh agricultural trade markets having small grain and pleasant aroma with soft texture upon cooking (Dutta *et al*., 2002).

The yield of aromatic rice is much lower than those of other rice growing countries because of lack of improved variety and judicious fertilizer management (Islam *et al.*, 1996). The lower yield of aromatic rice has already been ascribed to a variety of factors, including a lack of high yielding cultivars, weed infestation, market price fluctuations, and a lack of understanding and adequate agronomic management methods and so on. In such a situation, boosting rice production is demanding. As a result, efforts must be made to boost yield per unit area through the use of new rice cultivars, improved technology and improved agronomic management practices (such as clipping, irrigation, spacing, weed control, insect managements etc).

Rice crops can be sown directly or transplanted. Seeds are sown directly in the field in direct sowing. During transplantation, plants are initially grown in seedbeds prior to planting on the field. Transplantation involves less seed, but more work, and the transplantation shock takes more time (about 15 days) for the crop to develop. Hybrid seeds are frequently transplanted as one seedling per hill and more affordable, but sometimes conventional types with up to 6 seedlings are planted per hill. The farmers plan 2 to 3 plants per hill, in several countries.

Seedlings hill^{-1} is one of the most important agricultural factors for the uniform positioning of rice bushes (Rahimpour *et al.*, 2013). Seedlings hill^{-1} influences tiller formation, solar radiation interception, nutrient uptake, photosynthesis rate, and other physiological processes, all of which influence rice plant growth and development (Bozorgi *et al.*, 2011). Higher seedling hill^{-1} can lead to intense competition amongst plants, which can result in progressive shade and lodging, as well as an increase in straw output rather than grain. The number of seedlings per hill had a significant impact on the overall number of tillers per hill and total dry matter production. Rice yield is determined by many growth characteristics such as leaf area index, dry matter production and partitioning, tillering, and so on (Shams, 2002).

Clipping rice seedlings lowers the pressure of seedlings hill^{-1}, which aids in the creation of vigor seedlings hill^{-1}. Seedlings with a vigorous pattern of growth may compete effectively under stress and influence standing and eventually improve the production of grain by raising the tillers hill^{-1}, filled grains panicle^{-1}, panicle length etc. Extreme clipping, on the other hand, might have a detrimental influence on grain yield production. Besides the clipping parts of seedling may be an option as livestock feedings.

In rice, growing leaves are critical organs for photosynthesis, which is a major process that influences crop development rates and is influenced by the quantity or area of the leaves. In Bangladesh, the leaf cutting procedure must be used to enhance productivity vertically. Rice leaf clipping is a farmer's wisdom for a variety of reasons including minimizing wind damage due to overly heavy leaves, weed elimination, easier insect control, lower rice pest and weeding costs, uniform plant height, motivating all plants to bloom at the same time, and efficiency of harvesting. Leaf clipping in transplanted seedlings may have the ability to translocate assimilate towards the root zone, allowing for early seedling establishment and increased plant development (Paez *et. al.*, 1995). Leaf clipping throughout the reproductive and ripening stages of the rice crop has a direct relationship with biomass production and grain yield (Ray *et al.*, 1983). The top three leaves translocate assimilate towards grain filling, according to the observations of Misra and Misra (1991) in pearl millet and Mae (1997) in rice. The top three leaves have the greatest impact on grain yield (Yoshida, 1981; Misra, 1987). Leaf clipping in transplanted aman rice can help to decrease transplant shock (Bardhan and Mandal, 1988).

The length of rice leaf clippings should be some 30 cm at 30-60 days after planting and before flowering. It can be cut several times but the flag leaf should not be cut as this is the most significant source of photosynthetic energy during reproduction (Evans and Rawson, 1970). The flag leaf has a significant impact on rice growth and production. Flag leaf can provide up to 45 percent of rice grain output, and when it is removed, it becomes the primary contributor to rice yield loss (Abou-Khalifa *et al.*, 2008). After heading, a range of 60-90 percent of the total carbon content in the panicles is obtained from photosynthesis, whereas around equal to or more than 80 percent of nitrogen in the panicles is absorbed before heading and remobilized from vegetative organs such as roots, stems, leaves, and reproductive organs (Mae, 1997). In the case of wheat, however, a 34.5 percent loss in grain yield was recorded after the flag leaf was clipped at the heading stage (Mahmood and Chowdhury, 1997). Given the importance of leaves for grain productivity, it is vital to investigate the morphological and physiological properties of functional leaves in order to increase rice grain yield (Yue *et al.*, 2006). Removing the flag leaf reduced grain per spike, grain weight per spike, and 1000-grain weight by 13, 34, and 24 percent, respectively, and increased grain protein content by 2.8 percent. On the other hand with the presence of flag leaf, rice grain and straw yields increased dramatically (Birsin, 2005).

Therefore, this study was aimed to examine the effect of seedling and leaf clipping on growth, yield components and yield of recently released aromatic rice variety, BRRI dhan80. Under the above circumstances, the present experiment was undertaken with the following objectives:

- ✓ to determine the effect of seedling clipping on growth and yield of aromatic rice
- ✓ to determine the optimal leaf clipping for better production of aromatic rice, and
- ✓ to screen out the combined effect of seedling clipping and growing plant leaf clipping on growth and yield of aromatic rice.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Rice is a versatile crop that can thrive in a variety of environments. Rice's growth and development may be influenced by its cultivation methods. The rice plant's leaf is a vital component and a key source of photosynthetic activity. Leaf cutting at the seedling stage or after seedling transplantation can have an influence on rice's unique growth and production characteristics. By way of manipulating the partitioning physiology, physiological characteristics including leaf number, leaf area, dry matter accumulation, translocation, and regulation of assimilate connection between shoot and root,the grain yield potentiality of rice could be influenced. The work on leaf cutting that has been done in Bangladesh thus far has been insufficient and conclusive. In this section, an attempt was made to gather and study relevant information accessible in the country and worldwide in order to gain knowledge that would be useful in performing the current research and then writing up the results and discussion. In this chapter, some of the most significant and instructive publications and research findings on the effects of leaf clipping on rice growth and yield have been presented and discussed under the following headings and sub-headings:

2.1 Impacts of leaf clipping on growth contributing characters

Plant height

Karmaker and Karmakar (2019) conducted a study to evaluate that N-rates and leaf cutting affect forage and grain yield, as well as seed quality, in transplant aman (wet season) rice. Following a split-plot design with three replications, four nitrogen (N) rates (N_1=46, N_2=69, N_3=92, and N_4=115 kg N ha^{-1}) and four times of leaf clipping (C_0= no leaf clipping, C_1= leaf clipping at 25 DAT (Days after transplanting), C_2= 40, and C_3=55 DAT) were assessed. They observed that C_0 (no leaf clipping) had the maximum plant height (128.95 cm), whereas C_3 (leaf clipping time at 55 DAT) had the lowest plant height (116.83 cm). According to the findings, plant height considerably reduced in later leaf cut treatments compared to no and early cuttings.

Roy and Pradhan (1992) observed that the no leaf cutting treatment resulted in the highest value of plant height at all observation dates. The lowest plant height values were recorded at 28, 34, 42, and 49 DAT, as well as at maturity when the leaf cutting was done at 21, 28, 35, 35, and 35 DAT, respectively.

Sherif *et al.* (2015) conducted an experiment during 2013-2015 to determine the influence of leaf removal on rice growth parameters and yield. Defoliation levels of 0, 20, 40, 60, 80, and 100% were sprayed one month after transplanting in the experiment. They found that the rice plants in the control (non-defoliated) plots grew to be almost as tall as the defoliated plots, with heights of 92.60 and 91.55 cm in the first and second seasons, respectively. Defoliation at 20% or 40% in the first season and 20%, 40%, or 60% in the second season resulted in somewhat shorter rice plants, ranging between 91.80 and 92.64 cm and 89.50-90.65 cm, respectively, but with no significant changes when compared to the control. However, when 60, 80, or 100% of the leaves were removed in the first season, plant heights ranged from 90.00 to 90.50 cm, and when 80 or 100% of the rice plants were defoliated in the second season, plant heights ranged from 87.00 to 87.05 cm.

Ayutthaya (2011) conducted an experiment and stated that rice leaf cutting length of 30 cm was recommended 30–60 days after planting and prior to flowering. It is common to cut it on various occasions, however the flag leaf should not be clipped. Rice leaf cutting 60 days after planting had a significant impact on plant height and flowering uniformity.

Medhi *et al.* (2015) conducted a field trial to investigate the effect of foliage pruning on the growth and yield of two land rice varieties, TTB-3031-42 (Dhansiri) and TTB3031-23 (Difalu), grown in a rain-fed low land condition (50–100 cm water profundity) during the wet season. Expulsion of foliage several times considerably reduced plant height and prevented lodging, according to test data.

Total dry matter weight

Sherif *et al.* (2015) conducted an experiment between 2013 and 2015 to determine the influence of leaf removal on rice growth parameters and yield. The experiment included defoliation levels of 0, 20, 40, 60, 80, and 100% applied one month after transplanting. According to the results of the experiment, the highest dry matter content was found in the check or 20% defoliation, with levels of 1215.00 and 1103.60 g m-2 in the first season. In the second season, the comparable dry matter values were 1061.10 and 1164.94 g m-2. The first season saw a significant fall in dry matter content at 80 or 100 % defoliation (938.15 and 765.00 g m-2, respectively). In the second season, defoliation rates of 60%, 80%, and 100% resulted in low levels of dry matter content of 866.11, 861.26 and 840.04 g m-2, respectively.

.

Misra (1986) demonstrated that leaf cuttings had a significant effect on leaf area (cm^2) $plant^{-1}$, chlorophyll content (SPAD units), total dry matter (TDM) production, panicle length, spikelet number, number of grains per panicle, test weight (1000 grain weight), and grain yield (t ha^{-1}) of hybrid rice cultivar H5 and inbred Egyptian local cultivar Sakha 103. Under the control condition, with no leaf cutting, all of the parameters showed their maximum value.

Ros *et al.* (2003) conducted an experiment to investigate the concept of transplanted rice seedling vigor and to determine which plant characteristics conferred vigor on the seedlings. To determine the effect of leaf clipping or root pruning and water stress on plant growth after transplanting, seedling vigor treatments were established by subjecting seedlings to short-term submergence (0, 1 and 2 days/work) in one experiment and leaf clipping or root pruning and water stress in another. Pruning 30% of the leaves reduced shoot and root dry matter by 30% at panicle initiation (PI) and root dry matter by 20% at maturity. On shoot, root, and straw dry matter, the combined impacts of leaf trimming and root pruning were essentially additive. It was determined that the response of rice production to nursery treatments is mostly due to improved seedling vigor and can be influenced by a variety of nutritional and nonnutritional seedling treatments that increase seedling dry matter, nutrient content, and nutrient concentration. In the nursery, poor leaf growth and, to a lesser extent, poor root growth reduced seedling vitality after transplantation. Instead of enhancing stress tolerance, seedling vigor was more advantageous when post-transplant development was not constrained by nutritional or water stresses.

Osunkoya *et al.* (1994) revealed that removing all leaves except the most apical expanded leaf resulted in a decrease in all parameters measured, with total biomass being around 20% of the control value. Although the leaf dry mass of seedlings with only three leaves or with one-third of all leaves (average of 7.8 leaves) was lower when compared to control values, total biomass was significantly higher for seedlings in the one-third leaf treatment, but not significantly different from the control value in seedlings in the three-leaf treatment. Root dry mass increased significantly in response to the three-leaf and one-third leaf treatments, although stem dry mass was unaffected. The height of seedlings with one-third of their leaves was not different from the control values, although there was a considerable fall in height.

2.2 Impacts of leaf clipping on yield contributing characters

Effective tillers hill^{-1}

Fatima *et al.* (2019) conducted an experiment to investigate the influence of flag leaf clipping on the growth yield and yield characteristics of hybrid rice varieties during the Boro season. The experiment had two components. Factor A: Flag leaf cutting: T_1= Flag leaf cutting at heading; T_2= Control (without cutting). 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 are the six hybrid rice types. Regardless of variation, all of the examined characteristics outperformed the control treatment. Under control conditions, Heera 4 had the maximum number of effective tillers hill^{-1}.

Hachiya (1989) reported that the maximum value of total tillers hill^{-1} for observations at 28, 35, 42, 48 DAT, and at maturity were obtained in the control, whereas the lowest at the same date of observations were obtained when leaf cutting was done at 21, 21, 28, 28, and 35 DAT, respectively.

Medhi *et al.* (2015) conducted a field trial to determine the effect of foliage pruning on the growth and yield of two low land rice varieties, TTB-303-1-42 (Dhansiri) and TTB-303-1-23 (Difalu), during the wet season of 2010 and 2011. According to experimental results foliage pruning up to 100 days after germination (DAG) had no negative impact on crop tillers.

Daliri *et al.* (2009) carried out a field experiment to investigate the effect of cutting time and cutting height on yield and yield contributing characteristics of the Tarom langrodi variety of ratoon rice (*Oryza sativa* L.). The impact of cutting time on the number of effective tiller hill^{-1} was shown to be statistically significant. Cutting height has a substantial effect on the quantity of tillers in the hill and the number of effective tillers in the hill. There was a substantial interaction between cutting time and cutting height on the number of tiller hill^{-1} and the number of viable tillers hill^{-1}.

Non-effective tillers hill^{-1}

Ahmed *et al.* (2001) conducted a study to investigate the effect of nitrogen rate and timing of leaf cutting on rice green fodder and seed yield. The test had two components: (A) Nitrogen levels– i.e. 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) Leaf cutting time– *viz.* i) C_0–No cutting (control), ii) C_1Cutting at 21 DAT, iii) C_2–Cutting at 35 DAT and iv) C_3–Cutting at 49 DAT The highest number of non-bearing tillers hill^{-1} was observed in the no leaf cutting treatment, which was actually similar to leaf cutting at 21 DAT, and the lowest was observed in the leaf cutting treatment at 49 DAT.

Panicle length

Das *et al.* (2017) revealed that leaf clipping had no influence on panicle length in modern and local rice varieties.

Boonreund and Marsom (2015) conducted a study to establish the ideal cutting length for Pathum Thani1 rice leaf for increased production. The study consisted of 7 treatments of cutting lengths (0, 5, 10, 15, 20, 25, and 30 cm from the leaf tip) conducted by sickle 60 days after planting. Cutting leaves had little effect on rice panicle length, according to the findings.

Rahman *et al.* (2013) conducted an experiment to determine the correlation analysis of flag leaf with yield in several rice varieties. They revealed that when the FL length is long, the panicle length is similarly long. In the instance of BR11, the average FL length was 21.33, 25.90, 28.19, 37.33, 18.28, 37.84, 37.59, 25.90, 24.13, 35.50 cm, and the average panicle length was 18.03, 18.54, 20.32, 34.98, 17.52, 33.87, 33.36, 19.85, 22.60, 31.65 cm, with a significant correlation found in correlation analysis. In the case of BRRI dhan28, a similar substantial finding was discovered. Yield was shown to be strongly and positively related to panicle length. They also observed that flag leaf length was positively related to panicle length, implying that it was related to grain yield.

Grain panicle^{-1}

Karmaker and Karmakar (2019) carried out an experiment and revealed that in BRRI dhan41, the highest mean number of grains panicle^{-1} (118) was obtained in C_0 (no leaf clipping) and the lowest number of grains panicle^{-1} (106) was acquired from C_3 when leaf clipped at 55 DAT and concluded that forage removal at later stages of crop growth reduce photosynthetic leaf area, resulting in lower carbohydrate accumulation.

Ahmed *et al.* (2001) carried out an experiment with four varieties: Latishail, BR10, BR11, and BRRI dhan32, as well as four leaf cuttings: 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 effect of leaf cutting on growth parameters such as plant height, total number of tillers, and leaves hill^{-1} at various days after transplantation was significant. The highest plant height, total tillers hill^{-1}, productive tillers hill^{-1}, non-bearing tillers hill^{-1}, panicle length, grains panicle^{-1}, sterile grains panicle^{-1}, grain yield, straw yield, cumulative straw yield, biological yield and harvest index were obtained in no leaf cutting (control) which were observed in all investigated types. Leaf cutting reduces yield and yield contributing characteristics as compared to the control. At 35 DAT, Latishail leaf cutting resulted in considerably better forage production. The maximum grain yield was attained when no leaf cutting was used, which was statistically equivalent to leaf cutting at 21 and 28 DAT. It is possible to assume that leaf cutting at an early stage of crop growth could create almost identical grain or seed yields to regulate crops while also providing additional fodder production.

Hossain (2017) carried out a study to investigate the impact of leaf cutting on plant growth and yield of selected BRRI-released Aman varieties. The experiment had 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; Factor B: two leaf cutting, T_1= Leaf cutting (excluding flag and penultimate leaves), T_2= control (no leaf cutting). The maximum grains panicle^{-1} (105.63) was produced in no leaf cutting (control) treatment rather than leaf cutting treatment (94.73 grains panicle^{-1}).

Filled grains panicle^{-1}

Misra (1986) reported that leaf cuttings had a significant effect on leaf area (cm^2) plant^{-1}, chlorophyll content (SPAD units), total dry matter (TDM) production, panicle length, spikelet number, number of grains per panicle, test weight (1000 grain weight), and grain yield (t ha^{-1}) of hybrid rice cultivar H5 and inbred Egyptian local cultivar Sakha 103. Under the control condition, with no leaf cutting, all of the parameters showed their maximum value.

Mannan (1996) conducted an experiment and stated that panicle length varied among varieties. In comparison to BR10 and BRRI dhan32, BR11 had the highest grains panicle^{-1} (97.21), 1000-grain weight (22.11 g), grain yield (4.84 t ha^{-1}), biological yield (10.16 t ha^{-1}) and harvest index (46.80%).

Das *et al.* (2017) conducted an experiment to examine the effect of leaf clipping on yield attributes of modern and local rice varieties and revealed that in Binadhan-8, the highest number of filled grain panicle^{-1} was found in plants without leaf cutting (104.00), which did not differ significantly from the second and third leaf cut. Flag leaf cut (35.14%), flag leaf with 2nd leaf cut (62.62%), and flag leaf with 2nd and 3rd leaf cut all result in significant reductions in filled grains (51.83%).

Ahmed *et al.* (2001) conducted an experiment to investigate the influence of nitrogen rate and timing of leaf cutting on rice green fodder and seed yield. The experiment has two components: (A) Nitrogen levels– 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) Leaf cutting time – i.e. i) C_0–No cutting (control), ii) C_1–21 DAT cutting, iii) C_2–35 DAT cutting and iv) C_3–49 DAT cutting. The maximum number of sterile spikelets panicle^{-1} was observed for the no leaf cutting condition, which was statistically equal to cutting at 21 DAT. Cutting at 49 DAT resulted in the lowest number of sterile spikelets panicle^{-1}.

Usman *et al.* (2007) conducted an experiment to investigate the effect of detopping on rice forage and grain yield. The experiment included six treatments: control (T_1), 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). The control (no detopping) treatment produced the most spikelets panicle^{-1} (106.8) and perhaps the most filled grains panicle^{-1} (90) of all the other six treatments.

Unfilled grains panicle^{-1}

Moballeghi *et al.* (2018) conducted an experiment to investigate the influence of source-sink constraints on agronomic attributes and grain production of different rice lines. The field experiment was conducted in 2013 at the Chaparsar Rice Research Station in Mazandaran province as a factorial in a randomized complete block design with four replications. The treatments were source-sink limitation in four levels (including cutting of flag leaf, cutting of one-third of panicle, cutting of other leaves except flag leaf, and control or without limitation) and rice lines in four levels (line of No. 3, line of No. 6, line of No. 7, and line of No. 8). Among different source-sink limitation treatments, increased the panicle length and unfilled grain number per panicle and decreased the panicle fertility percentage, when all leaves except flag leaf removed.

Das *et al.* (2017) conducted an experiment to study the effect of leaf clipping on yield attributes of modern and local rice varieties and discovered that in Binadhan-8, unfilled grain number increased with increased intensity of leaf cutting and was highest (79.40) in flag leaf with 3rd leaf cut, which was similar to flag leaf with 2nd leaf cut (65.91). The control had the lowest empty grain (33.99), which did not vary with 3rd leaf cut alone (39.57). The flag leaf cut and the second leaf cut had similar and moderate values.

Total grains panicle^{-1}

Aktaruzzaman (2006) conducted an investigation into source-sink regulation and its impact on grain output in rainfed rice varieties. In source-sink control, there were nine treatments: T_0= Control, T_1= Flag leaf defoliation, T_2= Penultimate leaf defoliation, T_3= Tertiary leaf (Third leaf defoliation), T_4= Banner leaf and penultimate leaf defoliation, T_5= Banner leaf, penultimate leaf and tertiary leaf defoliation, T_6= Defoliation, everything else being equal, T_7= Defoliation of all leaves excluding the banner leaf and T_8= Removal of half spikelets. It was discovered that flag leaf defoliation resulted in a 17.34% decrease in spikelets per panicle. Similarly, the expulsion of the penultimate leaf resulted in a 10.98% decrease in spikelets per panicle. Similarly, defoliation of the third leaf resulted in a 7.20% drop in spikelets per panicle. Similarly, defoliation of the flag leaf, penultimate leaf, and third leaf at the same time resulted in a 29.20 % reduction in spikelets per panicle.

Usman *et al.* (2007) conducted an experiment to investigate the effect of detopping on rice forage and grain yield. The trial included six treatments: control (T_1), 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). The control (no detopping) treatment produced the most spikelets panicle^{-1} (106.8) and the most filled grains panicle^{-1} (90) of all the other six treatments.

Ghosh and Sharma (1998) found that early leaf cutting yielded more grains panicle^{-1} than late leaf cutting. The lowest value for all crop attributes was observed when the leaf was cut at 35 DAT.

1000 grain weight

Fatima (2019) conducted an experiment to investigate the influence of flag leaf clipping on the growth yield and yield characteristics of hybrid rice varieties during the Boro season. There were two components to the test. Factor A: Flag leaf removal: T_1= Flag leaf trimming at heading; T_2= Control (without cutting). Factor B consists of six hybrid rice varieties: V_1 denotes BRRI hybrid dhan1, V_2 denotes BRRI hybrid dhan2, V_3 denotes Heera2, V_4 denotes Heera 4, V_5 denotes Nobin and V_6 denotes Moyna. Following flag leaf cutting, the chlorophyll content (SPAD value) in the penultimate leaf 15 days after heading, grain filling duration, yield contributing characters, and yield were all measured. Despite the variability, all of the tested variables showed majority in the control treatment. Under regulated conditions, Heera 4 had a maximum weight of 1000 grains.

Mannan (1996) conducted an experiment and stated that panicle length varied among varieties. In comparison to BR10 and BRRI dhan32, BR11 had the highest grains panicle^{-1} (97.21), 1000-grain weight (22.11 g), grain yield (4.84 t ha^{-1}), biological yield (10.16 t ha^{-1}) and harvest index (46.80%).

Das *et al.* (2017) reported that leaf clipping had no effect on 1000 grain weight in modern varieties but was significant in local varieties.

Ahmed *et al.* (2001) revealed that the effect of leaf cutting was considerable in terms of crop characteristics except for 1000-grain weight. The control had the highest value of productive tillers hill^{-1} (9.19), panicle length (23.52 cm), sterile grains (18.68), grains panicle^{-1} (92.69), 1000-grain weight (22.72 g), 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%).

Sherif *et al.* (2015) revealed that defoliation at 0, 20, 40, or 60 % resulted in statistically identical 1000-grain weights, ranging between 21.87 and 23.18 g in the first season (2013) and between 27.47 and 29.21 g in the second season (2014). In the first and second seasons, the lowest 1000-grain values were obtained at 80% (20.73 and 26.67 g) and 100 % (20.28 and 24.71 g), respectively.

Hossain (2017) conducted an experiment to assess the effect of leaf cutting on plant growth and yield of selected BRRI-released Aman varieties. The experiment had two components: 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; Factor B: two leaf cutting, T_1= Leaf cutting (except flag and penultimate leaves) and T_2= Control (no leaf cutting). The maximum weight of 1000 grains was obtained in the no leaf cutting (control) treatment regardless of the varieties under study. When compared to the control, leaf cutting reduced yield and yield contributing characters. The weight of 1000 grains was significantly reduced in plants that had their leaves cut compared to plants in the control treatment.

2.3 Impact of leaf clipping on yield characters

Grain yield

Fatima (2019) conducted an experiment in Boro season to investigate the impact of flag leaf clipping on hybrid rice variety growth, yield, and yield attributes. There were two components to the experiment. Factor A: Flag leaf clipping: T_1= flag leaf clipping at the top and T_2= control (without clipping). 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. 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. In the control condition, all of the test varieties outperformed the others. Clipping of flag leaf enhanced chlorophyll and nitrogen content (SPAD value) in the penultimate (1.35% to 17.27%) and grain filling duration (4.5 to 6.25 days). Under control conditions, Heera 4 produced the highest grain yield. In the test Boro rice cultivars, cutting the flag leaf lowered grain production from 15.69% to 29.43%.

Mannan (1996) conducted an experiment and stated that panicle length varied among varieties. In comparison to BR10 and BRRI dhan32, BR11 had the highest grains panicle^{-1} (97.21), 1000-grain weight (22.11 g), grain yield (4.84 t ha^{-1}), biological yield (10.16 t ha^{-1}) and harvest index (46.80%).

Karmaker and Karmakar (2019) conducted an experiment to explore the effects of Nrates and leaf cutting on forage and grain yield, as well as seed quality, in transplant Aman (wet season) rice. Four nitrogen (N) rates (N_1=46, N_2=69, N_3=92, and N_4=115 kg N ha^{-1}) and four leaf clipping times (C_0=no leaf clipping, C_1=leaf clipping at 25 DAT), C_2=40 DAT, and C_3=55 DAT) were tested using a split-plot design with three replications. They discovered that the treatment combination of 115 kg N ha^{-1} and no leaf clipping (N_4C_0) produced the highest mean grain yield (5.25 t ha^{-1}) when compared to other treatments.

Das and Mukherjee (1992) conducted an experiment and reported that late leaf cutting reduce the grain yield.

Hossain (2017) conducted an experiment to determine the influence of leaf cutting on plant growth and yield of chosen BRRI-released Aman varieties. The experiment had two components: 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; Factor B: two leaf cutting, T_1= Leaf cutting (excluding flag and penultimate leaves) and T_2= Control (no leaf cutting). Regardless of the types studied, the highest grain production was attained when no leaf cutting was used (control). Leaf cutting reduced yield and yield contributing features when compared to the control. BRRI dhan33 yielded substantially more than the other types in the control (control 6.75 t ha^{-1}, treated 4.75 t ha^{-1}). The highest grain yield (6.75 t ha^{-1}) was attained when no leaf cutting was used.

Leaf cutting (except for the flag and penultimate leaves) reduced grain yield loss by 10 to 28 %. Due to leaf cutting, there was also a remarkable difference in grain filling duration among the different kinds. Grain yield was reduced by leaf cutting the lowest (10 %) in BRRI dhan39 (control 5.75 t ha^{-1}, treated 5.15 t ha^{-1}) than in the other varieties.

Abou-Khalifa *et al.* (2008) revealed that flag leaf contributes 45 % of grain yield and flag leaf removal is the single most important factor in yield loss.

Ros *et al.* (2003) revealed that pruning 30 % of the leaves reduced grain yield by 20 %.

Boonreund and Marsom (2015) conducted an experiment to determine the ideal length of cutting for Pathum Thani1 rice leaf in order to maximize production. The length of rice leaf cutting was found to have a positive effect on broadcasting Thai jasmine rice yield, but this was not confirmed in other varieties. The study included 7 treatments of cutting lengths (0, 5, 10, 15, 20, 25, and 30 cm from the leaf tip) conducted by sickle 60 days after planting. The findings revealed that trimming leaves had little influence on yield. Grain yield increased considerably after cutting. The optimal length of rice leaf cutting was found to be 15–30 cm, which resulted in the maximum grain production.

Misra (1986) demonstrated that leaf cuttings had a significant effect on leaf area (cm^2) $plant^{-1}$, chlorophyll content (SPAD units), total dry matter (TDM) production, panicle length, spikelet number, number of grains per panicle, test weight (1000 grain weight), and grain yield (t ha^{-1}) of hybrid rice cultivar H5 and inbred Egyptian local cultivar Sakha 103. Under the control condition, with no leaf cutting, all of the parameters showed their maximum value.

Khatun *et al.* (2011) revealed that flag leaf cutting produced the lowest grain yield of rice in their study on the effects of leaf cutting on rice growth and yield.

Prakash *et al.* (2011) revealed that in rice cultivars, grain yield was positively related to flag leaf area.

Straw yield

Hossain (2017) conducted an experiment to determine the influence of leaf cutting on plant development and yield of BRRI-released Aman varieties. The experiment included two components: 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; Factor B: two leaf cutting, T_1= Leaf cutting (excluding flag and penultimate leaves) and T_2= Control (no leaf cutting). Regardless of the types studied, the maximum straw production was achieved when no leaf cutting was used (control).

Mannan (1996) conducted an experiment and stated that panicle length varied among varieties. In comparison to BR10 and BRRI dhan32, BR11 had the highest grains panicle^{-1} (97.21), 1000-grain weight (22.11 g), grain yield (4.84 t ha^{-1}), biological yield (10.16 t ha^{-1}) and harvest index (46.80%).

Ahmed *et al.* (2001) conducted an experiment to determine the influence of preflowering leaf cutting on forage and seed yield of transplant aman rice. The feasibility of using rice for both human and animal use at the same time was investigated. The experiment included four varieties: Latishail, BR10, BR11 and BRRI dhan32 as well as four leaf cuttings: no leaf cutting (T_1), 21 DAT leaf cutting (T_2), 28 DAT leaf cutting (T_3) and 35 DAT leaf cutting (T_4). The results showed that among the kinds and leaf cutting treatments, the Latishail variety with leaf clipping at 35 DAT yielded substantially more forage. The maximum straw yield (5.60 t ha^{-1}) was recorded in the control. When compared to the control, leaf cutting reduced yield and yield contributing characteristics. When the leaf was cut at 35 DAT, the lowest value for all crop characteristics was recorded. Leaf cutting at an early stage of crop growth (28 DAT for investigated contemporary varieties and 35 DAT for Latishail) might provide grain or seed yields that are almost identical to control crops while adding forage yield.

Biological yield

Fatima (2019) conducted an experiment to investigate the influence of flag leaf cutting on the growth yield and yield characteristics of hybrid rice varieties during the Boro season. The experiment included two components. Factor A: Flag leaf clipping:

T_1= Flag leaf clipping at heading and T_2= Control (without clipping). 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 are the six hybrid rice types. Under regulated conditions, Heera 4 had the highest biological yield.

Usman *et al.* (2007) conducted an experiment to investigate the impact of detopping on rice forage and grain yield. The experiment included six treatments: control (T_1, no detopping), 22 DAT detopping (T_2), 29 DAT detopping (T_3), 36 DAT detopping (T_4), 43 DAT detopping (T_5) and 50 DAT detopping (T_6). The control (no detopping) treatment produced the highest biological yield (9.6 t ha^{-1}) of all the six treatments.

Harvest index

Karmaker and Karmakar (2019) conducted an experiment to evaluate the effects of Nrates and leaf clipping on forage and grain yield, as well as seed quality, in transplant Aman (wet season) rice. Four nitrogen (N) rates (N_1=46, N_2=69, N_3=92 and N_4=115 kg N ha^{-1}) and four leaf clipping timings (C_0= no leaf clipping, C_1= leaf clipping at 25 DAT, C_2= 40 DAT and C_3= 55 DAT) were tested using a split-plot design with three replications. They discovered that the treatment combination of 115 kg N ha^{-1} and no leaf clipping (N_4C_0) produced the greatest mean harvest index (46%) when compared to other treatment combinations.

Mannan (1996) conducted an experiment and stated that panicle length varied among varieties. In comparison to BR10 and BRRI dhan32, BR11 had the highest grains $panicle^{-1}$ (97.21), 1000-grain weight (22.11 g), grain yield (4.84 t ha^{-1}), biological yield (10.16 t ha^{-1}) and harvest index (46.80%).

Usman *et al.* (2007) conducted an experiment to investigate the effect of detopping on rice forage and grain yield. The trial included six treatments: control (T_1), 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). The control treatment had the greatest harvest index (42.70%) of all six treatments (no detopping).

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter provides a brief description of the experimental site, climate, soil, soil preparation, planting materials, treatments, experimental design, soil preparation, application of fertilizers, transplantation, irrigation and drainage, intercultural operation, data collection, data recording and analysis of the materials and methods of the experiment. Details of the investigation to achieve the stated objectives are outlined below.

3.1 Site description

The experiment was conducted during the period from July to November 2019 at the research farm of Sher-e-Bangla Agricultural University, Dhaka-1207. The experimental site was located at 23°74′ N latitude and 90°35′ E longitudes at an altitude of 8.2 m.

3.2 Agro-ecological region

The experimental site belongs to the "Madhupur Tract" agro-ecological zone, AEZ-28 (Anon., 1988a). This was an area of complex relief and soils created above the Madhupur clay, where the analyzed edges of the Madhupur Tract were covered by floodplain sediments, leaving small hills of red soils as „islands‟ encompassed by floodplain (Anon., 1988b). The experimental site is shown for better understanding in the AEZ of Bangladesh in Appendix I.

3.3 Climate and weather

The geographical location of the experimental site was characterized by three specific seasons in the sub-tropical climate, namely the monsoon or rainy season from May to October, associated with high temperatures, high humidity and heavy rainfall; the winter or dry season from November to February, associated with moderately low temperatures; and the pre-monsoon period. Information on the monthly maximum and minimum temperature, rainfall, relative humidity and sunshine during the period of the experimental site study was collected from the Meteorological Department of Bangladesh, Agargaon, and is provided in Appendix II.

3.4 Soil characteristics

The experiment was conducted in the typical rice-growing soil of the Madhupur Tract. Top soil was silty clay in texture, red brown terrace soil type, olive-gray with common fine to medium dark yellowish brown mottles. The pH of the soil was 5.6 and the organic carbon was 0.45%. With good irrigation facilities, the experimental land was well drained. The experimental site was a medium-high land. It was above the level of the flood. During the experimental period, sufficient sunshine was available. Soil series: Tejgaon, General soil: Non-calcareous Dark Grey (Appendix III). The morphological characteristics of the soil of the experimental plots are as follows. Appendix III presents the physicochemical properties of the soil.

3.5 Crop/planting material

BRRI dhan80 was being used as test crops for this experiment. **3.6 Description of the planting material**

Variety: BRRI dhan80	
Main Features of the Variety	
Developed by	Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh
Method of development/origin	Hybridization
Year of release	2017
Main characteristics	High yielding aromatic variety, plant height 120 cm, plant stout, tiller dense on the base of plant, not lodging, grain medium slender, 1000 grain weight 26.2 g, crop duration 120 days.
Planting season and time	Aman, seedling in seed bed 25 June-10 July
Harvesting time	Last week of November
Yield	4.5-5 t ha^{-1}
Quality of product	23.6% amylose content and 8.5% protein content

3.7 Seed collection and sprouting

The seeds of BRRI dhan80 rice variety were collected from BRRI (Bangladesh Rice Research Institute), Joydebpur, Gazipur. Healthy and disease free seeds were selected following the standard technique. Healthy seeds were selected by specific gravity strategy and subsequently immersed for 24 hours in water containers and then kept tightly in gunny bags in the wake of the disposal of water in containers. The seeds began to grow after 3 days and were planted in a nursery bed.

3.8 Preparation of nursery bed and seed sowing

According to BRRI recommendation seedbed was prepared with 1 m width. Sufficient amount of sprouted seeds were sown in the seedbed in order to have seedlings of 30 days old. Irrigation was delicately given to the bed as and when required. No fertilizers were used in the nursery bed.

3.9 Preparation of main field

The selected plot for the experiment was opened with a power tiller on 17 July 2019 and was exposed to the sun for a week. The chosen soil was harrowed, ploughed and cross-ploughed several times on 24 July 2019, followed by laddering to obtain a good tilth. Weeds and stubbles were removed and finally a desired tilth was acquired for seedlings transplanting.

3.10 Fertilizer management

The following doses of fertilizer were applied for cultivation of T. aman rice (BRRI, 2016).

Fertilizers	Quantity (kg ha^{-1})
Urea	130
TSP	120
MoP	70
Gypsum	60
Zinc sulphate	10

Fertilizers were applied as recommended doses to each plot. Fertilizers such as Urea, TSP, MoP, Gypsum and Zinc sulphate have been used as sources for N, P, K, S and Zn, respectively. Full doses of all fertilizers and one third of urea were applied as a basal dose to each plot during final land preparation at the time of final soil preparation by means of a broadcasting method. The first urea split was applied on 21 days after transplantation (DAT) and the second urea split was applied as top dressing at 45 DAT at the maximum tilling stage and third dose was applied at 60 DAT (panicle initiation stage) as recommended by BRRI (2016).

3.11 Experimental design and layout

The experiment was laid out in split-plot design having 3 replications. In main plot there was seedling clipping treatment and in sub plot there was leaf clipping treatment. There were 15 treatment combinations and 45 unit plots. The unit plot size was 5.76 m^2 (2.4 m × 2.4 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing, respectively. The layout of the experimental field was shown in Appendix- IV.

3.12 Experimental details

Seed bed preparation Date: 30 June 2019 **Seed Sowing Date:** 30 June 2019
Spacing: 15 cm × 20 cm
Fertilizer apply Date: All the fertilizers were applied at 24 July 2019 during final land preparation except total urea **Transplanting Date:** 30 July 2019
Harvesting Date: 5 December 2019

3.13 Experimental treatments

The experiment consisted of two factors as mentioned below:

Factor A: Seedling top clipping (3) *viz:*

S_0= Control (no clipping)

S_1= 1/3rd clipping

S_2= 1/2nd clipping

Factor B: Leaf clipping before panicle initiation(5) *viz:*

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

3.14 Experimental treatment combinations

Treatment Combinations	
S_1L_0	No seedling clipping × Control (no leaf clipping)
S_1L_1	No seedling clipping × Lower 1+2 leaves
S_2L_0	No seedling clipping × Lower 2+3 leaves
S_1L_3	No seedling clipping × Lower 3 +4 leaves
S_1L_2	No seedling clipping × Flag leaf clipping
S_0L_0	1/3rd top clipping × Control (no leaf clipping)
S_0L_2	1/3rd top clipping × Lower 1+2 leaves
S_2L_1	1/3rd top clipping × Lower 2+3 leaves
S_2L_2	1/3rd top clipping × Lower 3 +4 leaves
S_1L_4	1/3rd top clipping × Flag leaf clipping
S_0L_1	1/2nd top clipping × Control (no leaf clipping)
S_0L_3	1/2nd top clipping × Lower 1+2 leaves
S_2L_3	1/2nd top clipping × Lower 2+3 leaves
S_0L_4	1/2nd top clipping × Lower 3 +4 leaves
S_2L_4	1/2nd top clipping × Flag leaf clipping

3.15 Intercultural operations

3.15.1 Clipping

Both seedling and leaf clipping were done according to the treatment requirements.

3.15.2 Gap filling

Minor gap filling was done at 7–10 DAT with the same aged seedlings from the same source.

3.15.3 Irrigation and drainage

The experimental field was irrigated with adequate water and was maintained throughout the period of crop growth. Flood irrigation was provided to maintain 3-5 cm of water in the rice field as and when necessary. A good drainage facility for the immediate release of excess rainwater from the field has also been maintained.

3.15.4 Weeding

Some common weeds infested experimental plots, which were removed twice by uprooting. The first weeding of each plot was done at 20 DAT and the second weeding of each plot was done at 40 DAT.

3.15.5 Plant protection measures

In the experimental plots, some plants were infested with rice stem borer, leaf roller and rice bug to some extent; which was successfully controlled by application of insecticides such as Diazinon and Ripcord @10 ml/10 liter of water for 5 decimal lands. The insecticides (Virtago + Advantage + Cypermethrine) were applied to controlled rice stem borer and leaf roller. Crop was protected from birds and rats during the grain-filling period. For controlling birds, scarecrow and net were given and watching was done properly; especially during morning and afternoon.

3.15.6 General observations of the experimental field

Regular observations were made to see the growth and visual difference of the crops, due to application of different treatment were applied in the experimental field. In general, the field looked nice with normal green plants. Incidence of stem borer, green leaf hopper, leaf roller was observed during tillering stage and there were also some rice bug were present in the experimental field. But any bacterial and fungal disease was not observed. The flowering was,however, not uniform,which may close clipping effects. Lodging occurred in local variety compared to hybrid variety due to rainfall.

3.15.7 Harvesting and post-harvest operation

Depending on the maturity of the plant, the rice plant is harvested. Harvesting was done from each plot manually. Harvesting began with 105 DAT and continued with up to 120 DAT. When 80% of the grains became golden yellow in color, the maturity of the crop was determined. The harvested crop was bundled separately from each plot, tagged correctly and brought to the threshing floor. Proper care was taken when rice seeds were harvested, threshed and cleaned. Fresh grain and straw weight were recorded plot wise. The grains have been cleaned and dried by the sun. The weight was adjusted to 12% moisture content. Straw has also been properly dried by the sun. Grain and straw yield plot^{-1} were eventually recorded and converted to t ha^{-1}. Ten (10) pre-selected hills per plot from which various data were collected; harvested separately, properly bundled, tagged separately from outside and then brought for grain and straw yield recording to the threshing floor.

3.16 Data collection

The data were recorded on the following parameters

Crop growth characters

i. Plant height (cm) at 20 day intervals
ii. Leaves hill^{-1}
iii. Leaf area hill^{-1}
iv. Tillers hill^{-1} at 20 day intervals
v. Above ground dry matter weight of plant at 20 day intervals

Yield contributing characters

i. Effective tillers hill^{-1}
ii. Non-effective tillers hill^{-1}
iii. Filled grains panicle^{-1}
iv. Unfilled grains panicle^{-1}
v. Total grains panicle^{-1}
vi. Weight of 1000 grains (g)

Yield

i. Grain yield (t ha^{-1})
ii. Straw yield (t ha^{-1})

iii. Biological yield (t ha^{-1})

iv. Harvest index (%)

3.17 Procedure of recording data

i) Plant height (cm)

Plant height was recorded in centimeter (cm) at the time of 20, 40, 60, 80 DAT and at harvest. Data were recorded as the average of same 5 hills selected at random from the outer side rows (started after 2 rows from outside) of each plot. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf before heading; and to the tip of panicle after heading.

ii) Leaves $hill^{-1}$ (no.)

The number of leaves $hill^{-1}$ was recorded at different stages of crop growth (20, 40, 60, 80 DAT and at harvest, respectively). The number of leaves of 5 randomly selected hills from the inner rows per plot was measured by counting the number of leaves of the plant and the mean value of the number of leaves was recorded.

iii) Leaf area $hill^{-1}$ (cm^2)

Leaf area was estimated manually by counting the total number of leaves $plant^{-1}$ and measuring the length and average width of leaf and multiplying by a correction factor of 0.75 (Yoshida, 1981). It was done at 20, 40, 60 and 80 DAT respectively.

Leaf area $hill^{-1}$ =

$$\frac{\text{urface area of leaf sample (cm}^2\text{)} \quad \text{No of leaves hill} \quad \text{orrection factor}}{\text{No of leaves sampled}}$$

iv) Tillers $hill^{-1}$ (no.)

Number of tillers $hill^{-1}$ were counted at 20 days interval up to harvest from preselected hills and finally averaged as their number $hill^{-1}$. Only those tillers having three or more leaves were considered for counting.

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

Total above ground dry matter weight hill^{-1} was recorded at 20 days interval and harvest respectively by drying plant sample. The sample plants were oven dried for 72 hours at 70°C and then data were recorded from plant samples hill^{-1} plot^{-1} selected at random from the outer rows of each plot leaving the border line and expressed in gram.

vi) Panicle length (cm)

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle. Panicle length was measured with a meter scale from 5 selected panicles and average value was recorded.

vii) Effective tillers hill^{-1} (no.)

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 5 randomly selected hills at harvesting time and average value was recorded.

viii) Non-effective tillers hill^{-1} (no.)

The total number of non-effective tillers hill^{-1} was counted as the tillers, which have no panicle on the head. Data on non-effective tiller hill^{-1} were counted from 5 preselected (used in effective tiller count) hill at harvesting time and average value was recorded.

ix) Filled grains panicle^{-1} (no.)

Panicle was considered to be fertile if any kernel was present there in. The total number of filled grains was collected randomly from selected 5 plants of a plot and then average number of filled grains per panicle was recorded.

x) Unfilled grains penicle^{-1} (no.)

Panicle was considered to be sterile if no kernel was present there in. The total number of unfilled grains was collected randomly from selected 5 plants of a plot based on, no or partially developed grain in spikelet and then average number of unfilled grains per panicle was recorded.

xi) Total grains panicle^{-1} (no.)

The number of fertile grains panicle^{-1} alone with the number of sterile grains panicle^{-1} gave the total number of grains panicle^{-1}.

xii) Weight of 1000-grain (g)

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 12% moisture and the mean weight were expressed in gram.

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

Grain yield was adjusted at 14% moisture. Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1m^2 area was measured and then records the final grain yield of each plot^{-1} and finally converted to t ha^{-1}.

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

After separating the grains, straw yield was determined from the central 1 m^2 area of each plot. After threshing the sub-samples were sun dried to a constant weight and finally converted to t ha^{-1}.

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

The summation of grain yield and above ground straw yield was the biological yield.
Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + straw yield (t ha^{-1})

xvi) Harvest index (%)

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

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

Here, Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + straw yield (t ha^{-1})

3.18 Statistical analysis

The data obtained from different characters were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program name STATISTIX 10 data analysis software and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% levels of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV RESULTS AND DISCUSSION

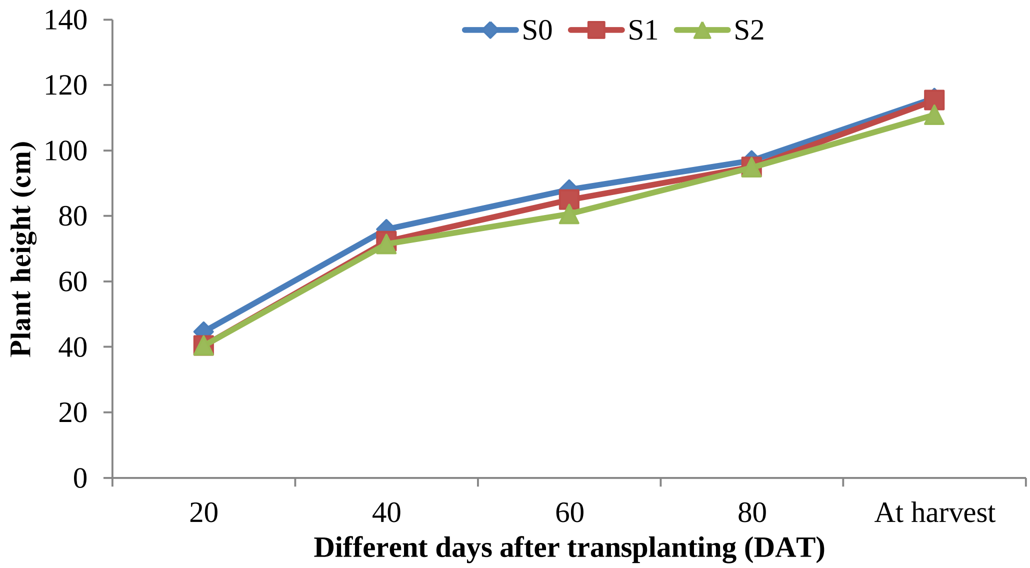
In this chapter the findings of present have been provided and analyzed in order to investigate the effects of seedling and leaf clipping on the growth and yield of aromatic rice variety. The information is presented in different tables and figures. The findings have been discussed, and possible interpretations are given under the headings listed below.

4.1 Plant growth parameters

4.1.1 Plant height (cm)

4.1.1.1 Effect of seedling clipping

Plant height is an important morphological attribute that acts as a potential indicator of availability of growth resources mobilized in plant body (Fig. 1). Plant height exerted significant differences due to seedling clipping under the present study. From the experimental result it reveals that plant height showed significant variation only at 20 and 60 DAT due to seedling clipping. The maximum plant height (44.63, 75.91, 88.01, 96.90 and 115.99 cm at 20, 40, 60, 80 DAT and harvest, respectively) were obtained from S_0 treatment which was statistically similar with S_1 (84.95 cm) treatment at 60 DAT. On the other hand,the minimum plant height (40.34, 71.42, 80.57, 94.43 and 110.90 cm at 20, 40, 60, 80 DAT and harvest, respectively) were obtained in S_2 treatment which was statistically similar with S_1 (40.37 cm) treatment at 20 DAT.



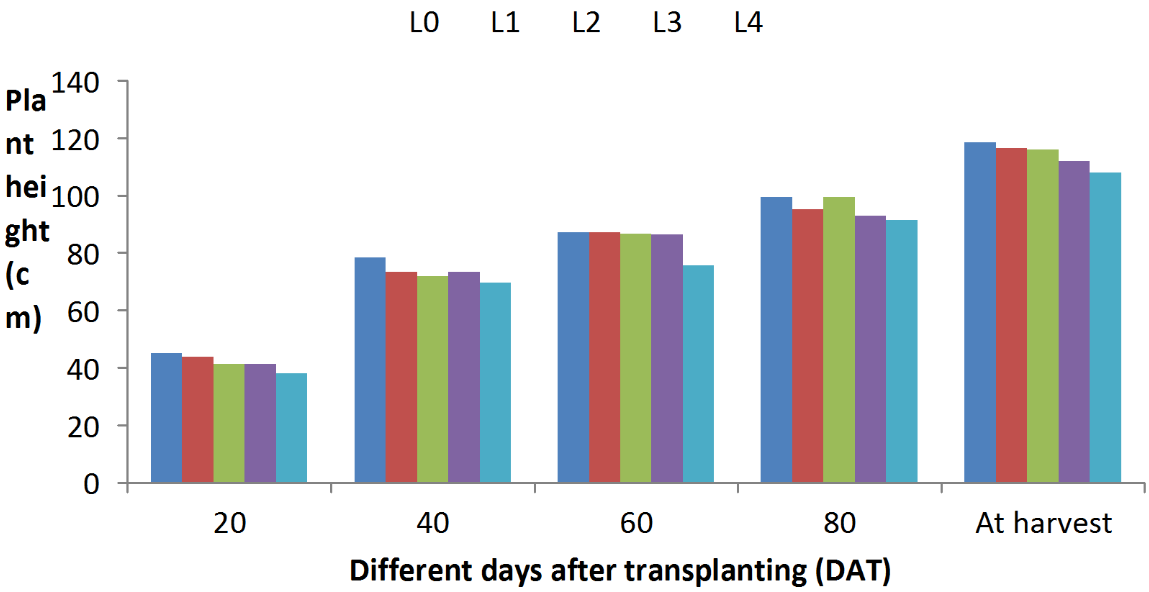
S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 1. Effect of seedling clipping on plant height (cm) of aromatic rice at different days after transplanting (DAT) ($LSD_{0.05}$= 3.53, NS, 3.08, NS and NS at 20, 40, 60, 80 DAT and harvest, respectively)

4.1.1.2 Effect of leaf clipping

Significant differences on plant height of aromatic rice at different growth stages were exerted due to leaf clipping under the study (Fig. 2). Results from the experiment revealed that the maximum plant height (44.93, 78.16, 87.09, 99.34 and 118.33 cm at 20, 40, 60, 80 DAT and harvest, respectively) were observed in L_0 treatment which was statistically similar with L_1 (43.64 cm) treatment at 20 DAT; L_1 (87.03 cm), L_2 (86.57 cm) and L_3 (86.42 cm) treatment at 60 DAT; with L_2 (99.33 cm) and L_1 (95.08 cm) treatment at 80 DAT and with L_1 (116.45 cm) and L_2 (115.78 cm) treatment at harvest, respectively. On the other hand the minimum plant height (37.85, 69.39, 75.46, 91.28 and 107.89 cm at 20, 40, 60, 80 DAT and harvest, respectively) were obtained from L_4 treatment which were statistically similar with L_2 (71.79 cm) treatment at 40 DAT; with L_3 (92.83 and 111.89 cm) treatment at 80 DAT and harvest, respectively.

Photosynthesis takes place in mesophyll cells of specialized organs like leaves. The rigid cell wall that encases photosynthetic cells regulates cell expansion and dispersion throughout photosynthetic tissues. Leaf area influences the link between photosynthesis and plant growth. Clipping leaves limits photosynthesis area, which affects photosynthesis and has an impact on plant dry matter accumulation; as a result, plant height becomes shorter when compared to plants that are not clipped. The findings of the present study were coincided with the findings of Karmaker and Karmakar (2019) who reported that the highest plant height (128.95 cm) was recorded at C_0 (No leaf clipping) and the lowest plant height (116.83 cm) was found in C_3 (leaf clipping time at 55 DAT). Medhi *et al*. (2015) who stated that multiple times expulsion of foliage significantly decreased the plant height and prevented lodging. Sherif *et al.* (2015) reported that the plant heights ranged 90.0090.50 cm when 60, 80 or 100% of the leaves were removed in the first season (201314), and ranged 87.00-87.05 cm when 80 or 100% of the rice plants were defoliated in the second season (2014-15).



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3+4 leaves and L_4= Flag leaf clipping

Figure 2. Effect of leaf clipping on plant height (cm) of aromatic rice at different days after transplanting (DAT) ($LSD_{0.05}$= 2.18, 3.18, 2.45, 5.05 and 5.48 at 20, 40, 60, 80 DAT and harvest, respectively)

4.1.1.3 Combined effect of seedling and leaf clipping

Significant variation was observed due to combined effect of seedling and leaf clipping (Table 1). Results of the present study revealed that the maximum plant height (48.50, 83.33, 95.29, 104.99 and 126.08 cm at 20, 40, 60, 80 DAT and harvest, respectively) were obtained from S_0L_0 treatment combination which was statistically similar with S_0L_2 (103.45 cm), S_2L_2 (101.95 cm), S_1L_1 (101.23 cm), S_1L_0 (98.58 cm) and S_0L_3 (97.08 cm) treatment combination at 80 DAT and with S_1L_1 (124.20 cm), S_2L_2 (118.20 cm), S_0L_3 (117.49 cm) and S_1L_2 (116.70 cm) at harvest, respectively. On the other hand the minimum plant height (35.53 cm) was observed in S_2L_4 treatment combination which was statistically similar with S_1L_4 (36.09 cm) treatment combination at 20 DAT. At 40 DAT, the minimum plant height (66.17 cm) was observed in S_1L_4 treatment combination which was statistically similar with S_2L_4 (67.01 cm), S_1L_2 (69.74 cm), S_0L_3 (70.46 cm) and S_2L_1 (70.94 cm) treatment combination. At 60 DAT, the minimum plant height (72.72 cm) was observed in S_2L_4 treatment combination which was statistically similar with S_1L_4 (73.10 cm). At 80 DAT, the minimum plant height (88.70 cm) was observed in S_0L_4 treatment combination which was statistically similar with S_1L_3 (89.95 cm), S_0L_1 (90.33 cm), S_2L_3 (91.45 cm), S_2L_4 (92.58 cm), S_1L_4 (92.58 cm), S_1L_2 (92.58 cm), S_2L_1 (93.70 cm), and S_2L_0 (94.45 cm) treatment combination. Finally at harvest respectively the minimum plant height (103.45 cm) was observed in S_2L_4 treatment combination which was statistically similar with S_2L_3 (108.07 cm), S_0L_4 (109.87 cm), S_1L_3 (110.12 cm), S_1L_4 (110.37 cm), S_2L_1 (111.08 cm) and S_0L_2 (112.45 cm) treatment combination.

Table 1. Combined effect of seedling and leaf clippings on plant height (cm) of aromatic rice (BRRI dhan80) at different days after transplanting (DAT)

Treatment Combination	Plant height (cm) at different days after transplanting (DAT)				
	20	40	60	80	At harvest
S_0L_0	48.50 a	83.33 a	95.29 a	104.99 a	126.08 a
S_0L_1	47.02 ab	76.86 b	86.13 c-e	90.33 de	114.07 cd
S_0L_2	42.19 c-e	73.92 b-d	89.55 bc	103.45 a	112.45 c-e
S_0L_3	43.49 b-d	70.46 c-f	88.55 b-d	97.08 a-e	117.49 a-d
S_0L_4	41.93 c-e	74.99 b-d	80.55 fg	88.70 e	109.87 c-e
S_1L_0	43.84 bc	77.15 b	87.43 b-d	98.58 a-d	115.20 b-d
S_1L_1	42.24 c-e	72.60 b-d	90.53 b	101.23 a-c	124.20 ab
S_1L_2	40.03 de	69.74 d-f	85.78 c-e	92.58 c-e	116.70 a-d
S_1L_3	39.64 ef	75.40 bc	87.90 b-d	89.95 de	110.12 c-e
S_1L_4	36.09 fg	66.17 f	73.10 h	92.58 c-e	110.37 c-e
S_2L_0	42.44 c-e	74.00 b-d	78.55 g	94.45 b-e	113.70 cd
S_2L_1	41.67 c-e	70.94 c-f	84.43 d-f	93.70 b-e	111.07 c-e
S_2L_2	41.44 c-e	71.70 b-e	84.38 d-f	101.95 ab	118.20 a-c
S_2L_3	40.63 c-e	73.44 b-d	82.80 ef	91.45 de	108.07 de
S_2L_4	35.53 g	67.01 ef	72.72 h	92.58 c-e	103.45 e
$LSD_{0.05}$	3.78	5.50	4.24	8.74	9.48
CV(%)	5.37	4.46	2.97	5.43	4.93

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

L_0= Control (no clipping)

NS= Non- significant

S_0= Control (no clipping)

S_1 =1/3rd top clipping

S_2= 1/2nd top clipping

L_1= Lower 1+2 leaves

L_2= Lower 2+3 leaves

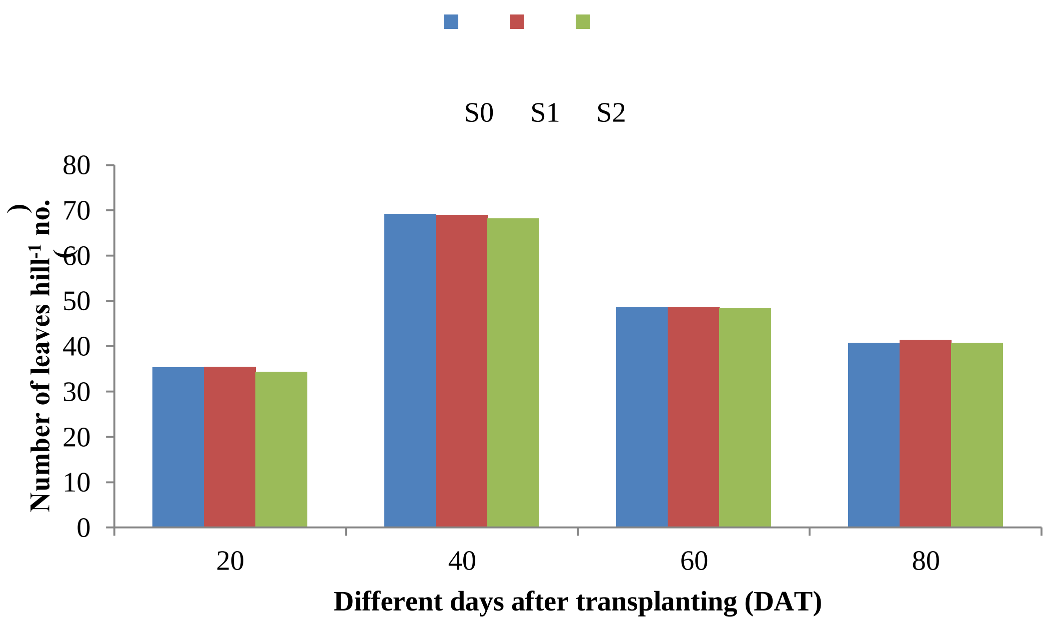
L_3= Lower 3 +4 leaves

L_4= Flag leaf clipping

4.1.2 Number of leaves hill^{-1} (no.)

4.1.2.1 Effect of seedling clipping

A leaf is the main lateral part of a vascular plant stem that is normally carried above ground and is specialized for photosynthesis. Non-significant effect on number of leaves hill^{-1} at various days after transplanting was observed due to seedling clipping under the present study (Fig. 3). Result revealed from the study that numerically the maximum number of leaves hill^{-1} (35.43) was obtained from S_1 treatment at 20 DAT; (69.27) was observed in S_0 treatment at 40 DAT. At 60 DAT and 80 DAT, the maximum number of leaves hill^{-1} (48.68) was obtained from S_1 treatment. On the other hand the minimum number of leaves hill^{-1} (34.40, 68.16, 48.50 and 40.75 at 20, 40, 60 and 80 DAT, respectively) were observed in S_2 treatment. The number of leaves on a plant is determined mostly by the plant's genetic characters, which regulates the arrangement of leaves on the stem could not alter the number of leaves in case of BRRI dhan80.

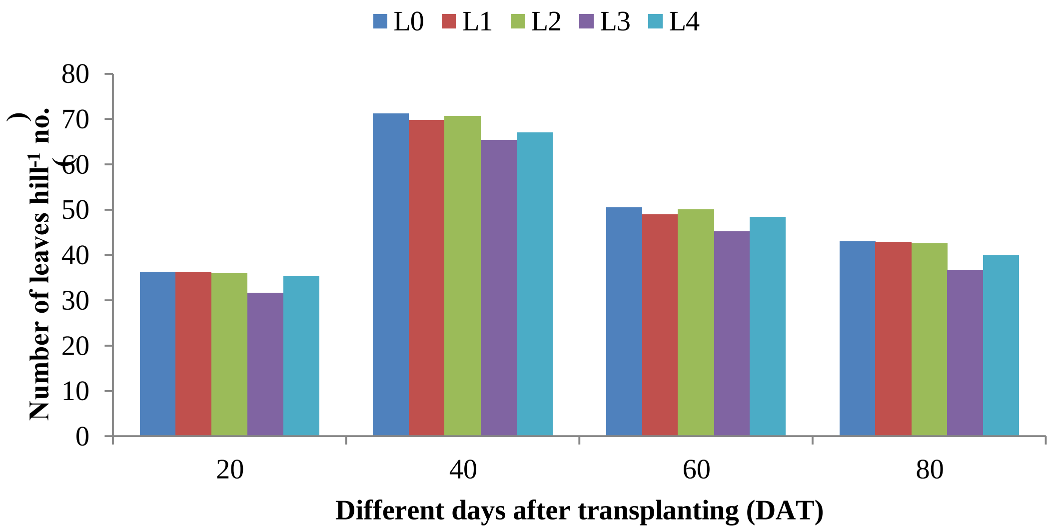


S_0= Control (no clipping), S_1=1/3rd top clipping and S_2= 1/2nd top clipping

Figure 3. Effect of seedling clipping on number of leaves hill^{-1} (no.) of aromatic rice at different days after transplanting (DAT) ($LSD_{0.05}$= NS, NS, NS and NS at 20, 40, 60, and 80 DAT, respectively)

4.1.1.2 Effect of leaf clipping

Significant effect showed on number of leaves $hill^{-1}$ at different days after transplanting due to leaf clipping (Fig. 4). From the experiment result revealed that the maximum number of leaves $hill^{-1}$ (36.30, 71.24, 50.49 and 43.00 at 20, 40, 60 and 80 DAT, respectively) were obtained from L_0 treatment which was statistically similar with L_1 (36.14) and L_2 (35.93) treatment at 20 DAT ; with L_2 (70.63) and L_1 (69.77) treatment at 40 DAT; with L_2 (50.06) treatment at 60 DAT and finally with L_1 (42.92) and L_2 (42.59) treatment at 80 DAT, respectively. On the other hand the minimum number of leaves $hill^{-1}$ (31.64, 65.37, 45.19 and 36.56 at 20, 40, 60 and 80 DAT, respectively) was observed in L_3 treatment. The relationship between source and sink was weakened as a result of leaf clipping, which had an impact on the plant's growth



and yield characteristics.

L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3 +4 leaf clipping and L_4= Flag leaf clipping

Figure 4. Effect of leaf clipping on number of leaves $hill^{-1}$ of aromatic rice at different days after transplanting (DAT) ($LSD_{0.05}$= 0.92, 1.61, 1.16 and 1.42 at 20, 40, 60, and 80 DAT, respectively)

4.1.1.3 Combined effect of seedling and leaf clipping

Significant variation was remarked for number of leaves hill^{-1} of aromatic rice due to combined effect of seedling and leaf clipping (Table 2). Results from the experiment revealed that the maximum number of leaves hill^{-1} (36.90, 72.87, 51.30 and 43.63 at 20, 40, 60 and 80 DAT, respectively) were achieved from S_0L_0 treatment combination which was statistically similar with S_1L_0 (36.90), S_0L_4 (36.53), S_0L_1 (36.37), S_1L_1 (36.17), S_1L_2 (36.07), S_0L_2 (36.03), S_2L_1 (35.90) and S_2L_2 (35.70) treatment combination at 20 DAT; with S_1L_0 (71.70), S_2L_2 (71.15), S_1L_2 (70.80) and S_0L_1 (70.73) at 40 DAT; with S_1L_2 (51.27), S_2L_0 (50.55), S_2L_1 (49.95), S_0L_1 (49.70), S_1L_0 (49.63), S_0L_2 (49.50) and S_2L_2 (49.42) treatment combination at 60 DAT and finally with S_1L_0 (43.17), S_0L_1 (43.00), S_1L_1 (43.00), S_0L_2 (42.97), S_2L_1 (42.75), S_2L_2 (42.75), S_2L_0 (42.20) and S_1L_2 (42.07) treatment combination at 80 DAT, respectively. On the other hand the minimum number of leaves hill^{-1} (30.83, 65.25, 43.95 and 35.50 at 20, 40, 60 and 80 DAT, respectively) were obtained from S_2L_3 treatment combination which was statistically similar with S_0L_3 (30.90) treatment combination at 20 DAT; with S_0L_3 (65.43), S_1L_3 (65.43), S_2L_4 (66.33), S_1L_4 (67.33) and S_0L_4 (67.37) treatment combination at 40 DAT; with S_0L_3 (44.71) treatment combination at 60 DAT and finally with S_0L_3 (35.87) treatment combination at 80 DAT.

Table 2. Combined effect of seedling and leaf clipping on number of leaves hill^{-1} (no.) of aromatic rice (BRRI dhan80) at different days after transplanting (DAT)

Treatment Combinations	No. of leaves hill^{-1} (no.) at different days after transplanting (DAT)			
	20	40	60	80
S_0L_0	36.90 a	72.87 a	51.30 a	43.63 a
S_0L_1	36.37 ab	70.73 a-c	49.70 a-c	43.00 a-c
S_0L_2	36.03 a-c	69.93 b-d	49.50 a-c	42.97 a-c
S_0L_3	30.90 e	65.43 f	44.71 e	35.87 fg
S_0L_4	36.53 a	67.37 d-f	48.03 cd	38.67 de
S_1L_0	36.90 a	71.70 ab	49.63 a-c	43.17 ab
S_1L_1	36.17 ab	69.67 cd	47.10 d	43.00 a-c
S_1L_2	36.07 ab	70.80 a-c	51.27 a	42.07 a-c
S_1L_3	33.20 d	65.43 f	46.90 d	38.30 ef
S_1L_4	34.80 bc	67.33 d-f	48.50 cd	40.77 b-d
S_2L_0	35.10 bc	69.15 cd	50.55 ab	42.20 a-c
S_2L_1	35.90 a-c	68.90 c-e	49.95 a-c	42.75 a-c
S_2L_2	35.70 a-c	71.15 a-c	49.42 a-c	42.75 a-c
S_2L_3	30.83 e	65.25 f	43.95 e	35.50 g
S_2L_4	34.45 cd	66.33 ef	48.65 b-d	40.55 c-e
$LSD_{(0.05)}$	1.59	2.79	2.00	2.46
CV(%)	2.69	2.40	2.45	3.56

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

NS= Non- significant

S_0= Control (no clipping)

S_1 =1/3rd top clipping

S_2= 1/2nd top clipping

L_0= Control (no clipping)

L_1= Lower 1+2 leaves

L_2= Lower 2+3 leaves

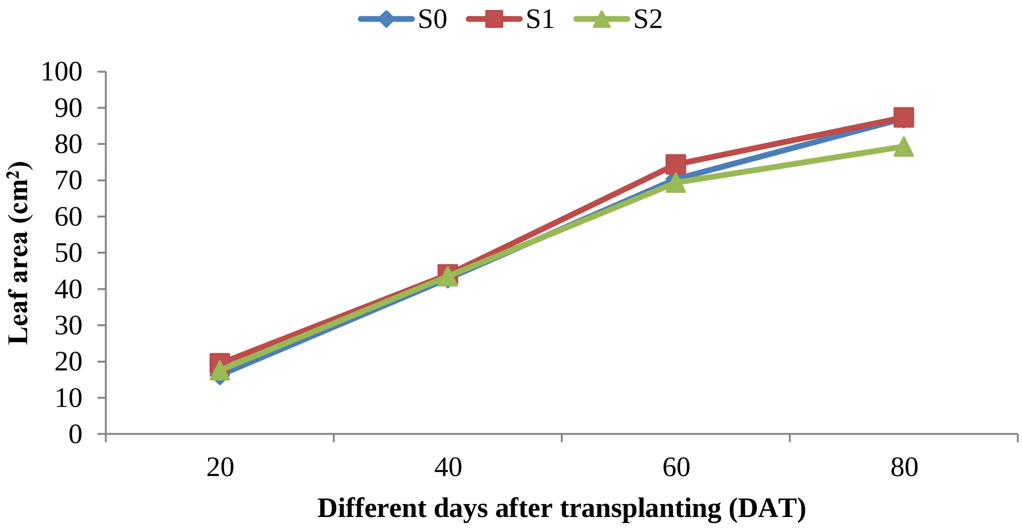
L_3= Lower 3+4 leaves

L_4= Flag leaf clipping

4.1.3 Leaf area $hill^{-1}$ (cm^2)

4.1.3.1 Effect of seedling clipping

Leaf area exerted remarkable variation due to seedling clipping under the present experiment (Fig. 5). Result from the experiment revealed that the maximum leaf area (19.48, 43.97, 74.37 and 87.34 cm^2 at 20, 40, 60 and 80 DAT, respectively) were obtained from S_1 treatment which was statistically similar with S_0 (87.07 cm^2) treatment at 80 DAT, respectively. On the other hand the minimum leaf area (16.22 and 42.92 cm^2 at 20 and 40 DAT, respectively) was obtained from S_0 treatment. At 60 and 80 DAT the minimum leaf area (69.33 cm^2 and 79.30 cm^2) were obtained from S_2 treatment which was statistically similar with S_0 (70.29 cm^2) treatment at 60 DAT. Plants leaves are one of their most vital organs. Photosynthesis occurs in leaves and is the process by which plants make food by using light, carbon dioxide (CO_2) and water. The structure and composition of leaves are optimized for photosynthesis. Light is captured by chloroplasts in leaves and as leaf area increases, more light energy is captured to make food. Stomata, or apertures on the underside of leaves, absorb carbon dioxide. Because photosynthesis relies on exploiting the sun's energy to synthesize sugar from carbon dioxide and water, higher carbon dioxide concentrations make plants more productive. Sugar is used by plants and ecosystems as an energy source as well as a basic building element for growth. Carbon dioxide intake by plants is influenced by leaf area, which in turn influences plant growth. Seedling clipping alters the physiology of leaf area to a lesser extent than non-clipping, which is due to the fact that seedling clipping reduces competition among seedlings and helps in uptake nutrients properly surrounding its source, which aids in vigor growth (increasing leaf area, increasing effective tiller number, above ground dry matter weight, and so on) of the seedling that is clipped.

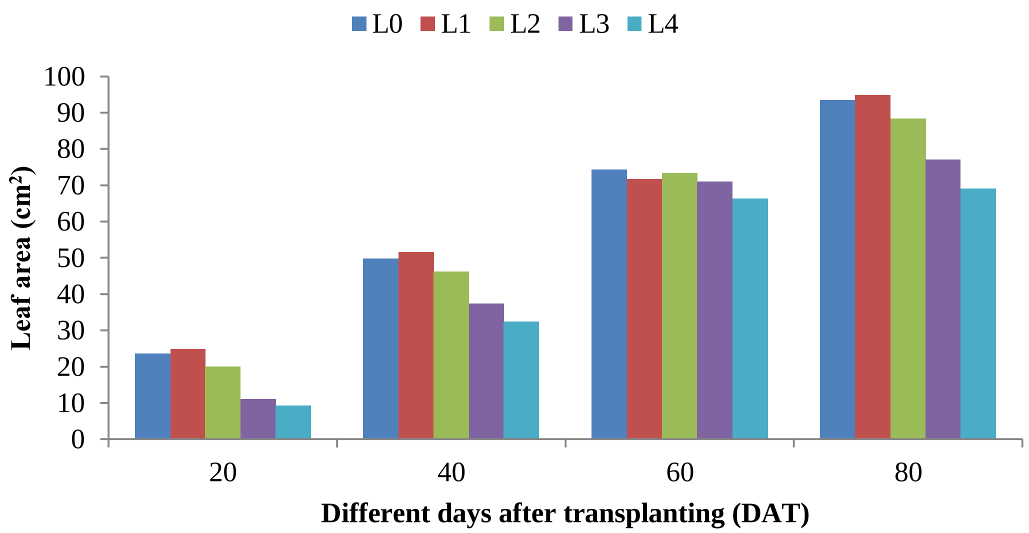


S_0= Control (no clipping), S_1=1/3rd top clipping and S_2= 1/2nd top clipping

Figure 5. Effect of seedling clipping on leaf area hill^{-1} (cm^2) of aromatic rice at different days after transplanting (DAT) (LSD$_{0.05}$= 0.89, NS, 1.95 and 2.64 at 20, 40, 60, and 80 DAT, respectively)

4.1.3.2 Effect of leaf clipping

No clipping or clipping some extent showed better result in case of leaf area comparable to other treatments under the present study (Fig. 6). From the experiment result revealed that the maximum leaf area (24.87 and 51.63 cm^2 at 20 and 40 DAT respectively) were achieved from L_1 treatment which was statistically as par with L_0 (49.78 cm^2) treatment at 40 DAT. At 60 and 80 DAT, the maximum leaf area (74.29 and 94.81 cm^2) were obtained from L_0 treatment which was statistically as par with L_2 (73.43 cm^2) and L_1 (71.66 cm^2) treatment at 60 DAT and with L_0 (93.54 cm^2) treatment at 80 DAT. On the other hand, minimum leaf area (9.28, 32.40, 66.25 and 69.06 cm^2 at 20, 40, 60 and 80 DAT, respectively) was observed in L_4 treatment which was statistically dissimilar with the other treatments under the study. Various leaf clipping lowered the number of leaves, which ultimately impacted on leaf area, since leaf area is related to the number of leaves, and reducing it affects photosynthetic activities of the plant, which has an impact on rice growth, development, and grain yield. The results of the experiment was also coincided with the findings of Misra (1986) who stated that under the control condition, with no leaf cutting, all of the parameters showed their maximum value.



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3+4 leaves and L_4= Flag leaf clipping

Figure 6. Effect of leaf clipping on leaf area hill^{-1} (cm^2) of aromatic rice at different days after transplanting (DAT) ($LSD_{0.05}$= 0.79, 2.22, 3.00 and 2.15 at 20, 40, 60, and 80 DAT, respectively)

4.1.3.3 Combined effect of seedling and leaf clipping

Leaf area exerted significant differences on aromatic rice due to combined effect of seedling and leaf clipping (Table 3). From the experiment result revealed that the maximum leaf area (27.21 cm^2) was obtained from S_1L_1 treatment combination which was statistically similar with S_1L_0 (26.38 cm^2) treatment combination at 20 DAT. At 40 DAT, the maximum leaf area (54.05 cm^2) was obtained from S_0L_0 treatment combination which was statistically as par with S_2L_2 (50.43 cm^2), S_1L_0 (51.51 cm^2), S_1L_1 (51.20 cm^2), S_2L_1 (53.39 cm^2) and S_0L_1 (50.28 cm^2) treatment combination. At 60 and 80 DAT respectively the maximum leaf area (80.50 and 101.78 cm^2) were observed in S_1L_0 treatment combination which was statistically similar with S_1L_1 (79.25 cm^2) and S_2L_2 (77.07 cm^2) treatment combination at 60 DAT and with S_1L_1 (99.33 cm^2) treatment combination at 80 DAT. On the other hand, the minimum leaf area (8.41 cm^2) was observed in S_2L_4 treatment combination which was statistically as par with S_0L_4 (9.19 cm^2) and S_2L_3 (9.64 cm^2) treatment combination at 20 DAT. At 40 DAT the minimum leaf area (31.30 cm^2) was observed in S_0L_4 treatment combination which was statistically as par with S_2L_4 (32.61) and S_1L_4 (33.30 cm^2)

treatment combination. At 60 and 80 DAT, the minimum leaf area (63.15 and 64.50 cm^2, respectively) was observed in S_2L_4 treatment combination which was statistically as par with S_0L_1 (66.35 cm^2), S_1L_4 (67.14 cm^2) and S_2L_3 (67.40 cm^2) treatment combination at 60 DAT.

Table 3. Combined effect of seedling and leaf clipping on leaf area (cm^2) of aromatic rice (BRRI dhan80) at different days after transplanting (DAT)

Treatment Combinations	Leaf area $hill^{-1}$ (cm^2) at different days after transplanting (DAT)			
	20	40	60	80
S_0L_0	22.61 cd	54.05 a	72.75 bc	96.57 b
S_0L_1	23.65 bc	50.28 a	66.35 ef	97.57 b
S_0L_2	13.23 e	42.05 b	71.76 cd	90.46 c
S_0L_3	12.43 ef	36.93 cd	72.15 b-d	78.19 e
S_0L_4	9.19 hi	31.30 e	68.45 c-e	72.58 fg
S_1L_0	26.38 a	51.51 a	80.50 a	101.78 a
S_1L_1	27.21 a	51.20 a	79.25 a	99.33 ab
S_1L_2	22.46 cd	45.88 b	71.44 c-e	87.67 c
S_1L_3	11.13 fg	37.95 c	73.52 bc	77.82 e
S_1L_4	10.23 gh	33.30 de	67.14 d-f	70.10 g
S_2L_0	21.75 d	43.77 b	69.62 c-e	82.26 d
S_2L_1	23.76 bc	53.39 a	69.39 c-e	87.54 c
S_2L_2	24.33 b	50.43 a	77.07 ab	86.93 c
S_2L_3	9.64 hi	37.37 c	67.40 d-f	75.25 ef
S_2L_4	8.41 i	32.61 e	63.15 f	64.50 h
$LSD_{0.05}$	1.38	3.85	5.20	3.73
CV(%)	4.60	5.26	4.33	2.61

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

Notes *viz:*

NS= Non- significant

S_0= Control (no clipping)

S_1 =1/3rd top clipping

S_2= 1/2nd top clipping

L_0= Control (no clipping)

L_1= Lower 1+2 leaves

L_2= Lower 2+3 leaves

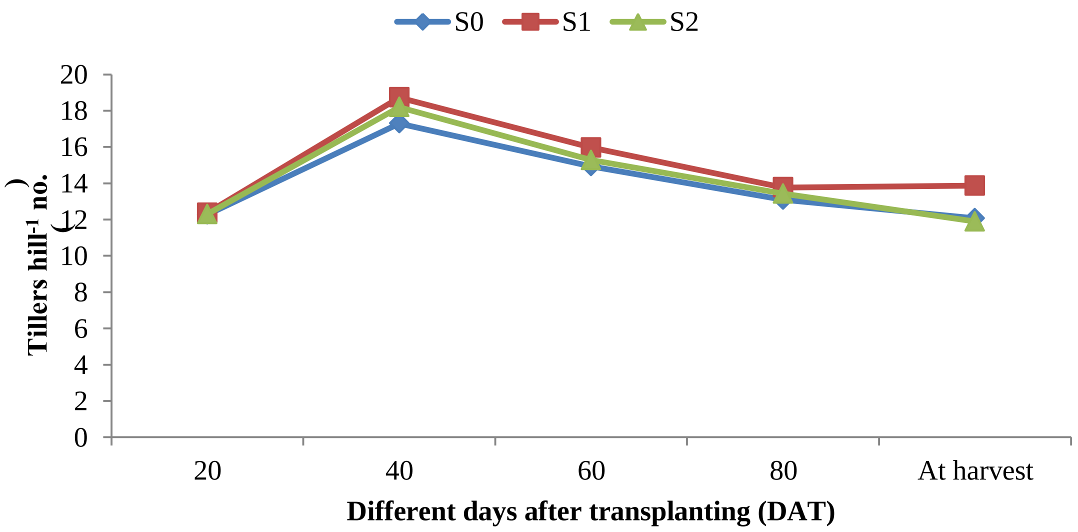
L_3= Lower 3 +4 leaves

L_4= Flag leaf clipping

4.1.4 Number of tillers hill^{-1} (no.)

4.1.4.1 Effect of seedling clipping

Aromatic rice exerted remarked variation on number of tillers hill^{-1} due to the effect of seedling clipping at different days after transplanting (Fig. 7). Result from the experiment revealed that the maximum number of tillers hill^{-1} (12.37, 18.73, 15.97, 13.77 and 13.87 at 20, 40, 60, 80 DAT and harvest respectively) were obtained from S_1 treatment which was statistically as par with S_2 (18.20) treatment at 40 DAT. On the other hand minimum number of tillers hill^{-1} (12.27, 17.30, 14.93 and 13.09 at 20, 40, 60 and 80 DAT respectively) was observed in S_0 treatment which was statistically similar with S_2 (15.28) treatment at 60 DAT. Finally at harvest the minimum number of tillers hill^{-1} (11.89) was obtained from S_2 treatment which was statistically similar with S_0 (12.07) treatment. Higher seedling hill^{-1} can induce intense competition between plants, which can result in gradual shading, a reduction in the number of tillers per hill^{-1}, lodging and an increase in the production of straw rather than grain. Clipping seedlings helps in vigor seedling generation by removing competition between plants which ultimately results in proper resource utilization and influences the number of tillers per hill^{-1}.

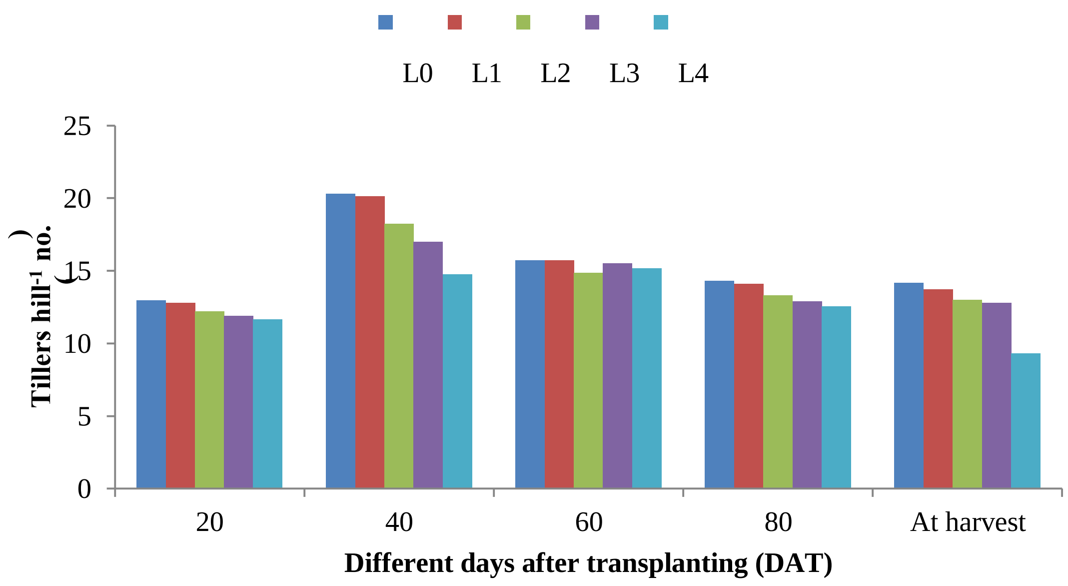


S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 7. Effect of seedling clipping on tillers hill^{-1} of aromatic rice at different days after transplanting (DAT) ($LSD_{0.05}$= NS, 0.57, 0.65, 0.24 and 0.58 at 20, 40, 60, 80 DAT and harvest, respectively)

4.1.3.2 Effect of leaf clipping

Number of tillers hill^{-1} exerted significant variation due to leaf clipping at different days after transplanting (Fig. 8). Results from the experiment revealed that the maximum number of tillers hill^{-1} (12.97, 20.29, 15.70, 14.29 and 14.18 at 20, 40, 60, 80 DAT and harvest, respectively) were achieved from L_0 treatment which was statistically as par with L_1 (12.79, 20.11, 15.70, 14.09 and 13.73) treatment at 20, 40, 60, 80 DAT and harvest respectively and with L_3 (15.52) and L_4 (15.17) treatment at 60 DAT. On the other hand the minimum number of tillers hill^{-1} (11.68 and 14.77 at 20 and 40 DAT, respectively) were obtained from L_4 treatment which was statistically similar with L_3 (11.90) treatment at 20 DAT. At 60 DAT, the minimum number of tillers hill^{-1} (14.88) was observed in L_2 treatment. At 80 DAT and harvest respectively the minimum number of tillers hill^{-1} (12.56 and 9.31) were obtained from L_4 treatment.



L_0 = Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3+4 leaves and L_4= Flag leaf clipping

Figure 8. Effect of leaf clipping on tillers hill^{-1} (no.) of aromatic rice at different days after transplanting (DAT) ($LSD_{0.05}$= 0.26, 0.56, 0.65, 0.26 and 0.52 at 20, 40, 60, 80 DAT and harvest, respectively)

4.1.3.3 Combined effect of seedling and leaf clipping

Significant difference was remarked for number of tillers hill^{-1} at different growth stages of aromatic rice due to combined effect of seedling and leaf clipping (Table 4). Results revealed that the maximum number of tillers hill^{-1} (13.10) was observed in S_1L_0 treatment combination which was statistically similar with S_1L_1 (13.03), S_2L_0 (13.03), S_2L_1 (12.90) and S_0L_0 (12.77) treatment combination at 20 DAT. At 40 DAT the maximum number of tillers hill^{-1} (21.40) was observed in S_1L_1 treatment combination which was statistically similar with S_2L_0 (21.13) and S_1L_0 (20.60) treatment combination. At 60, 80 DAT and harvest, the maximum number of tillers hill^{-1} (17.28, 14.91 and 15.13, respectively) was observed in S_1L_0 treatment combination which was statistically similar with S_1L_1 (14.51 and 15.07) treatment combination at 80 DAT and harvest, respectively. On the other hand the minimum number of tillers hill^{-1} (11.43) was observed in S_2L_4 treatment combination which was statistically as par with S_1L_4 (11.50) treatment combination at 20 DAT. At 40 DAT, the minimum number of tillers hill^{-1} (13.93) was obtained from the treatment combination of S_0L_4 which was statistically as par with S_2L_4 (14.73) treatment combination. At 60 DAT, the minimum number of tillers hill^{-1} (14.21) was achieved from the treatment combination of S_0L_2 which was statistically similar with S_0L_4 (14.61), S_2L_2 (14.74), S_0L_0 (14.81), S_2L_0 (15.01) and S_2L_4 (15.28) treatment combination. At 80 DAT, the minimum number of tillers hill^{-1} (12.38) was obtained from S_0L_4 treatment combination which was statistically similar with S_2L_4 (12.51), S_0L_3 (12.65) and S_1L_4 (12.78) treatment combination and finally at harvest respectively the minimum number of tillers hill^{-1} (7.80) was obtained from the treatment combination of S_2L_4 which was statistically similar with S_0L_4 (8.06) treatment combination.

Table 4. Combined effect of seedling and leaf clipping on number of tillers hill^{-1} (no.) of aromatic rice (BRRI dhan80) at different days after transplanting (DAT)

Treatment Combinations	Number of tillers hill^{-1} (no.) at different days after transplanting (DAT)				
	20	40	60	80	At harvest
S_0L_0	11.53 ab	15.60 c	11.10 b-d	10.53 c	11.33 b
S_0L_1	11.37 bc	15.40 cd	11.60 b	10.50 cd	10.87 c-e
S_0L_2	11.22 cd	15.17 ce	10.80 d	10.30 de	10.67 c-f
S_0L_3	11.10 de	14.27 gh	11.30 b-d	10.03 fg	10.47 ef
S_0L_4	11.20 cd	13.00 j	11.00 cd	9.90 g	8.33 g
S_1L_0	11.70 a	16.33 ab	12.33 a	11.17 a	11.87 a
S_1L_1	11.67 a	16.73 a	11.53 bc	10.97 ab	11.83 a
S_1L_2	11.30 cd	15.27 ce	11.53 bc	10.43 cd	11.07 bc
S_1L_3	11.10 de	14.80 ef	11.50 bc	10.30 de	11.07 bc
S_1L_4	10.90 ef	13.87 hi	11.50 bc	10.10 e-g	10.33 f
S_2L_0	11.67 a	16.60 ab	11.20 b-d	10.87 b	10.97 b-d
S_2L_1	11.60 a	16.13 b	11.50 bc	10.80 b	10.80 c-e
S_2L_2	11.27 cd	15.00 d-f	11.07 b-d	10.37 cd	10.70 c-f
S_2L_3	11.10 de	14.53 fg	11.57 b	10.13 ef	10.57 d-f
S_2L_4	10.87 f	13.40 ij	11.33 b-d	9.97 fg	8.20 g
$LSD_{0.05}$	0.22	0.49	0.56	0.22	0.45
CV(%)	1.18	1.92	2.93	1.26	2.54

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

Notes *viz:*

NS= Non- significant

S_0= Control (no clipping)

S_1 =1/3rd top clipping

S_2= 1/2nd top clipping

L_0= Control (no clipping)

L_1= Lower 1+2 leaves

L_2= Lower 2+3 leaves

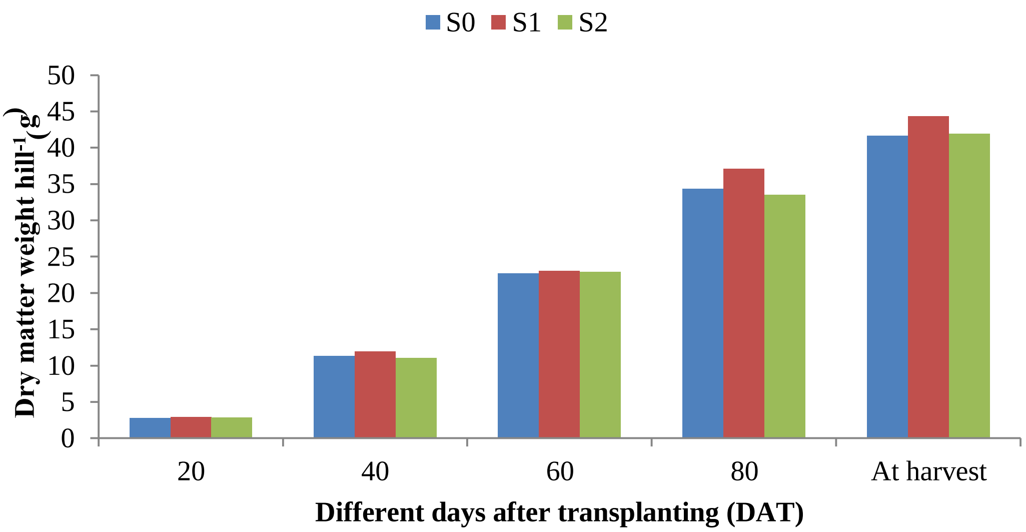
L_3= Lower 3 +4 leaves

L_4= Flag leaf clipping

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

4.1.5.1 Effect of seedling clipping

The above ground dry matter weight hill^{-1} made up of all its parts excluding water. Significant variation was noted on above ground dry matter weight hill^{-1} of aromatic rice at various days after transplanting due to seedling clipping (Fig. 9). Results from the experiment revealed that the maximum above ground dry matter weight hill^{-1} (2.94, 11.98, 23.02, 37.15 and 44.36 g at 20, 40, 60, 80 DAT and harvest, respectively) were obtained from S_1 treatment which was statistically similar with S_2 (2.88 g and 22.90 g) treatment at 20 DAT and 60 DAT. On the other hand the minimum above ground dry matter weight hill^{-1} (2.78 g at 20 DAT) was observed in S_0 treatment. At 40 and 80 DAT respectively the minimum above ground dry matter hill^{-1} (11.08 g and 33.55 g) were observed in S_2 treatment which was statistically similar with S_0 (11.35 g and 34.35 g) treatment at 40 and 80 DAT. At 60 DAT and harvest, respectively, minimum above ground dry matter hill^{-1} (22.71 g and 41.67 g) were observed in S_0 treatment which was statistically similar with S_2 (41.92 g) treatment at harvest. Excess seedlings foliage per hill led in intra plant competition in rice plants which reduced dry matter at a later stage due to tiller mortality and early senescence. Clipping, to some extent, aids in proper plant growth and increases dry matter accumulation by utilizing the plant's surrounding resources, whereas extreme clipping makes the plant more vulnerable to insect and pest infestation which slows physiological processes and reduces the above ground dry matter weight hill^{-1} in comparison to a lightly clipped plant.

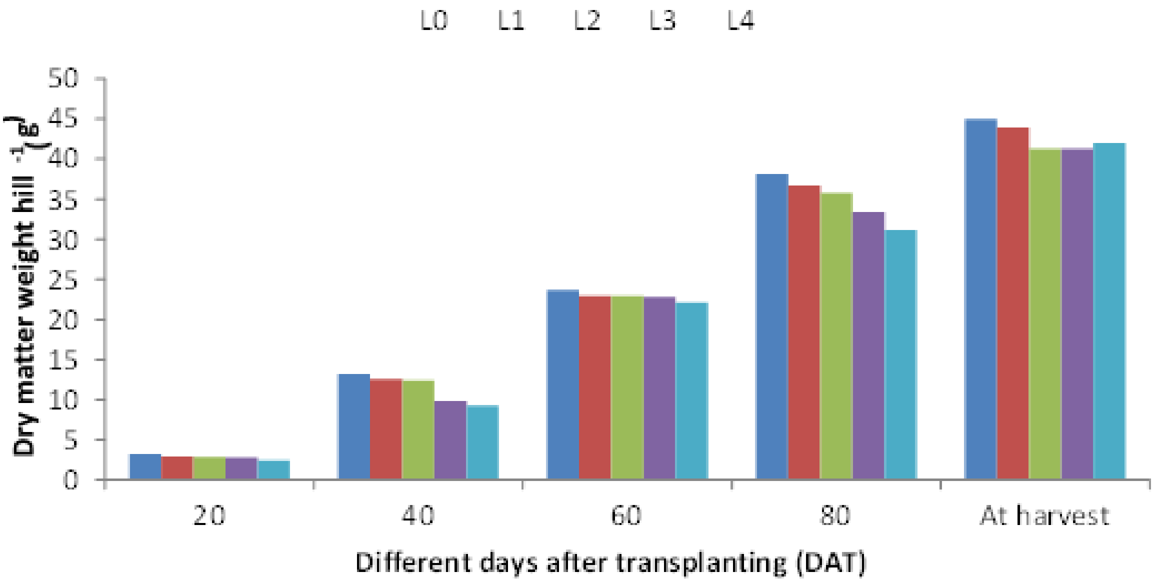


S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 9. Effect of seedling clipping on above ground dry matter weight hill^{-1} (g) of aromatic rice at different days after transplanting (DAT) ($LSD_{0.05}$= 0.12, 0.38, 0.23, 1.94 and 0.96 at 20, 40, 60, 80 DAT and harvest, respectively)

4.1.5.2 Effect of leaf clipping

Leaf clipping of aromatic rice exerted significant differences on above ground dry matter weight hill^{-1} at different days after transplanting (Fig. 10). Results from the experiment revealed that the maximum above ground dry matter weight hill^{-1} (3.23, 13.22, 23.59, 38.12 and 44.89 g at 20, 40, 60, 80 DAT and harvest, respectively) were obtained from L_0 treatment which was statistically similar with L_1 (12.59 and 36.72 g) treatment at 40 and at 80 DAT respectively. On the other hand the minimum above ground dry matter weight hill^{-1} (2.48, 9.30, 22.10 and 31.13 g at 20, 40, 60 and 80 DAT) were obtained from L_4 treatment which was statistically similar with L_3 (9.83 g) treatment at 40 DAT. At harvest, the minimum above ground dry matter weight hill^{-1} (41.24 g) was obtained from L_3 treatment which was statistically similar with L_2 (41.26 g) treatment and with L_4 (41.96 g) treatment. The number of leaves determines the area of the leaf where photosynthesis occurs. Plant dry matter accumulation increases as photosynthesis exceeds respiration, allowing the plant to grow and develop. However, leaf clipping reduces leaf area, resulting in decreased photosynthesis, which has an influence on plant development when compared to a non-clipped plant. The findings was coincided with the findings of Sherif *et al.* (2015) who reported that the sharp reduction in dry matter content was observed in the first season (2013-14) at 80 or 100% defoliation (938.15 and 765.00 g/m^2, respectively. In the second season (2014-15), defoliations at 60, 80 or 100% resulted in low levels of dry matter content; 866.11, 861.26 or 840.04 g/m^2, respectively.



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3+4 leaves and L_4= Flag leaf clipping

Figure 10. Effect of leaf clipping on above ground dry matter weight hill^{-1} of aromatic rice at different days after transplanting (DAT) ($LSD_{0.05}$= 0.16, 0.78, 0.32, 1.69 and 0.94 at 20, 40, 60, 80 DAT and harvest, respectively)

4.1.3.3 Combined effect of seedling and leaf clipping

Significant influence was observed in respect of above ground dry matter weight hill^{-1} of aromatic rice due to combined effect of seedling and leaf clipping at different days after transplanting (Table 5). Results from the experiment revealed that the maximum above ground dry matter weight hill^{-1} (3.30, 14.22, 23.74, 41.94 and 47.10 g at 20, 40, 60, 80 DAT and harvest, respectively) were obtained from S_1L_0 treatment combination which was statistically similar with S_1L_3 (3.27 g), S_2L_0 (3.26 g), S_2L_1 (3.23 g) and S_0L_0 (3.12 g) treatment combination at 20 DAT; with S_1L_1 (13.09 g) treatment combination at 40 DAT; with S_1L_3 (23.67 g), S_2L_0 (23.66 g), S_2L_1 (23.59 g) and S_0L_0 (23.37 g) treatment combination at 60 DAT; with S_1L_1 (41.74 g and 47.07 g) treatment combination at 80 DAT and harvest, respectively. On the other hand the minimum above ground dry matter weight hill^{-1} (2.43 g) was achieved from S_0L_4 treatment combination which was statistically similar with S_2L_4 (2.48 g), S_1L_4 (2.54 g), S_0L_3 (2.58 g), S_2L_3 (2.60 g) and S_1L_1 (2.70 g) treatment combination at 20 DAT. At 40 DAT, the minimum above ground dry matter weight hill^{-1} (8.67 g) was obtained from S_2L_4 treatment combination which was statistically similar with S_0L_3 (9.45 g), S_2L_3 (9.45 g), S_0L_4 (9.58 g) and S_1L_4 (9.63 g) treatment combination. At 60 DAT, the minimum above ground dry matter weight hill^{-1} (21.99 g) was obtained from S_0L_4 treatment combination which was statistically as par with S_2L_4 (22.09 g), S_1L_4 (22.21 g), S_0L_3 (22.30 g), S_2L_3 (22.34 g) and S_1L_1 (22.53 g) treatment combination. At 80

DAT, the minimum above ground dry matter weight hill^{-1} (30.82 g) was observed in S_2L_4 treatment combination which was statistically similar with S_0L_4 (31.05 g), S_1L_4 (31.53 g), S_2L_3 (31.94 g) and S_0L_3 (33.04 g) treatment combination at 80 DAT. Finally at harvest, the minimum above ground dry matter weight hill^{-1} (39.15 g) was obtained from S_2L_3 treatment combination which was statistically similar with S_2L_2 (40.05 g) treatment combination.

Table 5. Combined effect of seedling and leaf clipping on above ground dry matter weight hill^{-1} (g) of aromatic rice (BRRI dhan80) at different days after transplanting (DAT)

Treatment Combinations	Above ground dry mater weight hill^{-1} (g) at different days after transplanting (DAT)				
	20	40	60	80	At harvest
S_0L_0	3.12 a-c	12.72 b	23.37 a-c	36.68 b	42.60 c-e
S_0L_1	2.80 d-f	12.27 b	22.75 d-g	34.30 b-d	42.53 c-e
S_0L_2	2.99 b-d	12.75 b	23.11 b-d	36.69 b	41.51 e-g
S_0L_3	2.58 fg	9.45 cd	22.30 f-h	33.04 c-e	40.84 fg
S_0L_4	2.43 g	9.58 cd	21.99 h	31.05 e	40.88 fg
S_1L_0	3.30 a	14.22 a	23.74 a	41.94 a	47.10 a
S_1L_1	2.70 e-g	13.09 ab	22.53 e-h	41.74 a	47.07 a
S_1L_2	2.90 c-e	12.39 b	22.94 c-e	35.38 bc	42.23 c-f
S_1L_3	3.27 ab	10.59 c	23.67 ab	35.13 bc	43.73 bc
S_1L_4	2.54 fg	9.63 cd	22.21 gh	31.53 de	41.66 e-g
S_2L_0	3.26 ab	12.73 b	23.66 ab	35.75 bc	44.96 b
S_2L_1	3.23 ab	12.42 b	23.59 ab	34.13 b-d	42.08 d-f
S_2L_2	2.82 d-f	12.13 b	22.79 d-f	35.09 bc	40.05 gh
S_2L_3	2.60 fg	9.45 cd	22.34 f-h	31.94 de	39.15 h
S_2L_4	2.48 g	8.67 d	22.09 h	30.82 e	43.35 b-d
$LSD_{0.05}$	0.28	1.35	0.56	2.93	1.63
CV(%)	5.76	6.98	1.44	4.96	2.27

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

NS= Non- significant

S_0= Control (no clipping)

S_1 =1/3rd top clipping

S_2= 1/2nd top clipping

L_0= Control (no clipping)

L_1= Lower 1+2 leaves

L_2= Lower 2+3 leaves

L_3= Lower 3+4 leaves

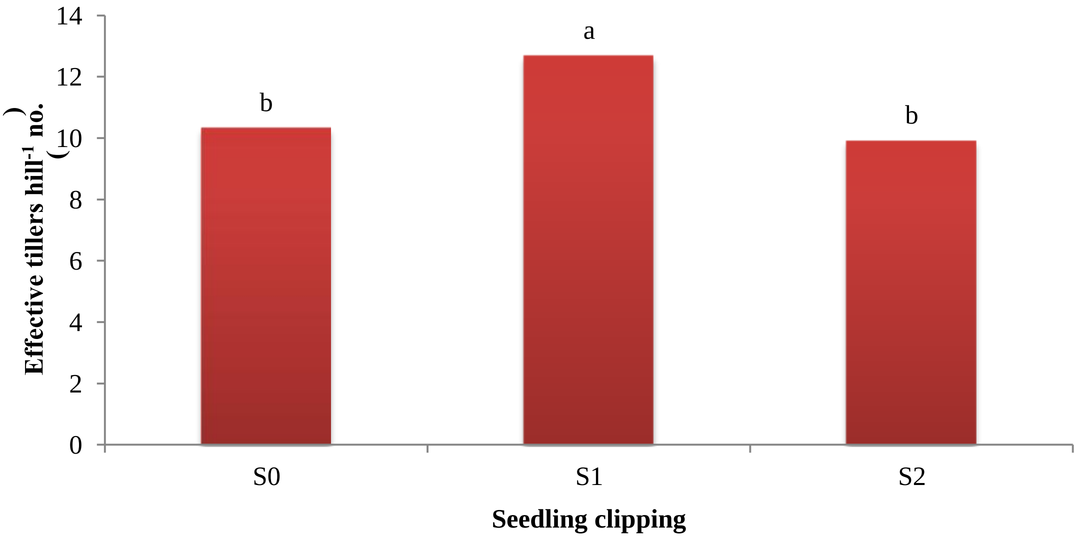
L_4= Flag leaf clipping

4.2. Yield contributing characters

4.2.1 Effective tillers hill^{-1} (no.)

4.2.1.1 Effect of seedling clipping

Significant influenced was obtained on number of effective tillers hill^{-1} due to seedling clipping (Fig. 11). Result from the experiment revealed that the maximum number of effective tillers hill^{-1} was obtained from S_1 (12.68) treatment while the minimum number of effective tillers hill^{-1} was achieved from S_2 (9.91) treatment which was statistically similar with S_0 (10.32) treatment. On the other hand, nonclipping seedlings developed lower productive tillers. It is possible that a lack of appropriate nutrients, light and mutual shade seedling foliage resulted in the decay of weak tillers and as a result, a reduction in productive tillers.

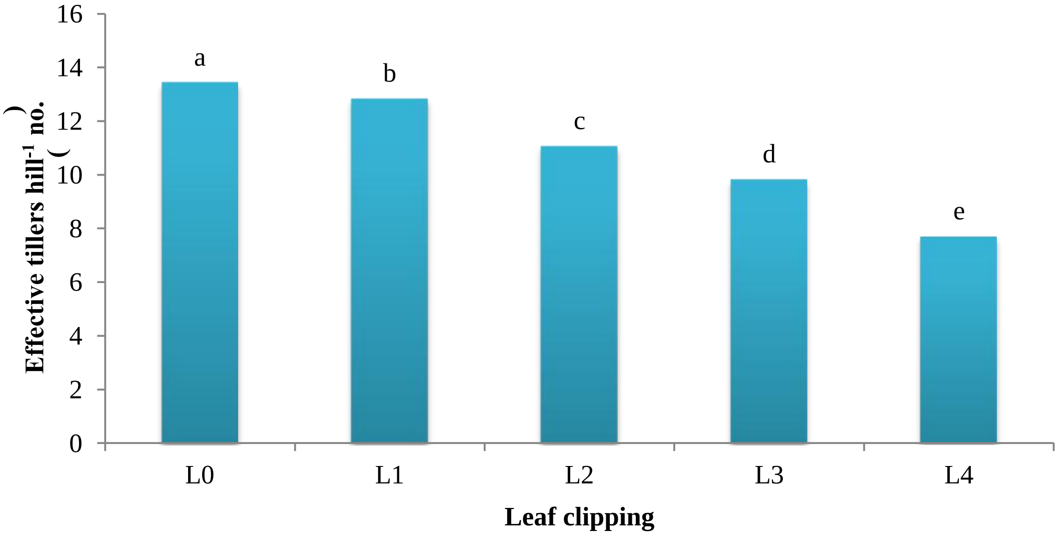


S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 11. Effect of seedling clipping on number of effective tillers hill^{-1} (no.) of aromatic rice at harvest respectively ($LSD_{0.05}$= 0.53)

4.2.1.2 Effect of leaf clipping

Leaf clipping exhibits significant variation on number of effect tillers hill^{-1} (Fig. 12). From the experiment result revealed that the maximum number of effect tillers hill^{-1} was obtained from L_0 (13.43) treatment which was statistically dissimilar with other treatments under the present study. On the other hand, the minimum number of effective tillers hill^{-1} was obtained from L_4 (7.70) treatment. The result of the present study was coincided with the findings of Fatima (2019) who reported that the highest number of effective tillers hill^{-1} was recorded from Heera 4 under control (without leaf cutting) condition. On the other hand, the dissimilar result was reported by Boonreund and Marsom (2015) who reported that cutting of leaves had no significant effect on tiller number plant^{-1}.



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3 +4 leaves and L_4= Flag leaf clipping

Figure 12. Effect of leaf clipping on number of effective tillers hill^{-1} (no.) of aromatic rice at harvest ($LSD_{0.05}$= 0.54)

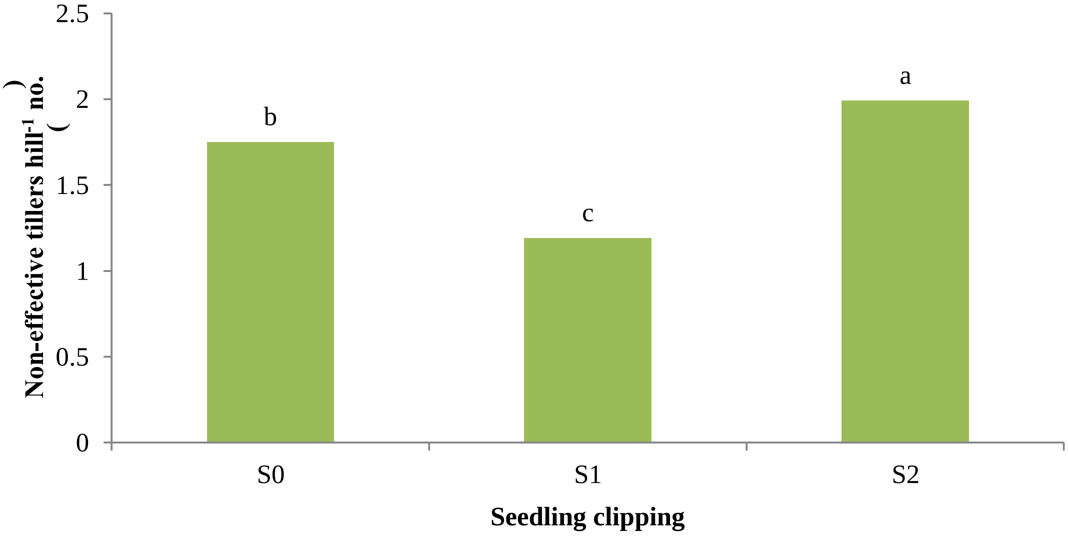
4.1.1.3 Combined effect of seedling and leaf clipping

Significant variation on number of effect tillers hill^{-1} of aromatic rice was observed due to combined effect of seedling and leaf clipping under the study (Table 6). Result revealed that the maximum number of effect tillers hill^{-1} (14.68) was obtained from S_1L_0 treatment combination which was statistically similar with S_1L_1 (14.53) treatment combination. On the other hand, the minimum number of effect tillers hill^{-1} (5.44) was obtained from S_2L_4 treatment combination which was statistically dissimilar with other treatment combinations. Due to seedling clipping, a good start of plant ensures more production of effective tillers.

4.2.2 Non-effective tillers hill^{-1} (no.)

4.2.2.1 Effect of seedling clipping

Number of non-effective tillers hill^{-1} exerted significant variation due to seedling clipping (Fig. 13). Result revealed that the maximum number of non-effective tillers hill^{-1} was obtained from S_2 (1.99) treatment while the minimum number of noneffective tillers hill^{-1} was obtained from S_1 (1.19) treatment. Seedling clipping allowed the crop to absorb more plant nutrients, moisture, and sun radiation for growth and it is possible that less plant competition among leaves resulted in quick growing of plants having non-effective tiller production.

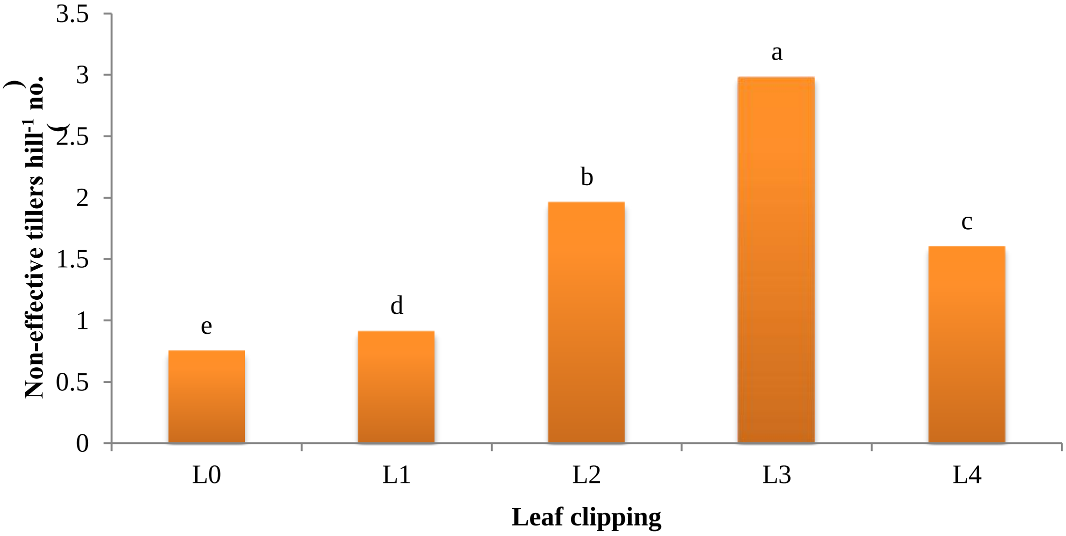


S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 13. Effect of seedling clipping on number of non-effective tillers hill^{-1} (no.) of aromatic rice at harvest ($LSD_{0.05}$= 0.06)

4.2.2.2 Effect of leaf clipping

Non-effective tillers hill^{-1} exerted significant variation due to leaf clipping of aromatic rice under the study (Fig. 14). Result from the experiment revealed that the maximum number of non-effective tillers hill^{-1} was obtained from L_3 (2.98) treatment while the minimum number of non-effective tillers hill^{-1} was obtained from L_0 (0.75) treatment which was statistically dissimilar with other treatments. Dissimilar result was observed by Ahmed *et al.* (2001) who reported that the greatest number of nonbearing tillers hill^{-1} was recorded from no leaf cutting treatment, which was genuinely like leaf cutting at 21 DAT and the minimum was seen in leaf cutting at 49 DAT.



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3+4 leaves and L_4= Flag leaf clipping

Figure 14. Effect of leaf clipping on number of non-effective tillers hill^{-1} (no.) of aromatic rice at harvest ($LSD_{0.05}$= 0.07)

4.2.2.3 Combined effect of seedling and leaf clipping

Significant variation on number of non-effective tillers hill^{-1} of aromatic rice was exerted due to combined effect of seedling and leaf clipping under the study (Table 6). Result revealed that the maximum number of non-effective tillers hill^{-1} (3.56) was observed in S_0L_3 treatment combination. On the other hand the minimum number of non-effective tillers hill^{-1} (0.45) was observed in S_1L_0 treatment combination which was statistically similar with S_1L_1 (0.54) treatment combination.

Table 6. Combined effect of seedling and leaf clipping on number of effective and non-effective tillers hill^{-1} of aromatic rice (BRRI dhan80) at harvest

Treatment Combinations	Effective tillers hill^{-1} (no.)	Non- effective tillers hill^{-1} (no.)
S_0L_0	13.17 b	0.89 g
S_0L_1	11.97 cd	1.16 f
S_0L_2	11.17 de	1.56 e
S_0L_3	8.77 f	3.56 a
S_0L_4	6.50 g	1.56 e
S_1L_0	14.68 a	0.45 h
S_1L_1	14.53 a	0.54 h
S_1L_2	11.57 cd	1.96 d
S_1L_3	11.44 d	2.09 d
S_1L_4	11.17 de	0.89 g
S_2L_0	12.44 bc	0.89 g
S_2L_1	11.97 cd	1.03 fg
S_2L_2	10.44 e	2.36 c
S_2L_3	9.24 f	3.29 b
S_2L_4	5.44 h	2.36 c
$LSD_{0.05}$	**0.93**	**0.14**
CV(%)	**5.06**	**5.00**

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

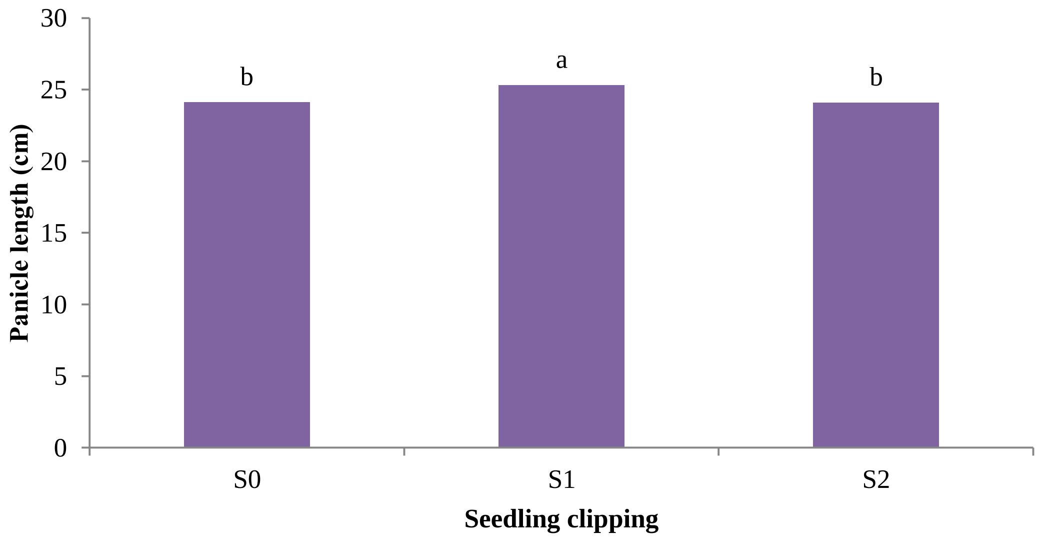
Notes *viz:*
NS= Non- significant
S_0= Control (no clipping)
S_1 =1/3rd top clipping
S_2= 1/2nd top clipping

L_0= Control (no clipping)
L_1= Lower 1+2 leaves
L_2= Lower 2+3 leaves
L_3= Lower 3 +4 leaves
L_4= Flag leaf clipping

4.2.3 Panicle length

4.2.3.1 Effect of seedling clipping

Panicle length exerted significant variation due to seedling clipping of aromatic rice under the present study (Fig. 15). Results from the experiment revealed that the maximum panicle length (25.31 cm) was obtained from S_1 treatment while the minimum panicle length (24.09 cm) was achieved from S_2 treatment which was statistically similar with S_0 (24.11 cm). The number of seedlings hill^{-1} was lowered via seedling clipping. Seedlings hill^{-1} at a certain level ensure plants grow in both aerial and underground parts by efficiently utilizing solar radiation, water, and nutrients without competition from established seedling hill^{-1} and aid in the development of yield contributing characters (such as panicle length) that aid in grain yield production comparable to extreme or non-clipping seedling.

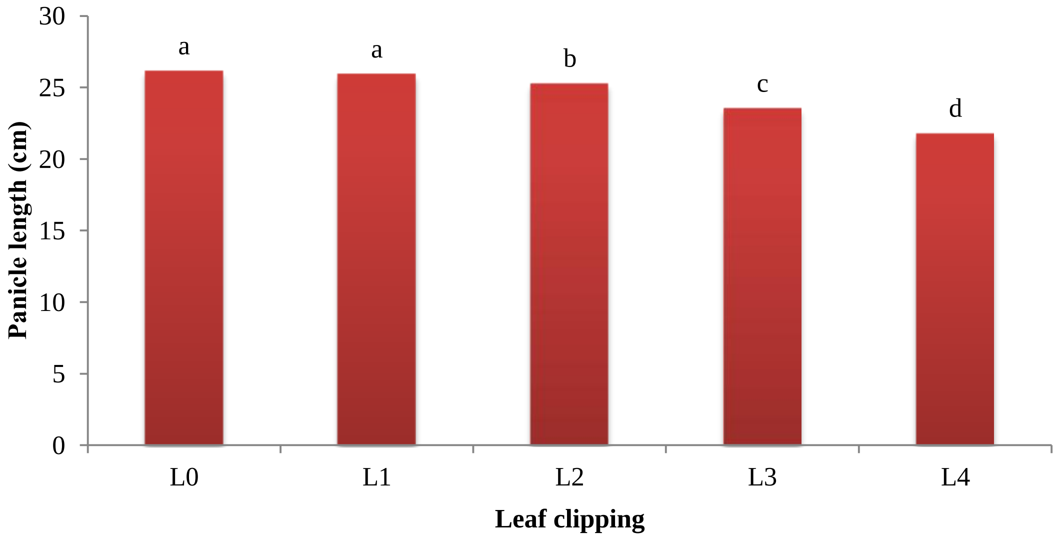


S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 15. Effect of seedling clipping on number of panicle length (cm) of aromatic rice at harvest ($LSD_{0.05}$= 0.86)

4.2.3.2 Effect of leaf clipping

Significant variation on panicle length was observed due to leaf clipping of aromatic rice under the experiment (Fig. 16). Results from the experiment showed that the maximum panicle length was observed in L_0 (26.12 cm) treatment which was statistically similar with L_1 (25.91 cm) treatment while the minimum panicle length was obtained from L_4 (21.76 cm) treatment. Dissimilar result was reported by Das *et al.* (2017) and Boonreund and Marsom (2015). They reported that cutting of leaves had no significant effect on panicle length of rice. 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. Rahman *et al.* (2013) reported that flag leaf increasing the panicle length in some extent which supported the present finding.



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3+4 leaves and L_4= Flag leaf clipping

Figure 16. Effect of seedling clipping on panicle length (cm) of aromatic rice at harvest ($LSD_{0.05}$= 0.65)

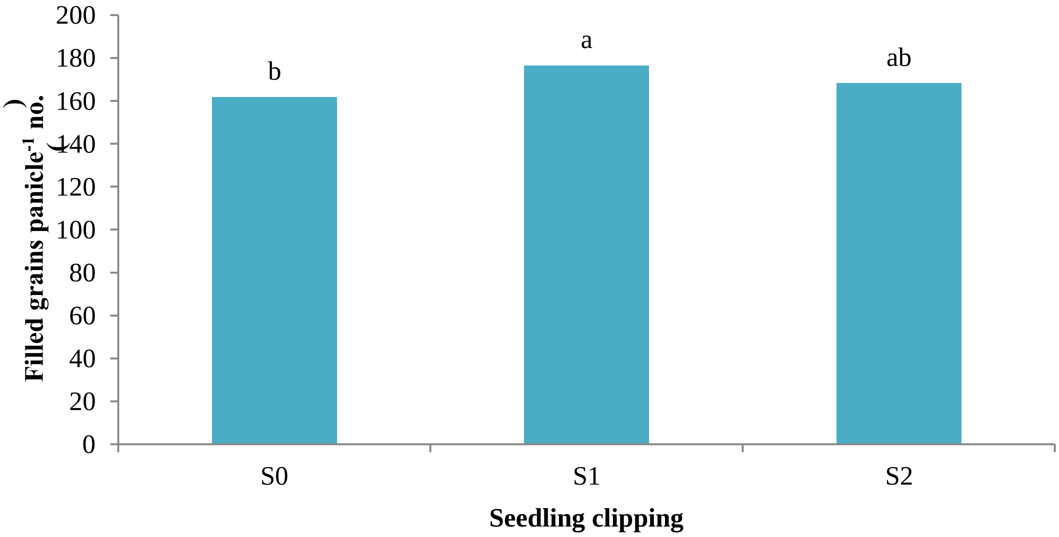
4.2.3.3 Combined effect of seedling and leaf clipping

Combined effect of seedling and leaf clipping exerted significant influenced on panicle length (cm) of aromatic rice under the experiment (Table 7). Result revealed that the maximum panicle length (27.19 cm) was obtained from S_1L_0 treatment combination which was statistically similar with S_1L_1 (26.60 cm) and S_1L_2 (26.36 cm) treatment combination. On the other hand the minimum panicle length (20.04 cm) was obtained from S_0L_4 treatment combination which was statistically dissimilar with the other treatment combinations.

4.2.4 Filled grains panicle^{-1}

4.2.4.1 Effect of seedling clipping

Filled grains panicle^{-1} is an important yield contributing attributes which influences the yield of the plant (Fig. 17). Significant variation was marked in respect of filled grains panicle^{-1} of aromatic rice variety due to seedling clipping. From the experiment result revealed that the maximum number of filled grains panicle^{-1} (176.58) was obtained from S_1 treatment which was statistically similar with S_2 (168.32) treatment while the minimum number of filled grains panicle^{-1} (161.79) was obtained from S_0 treatment.



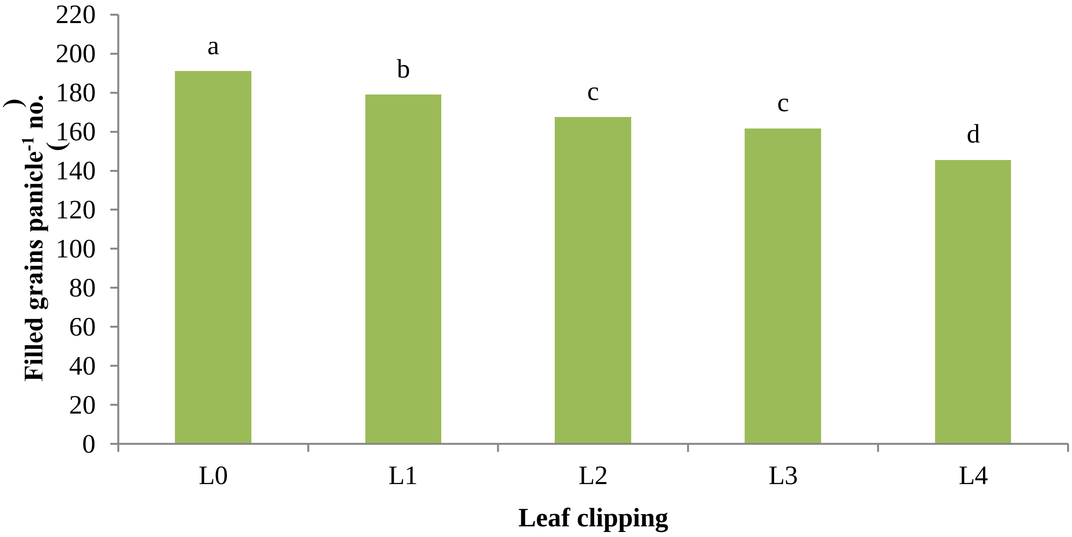
S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 17. Effect of seedling clipping on filled grains panicle^{-1} (no.) of aromatic rice at harvest ($LSD_{0.05}$= 9.85)

4.2.4.2 Effect of leaf clipping

Leaf clipping of aromatic rice exerted significant influence on number of filled grains panicle^{-1} under the study (Fig. 18). From the experiment result noted that the maximum number of filled grains panicle^{-1} was obtained from L_0 (190.95) treatment. On the other hand the minimum number of filled grains panicle^{-1} was obtained from L_4 (145.56) treatment. The result obtained from the present study was similar with the findings of Das *et al.* (2017) who reported that the reduction in filled grains takes place by flag leaf cut (35.14%), flag leaf with 2nd leaf cut (62.62%) and flag leaf with

2nd and 3rd leaf cut (51.83%). The findings also coincided with the findings of Usman *et al.* (2007) who reported that the highest number of filled grains panicle^{-1} (90) were obtained from control (no detopping) treatment. Ahmed *et al.* (2001) also reported that the number of sterile spikelets panicle^{-1} was found to be the highest for no leaf cutting treatment; which was statistically similar to cutting at 21 DAT. The lowest value for number of sterile spikelets panicle^{-1} was recorded from cutting at 49 DAT.



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3 +4 leaves and L_4= Flag leaf clipping

Figure 18. Effect of leaf clipping on filled grains panicle^{-1} (no.) of aromatic rice at harvest ($LSD_{0.05}$= 7.70)

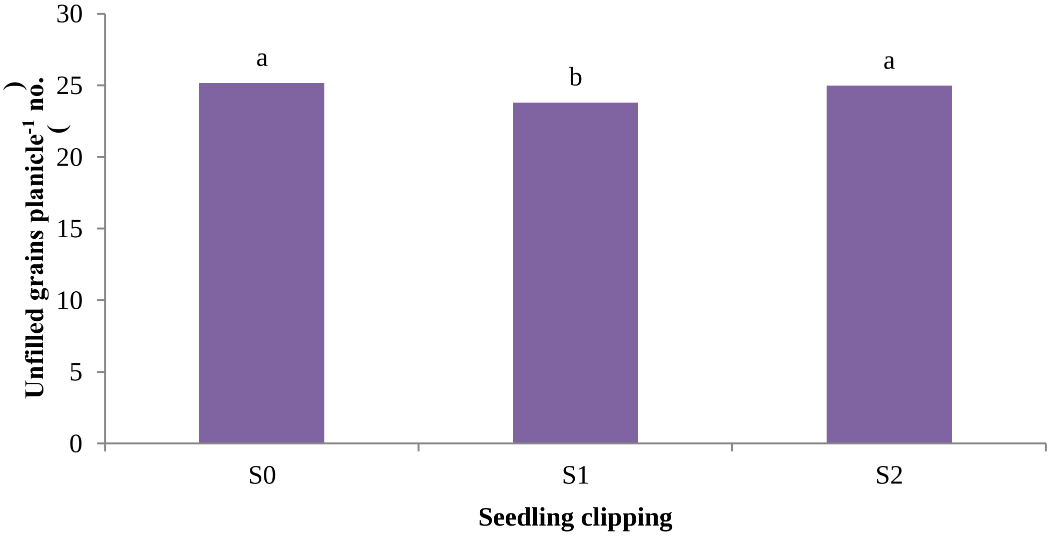
4.2.4.3 Combined effect of seedling and leaf clipping

Combined effect of seedling and leaf clipping showed remarked influence on number of filled grains panicle^{-1} of aromatic rice under the study (Table 7). Result revealed that the maximum number of filled grains panicle^{-1} (206.07) was observed in S_1L_0 treatment combination which was statistically as par with S_2L_0 (196.94) and S_1L_1 (194.08) treatment combination. On the other hand the minimum number of filled grains panicle^{-1} (140.92) was obtained from S_2L_4 treatment combination which was statistically similar with S_0L_4 (143.29) and S_1L_4 (152.47) treatment combination.

4.2.5 Unfilled grains panicle^{-1} (no.)

4.2.5.1 Effect of seedling clipping

Seedling clipping exerted significant difference in respect of unfilled grains panicle^{-1} of aromatic rice variety (Fig. 19). Result from the experiment revealed that the maximum number of unfilled grains panicle^{-1} (25.17) was observed in S_0 treatment which was statistically similar with S_2 (24.95) treatment while the minimum number of unfilled grains panicle^{-1} (23.80) was obtained from S_1 treatment.



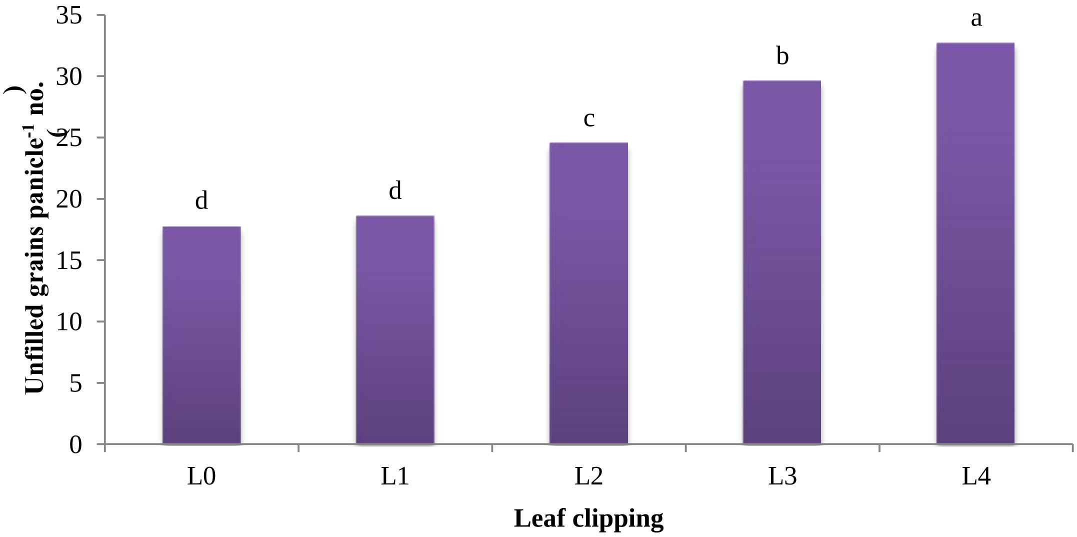
S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 19. Effect of seedling clipping on unfilled grains panicle^{-1} (no.) of aromatic rice at harvest ($LSD_{0.05}$= 0.97)

4.2.5.2 Effect of leaf clipping

Leaf clipping of aromatic rice exerted remarked effect on number of unfilled grains panicle^{-1} (Fig. 20). From the experiment result showed that the maximum number of unfilled grains panicle^{-1} was obtained from L_4 (32.70) treatment. On the other hand the minimum number of unfilled grains panicle^{-1} was obtained from L_0 (17.78) treatment which was statistically as par with L_1 (18.60) treatment. The result obtained from the present study was similar with the findings of Das *et al.* (2017) who reported that unfilled grain number increased with higher intensity of leaf cutting and was the highest (79.40) in flag leaf with 3rd leaf cut, which was similar with flag leaf with 2nd

leaf cut (65.91). The lowest unfilled grain was observed in the control (33.99) treatment.



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3+4 leaves and L_4= Flag leaf clipping

Figure 20. Effect of leaf clipping on unfilled grains panicle^{-1} (no.) of aromatic rice at harvest ($LSD_{0.05}$= 1.80)

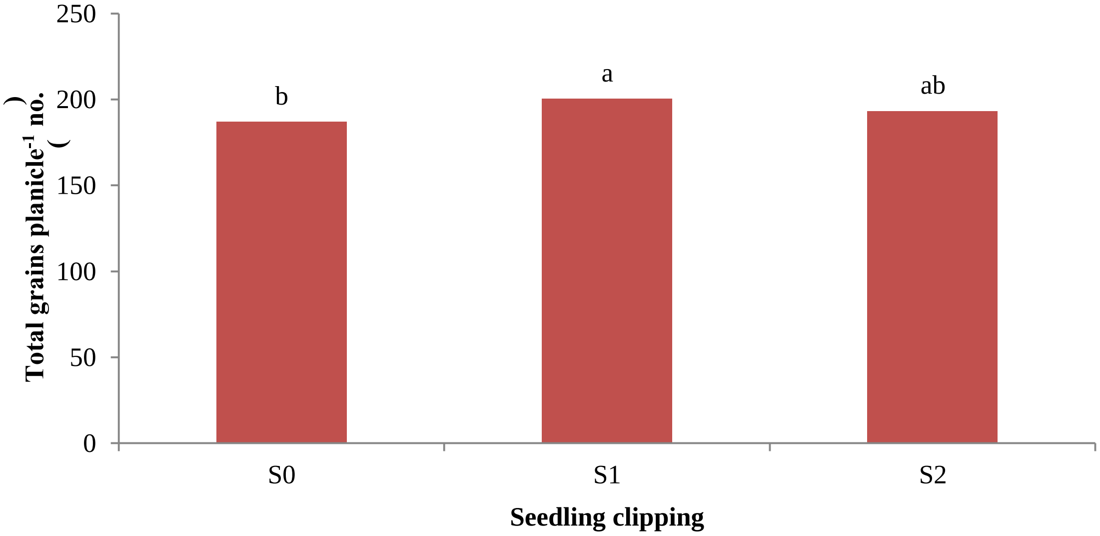
4.2.5.3 Combined effect of seedling and leaf clipping

Significant variation was observed on number of unfilled grains panicle^{-1} of aromatic rice due to combined effect of seedling and leaf clipping (Table 7). Result revealed that the maximum number of unfilled grains panicle^{-1} (35.18) was obtained from S_0L_4 treatment combination. On the other hand the minimum number of unfilled grains panicle^{-1} (15.36) was obtained from S_1L_0 treatment combination which was statistically similar with S_1L_1 (17.06) and S_2L_1 (17.99) treatment combination.

4.2.6 Total grains panicle^{-1}

4.2.6.1 Effect of seedling clipping

Seedling clipping exerted significant variation in respect of total grains panicle^{-1} of aromatic rice variety (Fig. 21). From the experiment result revealed that the maximum number of total grains panicle^{-1} (200.39) was observed in S_1 treatment which was statistically as par with S_2 (193.27) treatment while the minimum number of total grains panicle^{-1} (186.95) was obtained from S_0 treatment.

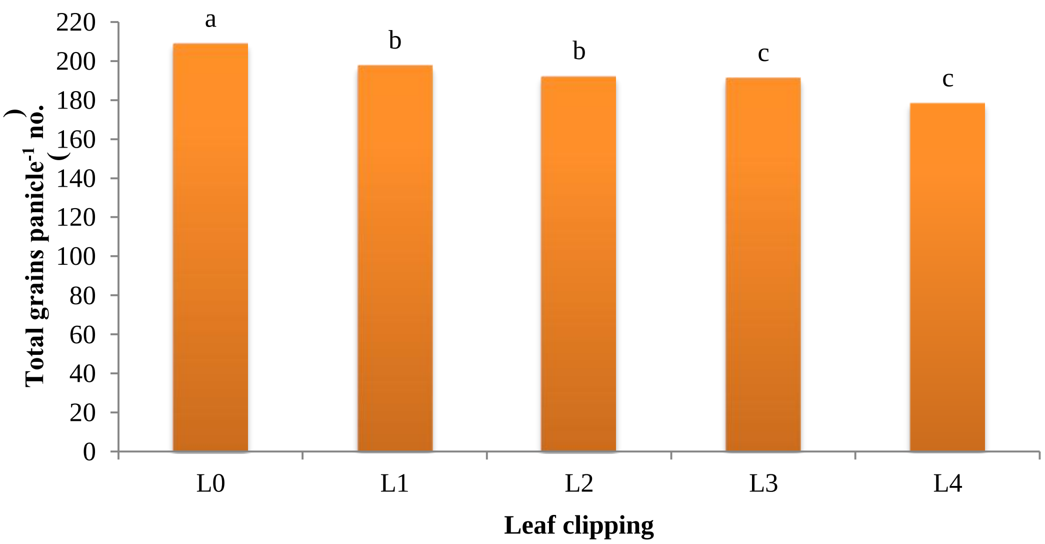


S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 21. Effect of seedling clipping on total grains panicle^{-1} (no.) of aromatic rice at harvest (LSD$_{0.05}$= 9.01)

4.2.6.2 Effect of leaf clipping

Leaf clipping of aromatic rice exhibits significant variation on number of total grains panicle^{-1} under the study (Fig. 22). From the experiment result showed that the maximum number of total grains panicle^{-1} was obtained from L_0 (208.73) treatment. On the other hand the minimum number of total grains panicle^{-1} was obtained from L_4 (178.27) treatment. The findings of the experiment was also coincided with the findings of Usman *et al.* (2007) who reported that the highest number of spikelets panicle^{-1} (106.8) was obtained from control (no detopping) treatment. Aktaruzzaman (2006) also reported that the defoliation of flag leaf caused significant decrease on spikelets per panicle by 17.34 %. Likewise, the expulsion of penultimate leaf caused decrease of 10.98 % for spikelets per panicle. Similarly, the defoliation of third leaf caused decrease of 7.20 % for spikelets per panicle. Likewise, the defoliation of flag leaf, penultimate leaf and third at a time caused reduction of 29.20 % for spikelets per panicle.



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3+4 leaves and L_4= Flag leaf clipping

Figure 22. Effect of leaf clipping on total grains panicle^{-1} (no.) of aromatic rice at harvest ($LSD_{0.05}$= 8.04)

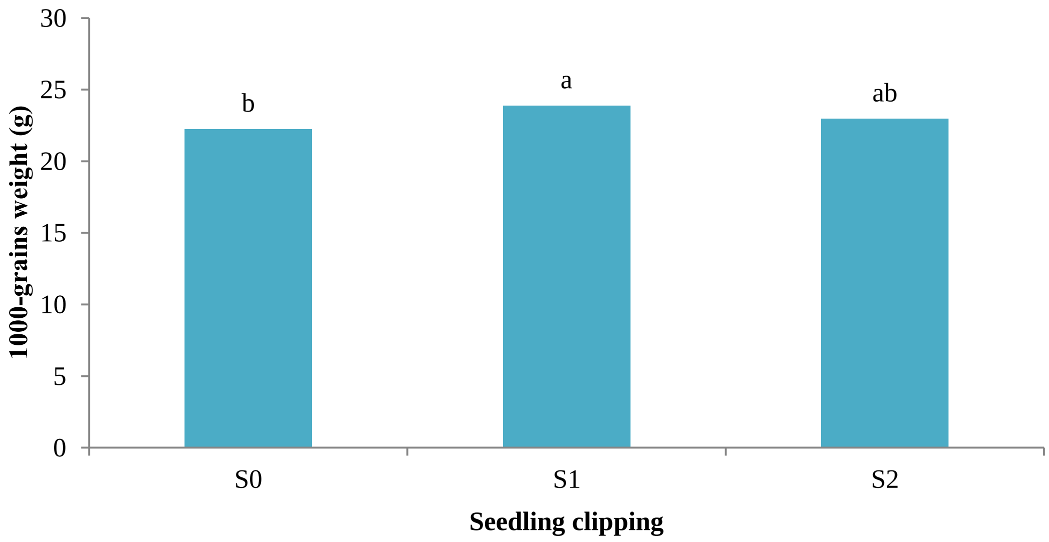
4.2.6.3 Combined effect of seedling and leaf clipping

Combined effect of seedling and leaf clipping exerted significant influence on number of total grains panicle^{-1} of aromatic rice under the present study. Result revealed that the maximum number of total grains panicle^{-1} (221.42) was observed in S_1L_0 treatment combination which was statistically similar with S_2L_0 (215.49) and S_1L_1 (211.14) treatment combination. On the other hand the minimum number of total grains panicle^{-1} (172.27) was obtained from S_2L_4 treatment combination which was statistically similar with S_0L_4 (178.47) and S_1L_4 (184.07) treatment combination.

4.2.7 1000-grains weight (g)

4.2.7.1 Effect of seedling clipping

Effect of seedling clipping exerted significant difference in 1000 grains weight of aromatic rice (Fig. 23). Results from the experiment revealed that the maximum 1000 grains weight of aromatic rice (23.89 g) was obtained from S_1 treatment which was statistically similar with S_2 (22.98 g) treatment while the minimum 1000 grains weight of aromatic rice (22.25 g) was obtained from S_0 treatment.

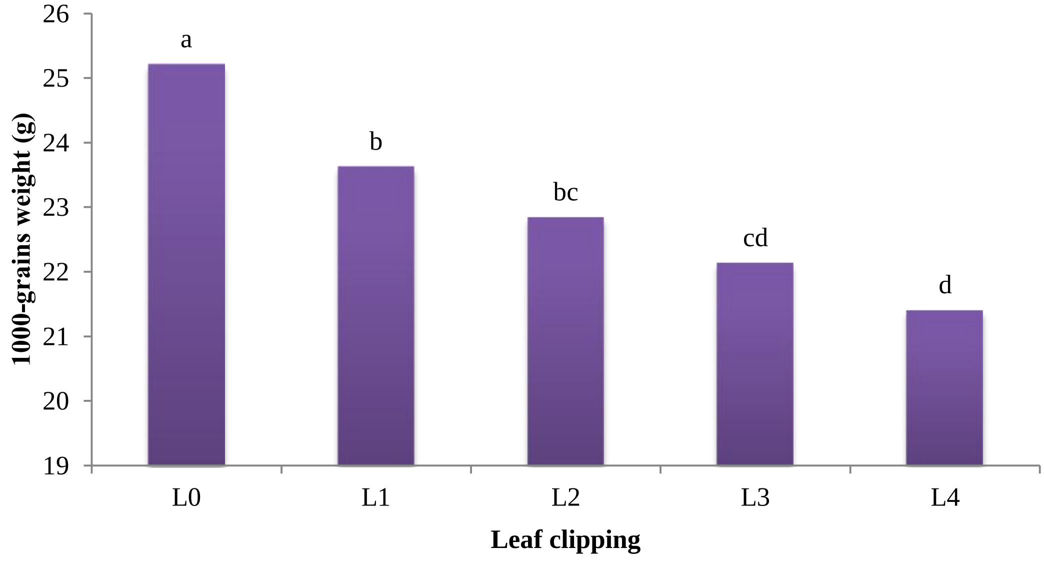


S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 23. Effect of seedling clipping on 1000 grains weight of aromatic rice at harvest ($LSD_{0.05}$= 0.99)

4.2.6.2 Effect of leaf clipping

Significant effect showed on 1000 grains weight of aromatic rice due to leaf clipping (Fig. 24). Result from the experiment showed that the maximum 1000 grains weight of aromatic rice was obtained from L_0 (25.21 g) treatment. On the other hand the minimum 1000 grains weight of aromatic rice was obtained from L_4 (21.40 g) treatment which was statistically similar with L_3 (22.13 g) treatment. The findings was also coincided with the findings of Fatima (2019) who reported that the maximum weight of 1000-grains was recorded from Heera4 under control (without flag leaf cutting) condition. Das *et al.* (2017) showed the same result of the present study and reported that leaf clipping had significant effect on 1000 grains weight of local variety. Hossain (2017) also reported that 1000-grains weight was significantly reduced in plants those had the leaves cut compared with the plant in control treatment.



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3+4 leaves and L_4= Flag leaf clipping

Figure 24. Effect of leaf clipping on 1000 grains weight of aromatic rice at harvest ($LSD_{0.05}$= 1.01)

4.2.7.3 Combined effect of seedling and leaf clipping

Combined effect of seedling and leaf clipping exhibits significant differences on 1000 grains weight of aromatic rice under the present study (Table 7). Result revealed that the maximum 1000 grains weight of aromatic rice (26.24 g) was observed in S_1L_0 treatment combination which was statistically similar with S_1L_1 (26.02 g) and S_2L_0 (25.02 g). On the other hand the minimum 1000 grains weight of aromatic rice (21.02 g) was observed in S_0L_4 treatment combination which was statistically similar with S_1L_4 (21.15 g), S_0L_2 (21.15 g), S_2L_3 (21.69 g), S_0L_3 (22.02 g), S_2L_4 (22.02 g), S_2L_1 (22.15 g), S_0L_1 (22.69 g) and S_1L_3 (22.69 g) treatment combination.

Table 7. Combined effect of seedling and leaf clipping on panicle length, filled grains panicle^{-1}, unfilled grains panicle^{-1}, total grains panicle^{-1} and weight of 1000-grains of aromatic rice (BRRI dhan80)

Treatment Combinations	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Total grains panicle^{-1} (no.)	Weight of 1000 grains (g)
S_0L_0	25.95 bc	169.84 b	19.46 g-i	189.29 bc	24.35 b-d
S_0L_1	25.90 bc	168.91 b	20.76 gh	189.66 bc	22.69 d-f
S_0L_2	25.50 bc	165.83 b	22.30 fg	188.13 bc	21.15 f
S_0L_3	23.16 d-f	161.07 c	28.14 cd	189.21 bc	22.02 ef
S_0L_4	20.04 g	143.29 d	35.18 a	178.47 cd	21.02 f
S_1L_0	27.19 a	206.07 a	15.36 j	221.42 a	26.24 a
S_1L_1	26.60 ab	194.08 a	17.06 ij	211.14 a	26.02 ab
S_1L_2	26.36 ab	167.80 b	24.92 ef	192.72 b	23.35 c-e
S_1L_3	23.76 de	162.49 bc	30.09 bc	192.58 b	22.69 d-f
S_1L_4	22.62 f	152.47 cd	31.59 b	184.07 b-d	21.15 f
S_2L_0	25.21 c	196.94 a	18.54 hi	215.49 a	25.02 a-c
S_2L_1	25.21 c	173.65 b	17.99 h-j	191.64 bc	22.15 ef
S_2L_2	23.85 d	168.92 b	26.33 de	195.25 b	24.02 cd
S_2L_3	23.54 d-f	161.18 bc	30.54 bc	191.72 bc	21.69 ef
S_2L_4	22.63 ef	140.92 d	31.34 b	172.27 d	22.02 ef
$LSD_{0.05}$	1.13	13.34	3.12	13.93	1.75
CV(%)	2.75	4.69	7.52	4.27	4.50

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

NS= Non- significant

S_0= Control (no clipping)

S_1 =1/3rd top clipping

S_2= 1/2nd top clipping

L_0= Control (no clipping)

L_1= Lower 1+2 leaves

L_2= Lower 2+3 leaves

L_3= Lower 3+4 leaves

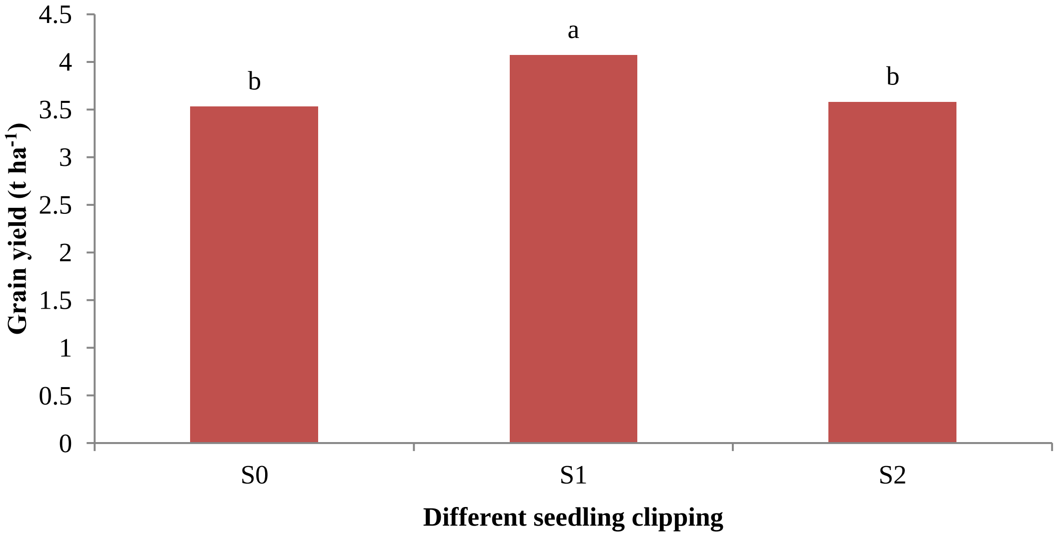
L_4= Flag leaf clipping

4.3 Yield characters

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

4.3.1.1 Effect of seedling clipping

Significant variation on grain yield (t ha^{-1}) of aromatic rice was observed due to effect of different seedling clipping (Figure 25). From the experiment result revealed that the maximum grain yield (4.07 t ha^{-1}) was obtained from S_1 treatment while the minimum grain yield (3.53 t ha^{-1}) was obtained from S_0 treatment which was statistically similar with S_2 (3.58 t ha^{-1}) treatment. These could be attributed to the fact that seedling clipping maintained the rice field well aerated, allowing the crop to absorb a greater amount of plant nutrients, moisture, and solar radiation for better growth.



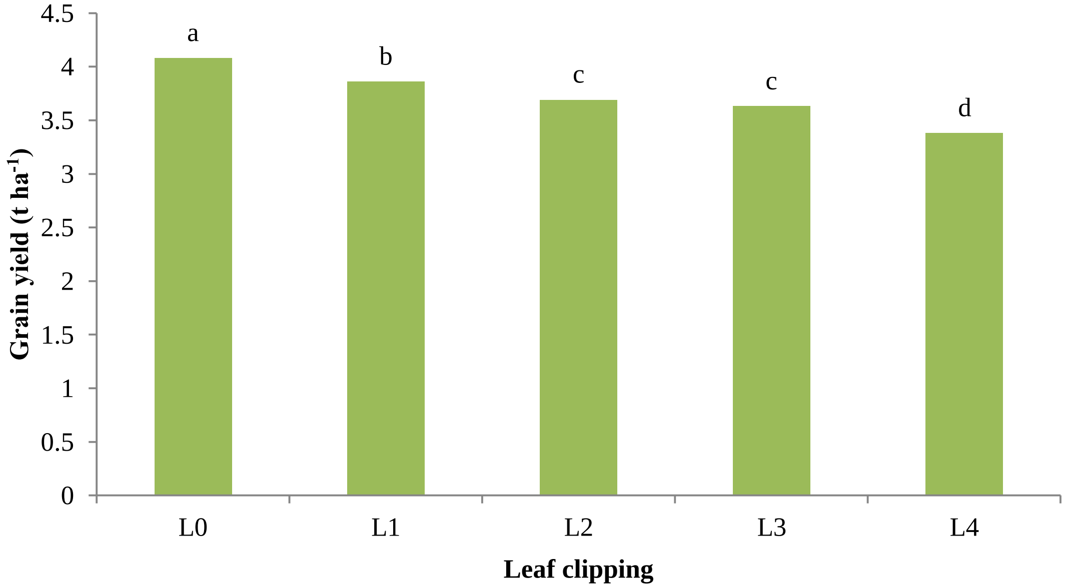
S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 25. Effect of seedling clipping on grain yield of aromatic rice at harvest ($LSD_{0.05}$= 0.14)

4.3.1.2 Effect of leaf clipping

Leaf clipping of exerted significant variation on grain yield (t ha^{-1}) of aromatic rice (Fig. 26). From the experiment result showed that the maximum grain yield of aromatic rice was obtained from L_0 (4.08 t ha^{-1}) treatment. On the other hand the minimum grain yield of aromatic rice was obtained from L_4 (3.38 t ha^{-1}) treatment. The finding of the experiment was coincided with the findings of Fatima (2019).

Karmaker and Karmakar (2019) found the same results and reported that the highest mean grain yield (5.25 t ha^{-1}) was obtained from the treatment combination of 115 kg N ha^{-1} and no leaf clipping (N_4C_0) comparable to other treatment. Hossain (2017) observed that the reduction of grain yield was minimum (10%) in BRRI dhan39 (control 5.75 t ha^{-1}, treated 5.15 t ha^{-1}) with leaf cutting than that of the rest varieties. Abou-khalifa *et al*. (2008) also reported that flag leaf contributed to 45% of grain yield and removal of flag leaf is the single most component for yield loss and this was true for present experiment. Ros *et al.* (2003) found that pruning 30% of leaves depressed grain yield by 20%.



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3+4 leaves and L_4= Flag leaf clipping

Figure 26. Effect of leaf clipping on grain yield of aromatic rice at harvest ($LSD_{0.05}$= 0.11)

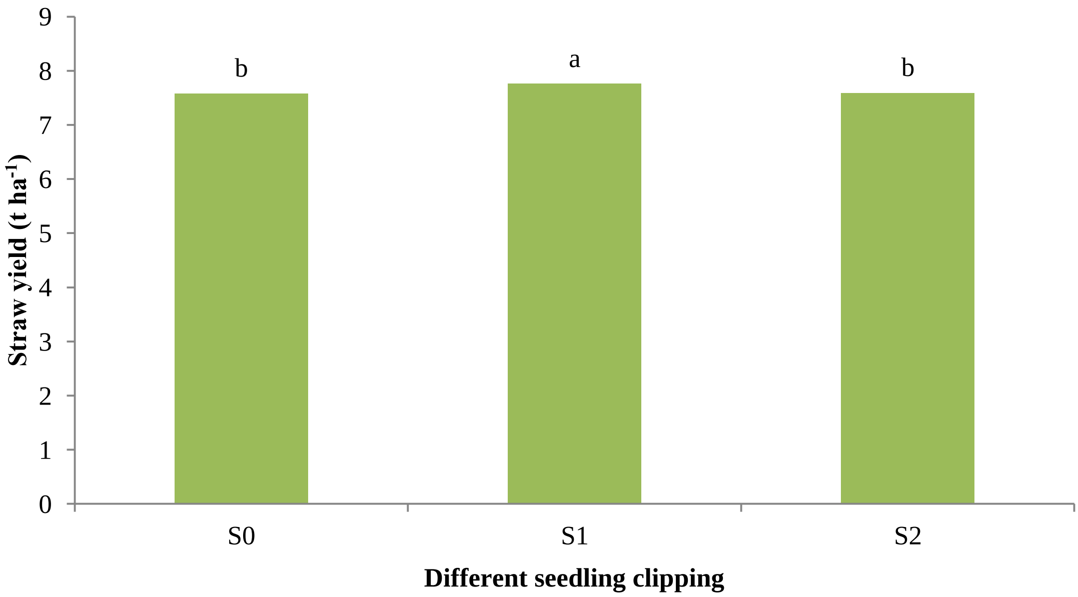
4.3.1.3 Combined effect of seedling and leaf clipping

Combined effect of seedling and leaf clipping exhibits significant difference on grain yield (t ha^{-1}) of aromatic rice under the present study (Table 8). Result from the experiment revealed that the maximum grain yield of aromatic rice (4.52 t ha^{-1}) was obtained from S_1L_0 treatment combination which was statistically as par with S_1L_1 (4.49 t ha^{-1}) treatment combination. On the other hand the minimum grain yield of aromatic rice (3.28 t ha^{-1}) was obtained from S_2L_4 treatment combination which was statistically similar with S_0L_4 (3.34 t ha^{-1}) and S_2L_3 (3.42 t ha^{-1}) treatment combination.

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

4.3.1.1 Effect of seedling clipping

Significant variation was exerted on straw yield (t ha^{-1}) of aromatic rice due to effect of different seedling clipping (Figure 27). From the experiment result revealed that the maximum straw yield (7.76 t ha^{-1}) was achieved from S_1 treatment. On the other hand the minimum straw yield (7.58 t ha^{-1}) was obtained from S_0 treatment which was statistically similar with S_2 (7.59 t ha^{-1}) treatment. Seedling clipping at a specific level aids in the production of vigor seedling hill-1. Produce higher biomass by relocating enough food components from the body to the expanding panicles, favoring the creation of more straw and grain in comparison to a week seedling. Week seedlings are less competition among seedlings for nutrients for seedling development.

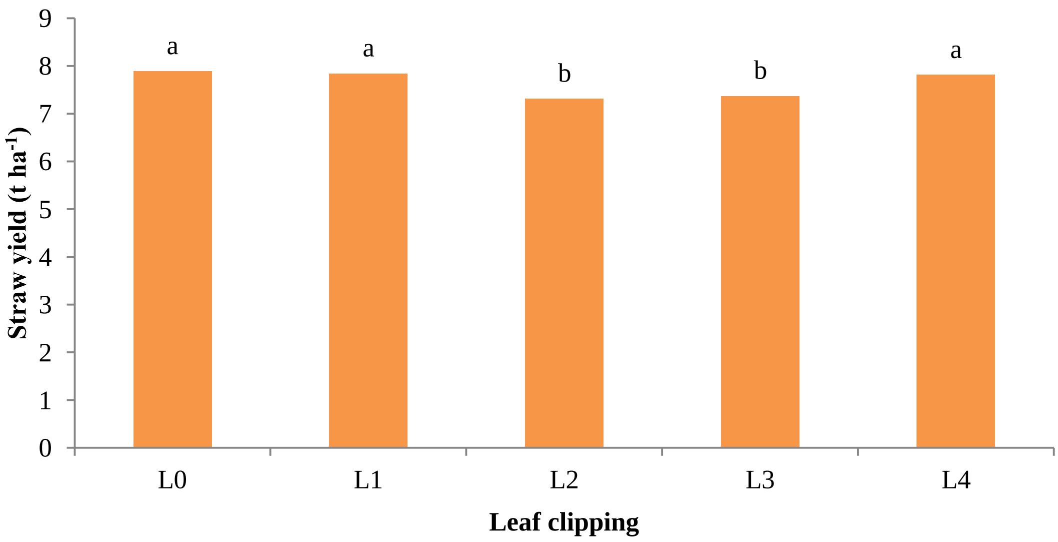


S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 27. Effect of seedling clipping on straw yield of aromatic rice at harvest ($LSD_{0.05}$= 0.13)

4.3.1.2 Effect of leaf clipping

Significant effect was observed on straw yield (t ha^{-1}) of aromatic rice due to leaf clipping (Fig. 28). From the experiment result showed that the maximum straw yield of aromatic rice was obtained from L_0 (7.89 t ha^{-1}) treatment which was statistically similar with L_1 (7.84 t ha^{-1}) and L_4 (7.81 t ha^{-1}). On the other hand the minimum straw yield of aromatic rice was obtained from L_2 (7.31 t ha^{-1}) treatment which was statistically similar with L_3 (7.37 t ha^{-1}) treatment. The findings was coincided with the findings of Hossain (2017) who reported that irrespective of all the varieties under study, the highest straw yield was obtained in no leaf cutting (control).



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3+4 leaves and L_4= Flag leaf clipping

Figure 28. Effect of leaf clipping on straw yield of aromatic rice at harvest ($LSD_{0.05}$= 0.26)

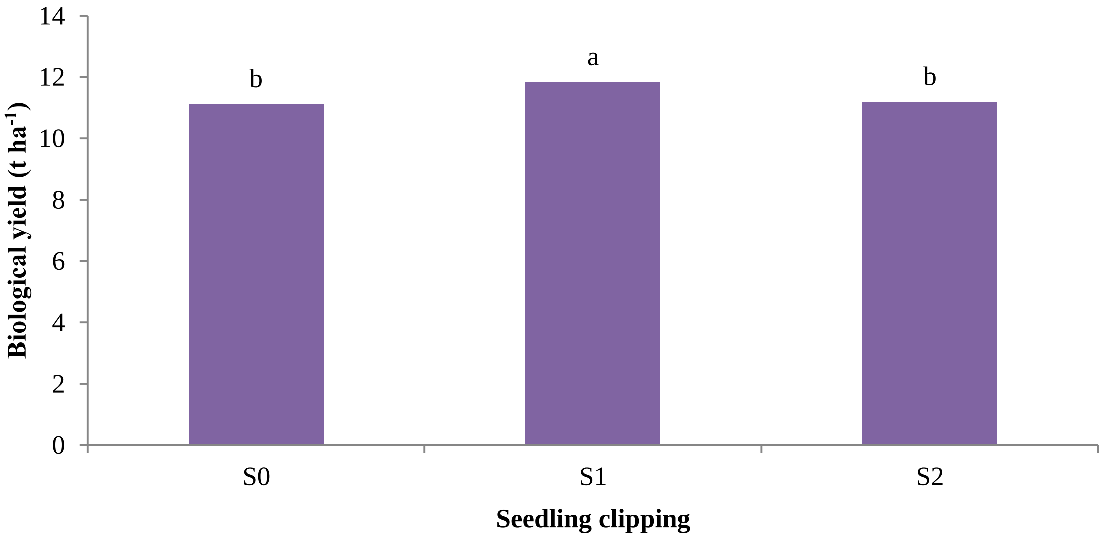
4.3.1.3 Combined effect of seedling and leaf clipping

Combined effect of seedling and leaf clipping showed significant influences on straw yield (t ha^{-1}) of aromatic rice (Table 8). Result revealed that the maximum straw yield of aromatic rice (8.28 t ha^{-1}) was obtained from S_2L_4 treatment combination which was statistically similar with S_1L_1 (8.07 t ha^{-1}), S_1L_0 (8.04 t ha^{-1}), S_2L_0 (7.98 t ha^{-1}) and S_0L_1 (7.86 t ha^{-1}) treatment combination. On the other hand the minimum straw yield of aromatic rice (7.02 t ha^{-1}) was obtained from S_2L_3 treatment combination which was statistically similar with S_2L_2 (7.09 t ha^{-1}), S_0L_2 (7.40 t ha^{-1}), S_0L_3 (7.42 t ha^{-1}) and S_1L_2 (7.45 t ha^{-1}) treatment combination.

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

4.3.3.1 Effect of seedling clipping

Aromatic rice exerted significant influence on biological yield due to effect of different seedling clipping (Fig. 29). From the experiment result revealed that the maximum biological yield (11.83 t ha^{-1}) was obtained from S_1 treatment. On the other hand the minimum biological yield (11.11 t ha^{-1}) was achieved from S_0 treatment which was statistically as par with S_2 (11.18 t ha^{-1}) treatment.



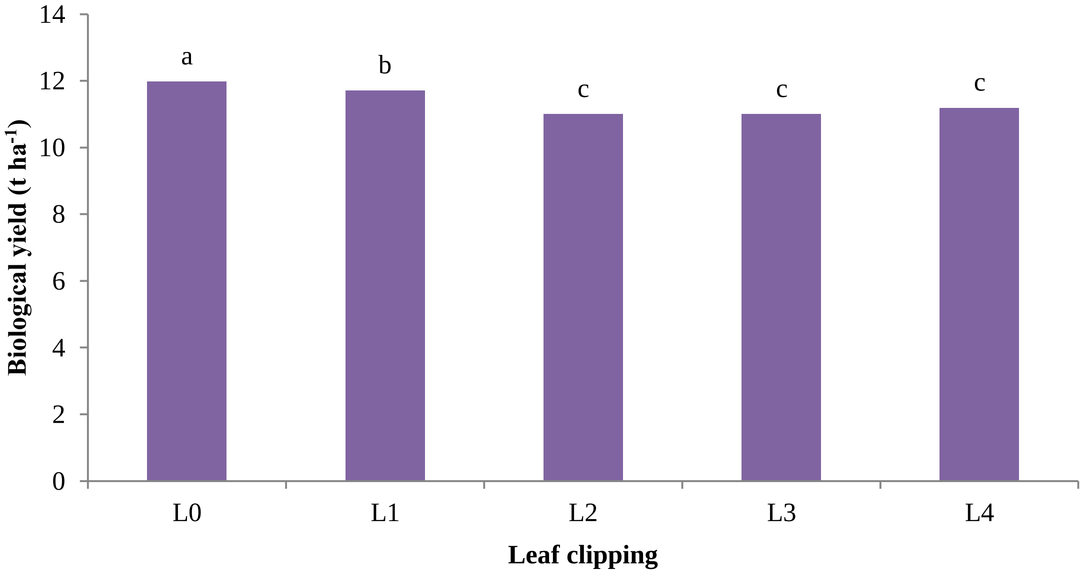
S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 29. Effect of seedling clipping on biological yield of aromatic rice at harvest ($LSD_{0.05}$= 0.25)

4.3.3.2 Effect of leaf clipping

Significant effect on biological yield was observed due to different leaf clipping of aromatic rice under the present study (Fig. 30). From the experiment result showed that the maximum biological yield of aromatic rice was observed in L_0 (11.97 t ha^{-1}) treatment. On the other hand the minimum biological yield of aromatic rice was obtained from L_3 (11.00 t ha^{-1}) treatment which was statistically similar with L_2

(11.00 t ha^{-1}) and L_4 (11.19 t ha^{-1}) treatment. Fatima (2019) and Usman *et al.* (2007) also found similar results with the present study. That reported that the highest biological yield was obtained from control treatment.



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3 +4 leaves and L_4= Flag leaf clipping

Figure 30. Effect of leaf clipping on biological yield of aromatic rice at harvest ($LSD_{0.05}$= 0.25)

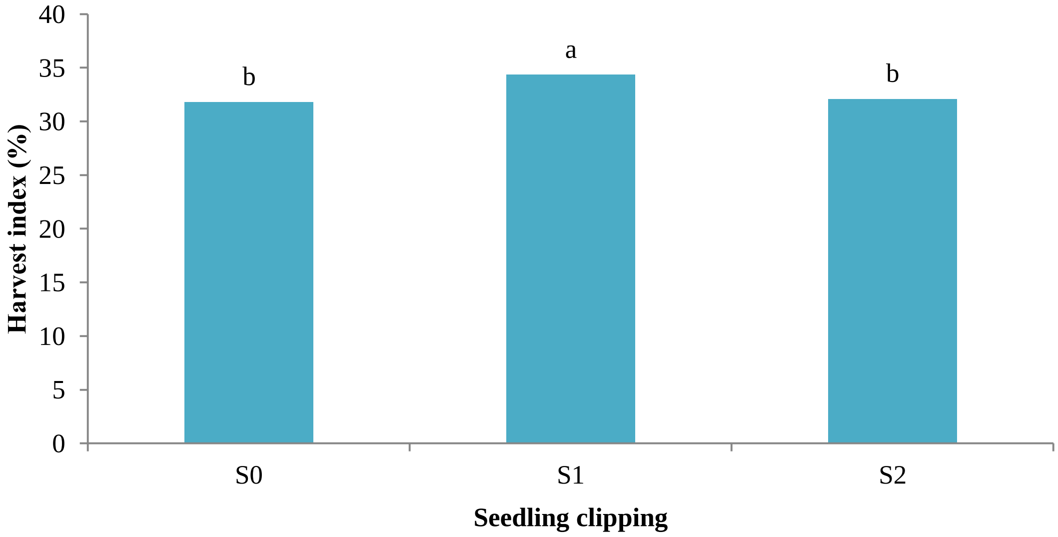
4.3.3.3 Combined effect of seedling and leaf clipping

Combined effect of seedling and leaf clipping showed significant difference on biological yield (t ha^{-1}) of aromatic rice under the study (Table 8). Result revealed that the maximum biological yield of aromatic rice (12.56 t ha^{-1}) was achieved from S_1L_0 treatment combination which was statistically similar with S_1L_1 (12.56 t ha^{-1}). On the other hand the minimum biological yield of aromatic rice (10.44 t ha^{-1}) was observed in S_2L_3 treatment combination which was statistically similar with S_2L_2 (10.68 t ha^{-1}) treatment combination.

4.3.4 Harvest index (%)

4.3.4.1 Effect of seedling clipping

Harvest index (%) of aromatic rice showed significant influences due to effect of different seedling clipping (Fig. 31). Result from the experiment noted that the maximum harvest index (34.34 %) was obtained from S_1 treatment. On the other hand the minimum harvest index (31.78 %) was observed in S_0 treatment which was statistically similar with S_2 (32.09 %) treatment.

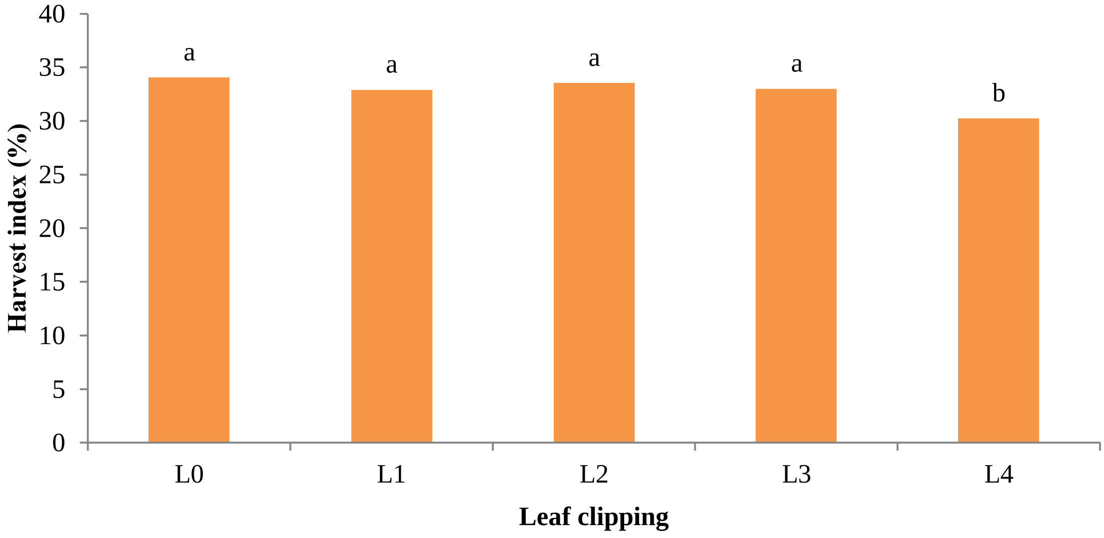


S_0= Control (no clipping), S_1 =1/3rd top clipping and S_2= 1/2nd top clipping

Figure 31. Effect of seedling clipping on harvest index of aromatic rice at harvest ($LSD_{0.05}$= 0.55)

4.3.3.2 Effect of leaf clipping

Significant effect on harvest index (%) was observed due to different leaf clipping of aromatic rice under the study (Fig. 32). From the experiment result showed that the maximum harvest index of aromatic rice was obtained from L_0 (34.04%) treatment which was statistically similar with L_2 (33.53%), L_3 (32.98%) and L_1 (32.90%) treatment. On the other hand the minimum harvest index of aromatic rice was obtained from L_4 (30.23%) treatment. The findings of the study was also coincided with the findings of Karmaker and Karmakar (2019) who reported that the highest mean harvest index (46%) was obtained from the treatment combination of 115 kg N ha^{-1} and no leaf clipping (N_4C_0) comparable to others treatment combinations. Usman *et al.* (2007) also reported that the highest harvest index (42.70%) was obtained from control.



L_0= Control (no clipping), L_1= Lower 1+2 leaves, L_2= Lower 2+3 leaves, L_3= Lower 3 +4 leaf clipping and L_4= Flag leaf clipping

Figure 32. Effect of leaf clipping on harvest index of aromatic rice at harvest ($LSD_{0.05}$= 1.15)

4.3.3.3 Combined effect of seedling and leaf clipping

Different seedling along with different leaf clipping remarked significant difference on harvest index (%) of aromatic rice (Table 8). Result revealed that the maximum harvest index of aromatic rice (36.11%) was obtained from S_1L_0 treatment combination which was statistically similar with S_1L_1 (35.75%) and S_1L_3 (34.31%) treatment combination. On the other hand the minimum harvest index of aromatic rice (28.37%) was obtained from S_2L_4 treatment combination which was statistically dissimilar with the other treatment combination under the study.

Table 8. Combined effect of seedling and leaf clipping on grain yield, straw yield, biological yield and harvest index of aromatic rice (BRRI dhan80)

Treatment Combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
S_0L_0	3.70 de	7.66 b-e	11.36 cd	32.57 c-f
S_0L_1	3.48 f-i	7.86 a-e	11.34 c-e	30.69 f
S_0L_2	3.67 d-f	7.40 ef	11.07 d-g	33.15 c-e
S_0L_3	3.47 g-j	7.42 ef	10.89 fg	31.86 d-f
S_0L_4	3.34 ij	7.56 de	10.90 e-g	30.64 f
S_1L_0	4.52 a	8.04 a-c	12.56 a	36.11 a
S_1L_1	4.49 a	8.07 ab	12.56 a	35.75 ab
S_1L_2	3.81 cd	7.45 ef	11.26 c-f	33.84 b-d
S_1L_3	4.00 bc	7.66 b-e	11.66 bc	34.31 a-c
S_1L_4	3.52 e-i	7.59 c-e	11.11 d-g	31.68 ef
S_2L_0	4.01 b	7.98 a-d	11.99 b	33.45 c-e
S_2L_1	3.62 d-g	7.60 c-e	11.22 c-f	32.26 d-f
S_2L_2	3.59 e-h	7.09 f	10.68 gh	33.61 c-e
S_2L_3	3.42 h-j	7.02 f	10.44 h	32.76 c-e
S_2L_4	3.28 j	8.28 a	11.56 bc	28.37 g
$LSD_{0.05}$	**0.19**	**0.46**	**0.44**	**1.99**
CV(%)	**3.08**	**3.55**	**2.28**	**3.61**

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

NS= Non- significant

S_0= Control (no clipping)

S_1 =1/3rd top clipping

S_2= 1/2nd top clipping

L_0= Control (no clipping)

L_1= Lower 1+2 leaves

L_2= Lower 2+3 leaves

L_3= Lower 3+4 leaves

L_4= Flag leaf clipping

CHAPTER V

SUMMARY, CONCLUSION

AND

RECOMMENDATIONS

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The present piece of work was carried out at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during July to December 2019, to investigate the effect of seedling and leaf clipping on growths, yield and yield contributing characters of aromatic rice. The experimental field belongs to the Agro-ecological zone (AEZ) of "Madhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Deep Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of two factors, and followed split plot design. Factor A: Seedling top clipping (3) *viz:* S_0= Control (no clipping), S_1=1/3rd clipping and S_2= 1/2nd clipping and Factor B: Leaf clipping (5) *viz:* L_0= Control (no clipping), L_1= Lower 1 + 2 leaves, L_2= Lower 2 + 3 leaves, L_3= Lower 3 + 4 leaves and L_4= Flag leaf clipping. The total numbers of unit plots were 45. The size of unit plot was 5.76 m^2 (2.4 m × 2.4 m). Data on different growth, yield contributing characters and yield were recorded to find out the impacts of seedling and leaf clipping for the production of highest grain yield of aromatic rice (BRRI dhan80).

Seedling and leaf clipping either individually or combined showed significant influences in most of the characters of aromatic rice.

In respect of seedling clipping the maximum plant height (44.63, 75.91, 88.01, 96.90 and 115.99 cm at 20, 40, 60, 80 DAT and harvest, respectively), number of leaves hill^{-1} (35.43) was obtained from S_1 treatment at 20 DAT; (69.27) was observed in S_0 treatment at 40 DAT. At 60 DAT and 80 DAT, the maximum leaves hill^{-1} (48.68) was obtained from S_1 treatment. (19.48, 43.97, 74.37 and 87.34 cm^2 at 20, 40, 60 and 80 DAT, respectively), tillers hill^{-1} (12.37, 18.73, 15.97, 13.77 and 13.87 at 20, 40, 60, 80 DAT and harvest, respectively), above ground dry matter weight hill^{-1} (2.94, 11.98, 23.02, 37.15 and 44.36 g at 20, 40, 60, 80 DAT and harvest, respectively), effective tillers hill^{-1} (12.68) were obtained from S_1 treatment. The maximum number of noneffective tillers hill^{-1} was observed in S_2 (1.99) treatment. The maximum panicle length (25.31 cm), the numbers of filled grains panicle^{-1} (176.58) were observed in S_1 treatment. The maximum unfilled grains panicle^{-1} (25.17) was obtained from S_0 treatment. The maximum total grains panicle^{-1} (200.39), 1000 grains weight of aromatic rice (23.89 g), grain yield (4.07 t ha^{-1}), straw yield (7.76 t ha^{-1}), biological yield (11.83 t ha^{-1}) and the maximum harvest index (34.34 %) were obtained from S_1 treatment. On the other hand the minimum plant height (40.34, 71.42, 80.57, 94.43 and 110.90 cm at 20, 40, 60, 80 DAT and harvest respectively), leaves $hill^{-1}$ (34.40, 68.16, 48.50 and 40.75 at 20, 40, 60 and 80 DAT, respectively) were observed in S_2 treatment. On the other hand the minimum leaf area (16.22 and 42.92 cm^2 at 20 and 40 DAT, respectively) was obtained from S_0 treatment. At 60 and 80 DAT the minimum leaf area (69.33 cm^2 and 79.30 cm^2) were obtained from S_2 treatment. The minimum tillers $hill^{-1}$ (12.27, 17.30, 14.93 and 13.09 at 20, 40, 60 and 80 DAT, respectively) was obtained from S_0 treatment. On the other hand the minimum above ground dry matter weight $hill^{-1}$ (2.78 g at 20 DAT) was observed in S_0 treatment. At 40 and 80 DAT respectively the minimum above ground dry matter $hill^{-1}$ (11.08 g and 33.55 g) were observed in S_2 treatment at 40 and 80 DAT. At 60 DAT and harvest respectively, minimum above ground dry matter $hill^{-1}$ (22.71 g and 41.67 g) were observed in S_0 treatment at harvest. The minimum effective tillers $hill^{-1}$ was observed in S_2 (9.91) treatment. The minimum non-effective tillers $hill^{-1}$ was observed in S_1 (1.19) treatment. The minimum panicle length (24.09 cm) was achieved from S_2 treatment. The minimum filled grains $panicle^{-1}$ (161.79) was obtained from S_0 treatment. The minimum unfilled grains $panicle^{-1}$ (23.80) was observed in S_1 treatment. The minimum total grains $panicle^{-1}$ (186.95), 1000 grains weight of aromatic rice (22.25 g), grain yield (3.53 t ha^{-1}), straw yield (7.58 t ha^{-1}), biological yield (11.11 t ha^{-1}) and harvest index (31.78 %) were obtained from S_0 treatment.

In respect of leaf clipping the maximum plant height ((44.93, 78.16, 87.09, 99.34 and 118.33 cm at 20, 40, 60, 80 DAT and harvest, respectively), leaves $hill^{-1}$ (36.30, 71.24, 50.49 and 43.00 at 20, 40, 60 and 80 DAT, respectively) were obtained from L_0 treatment. The maximum leaf area (24.87 and 51.63 cm^2 at 20 and 40 DAT respectively) were achieved from L_1 treatment. At 60 and 80 DAT, the maximum leaf area (74.29 and 94.81 cm^2) was obtained from L_0 treatment. The maximum number of tillers $hill^{-1}$ (12.97, 20.29, 15.70, 14.29 and 14.18 at 20, 40, 60, 80 DAT and harvest respectively), above ground dry matter weight $hill^{-1}$ (3.23, 13.22, 23.59, 38.12 and 44.89 g at 20, 40, 60, 80 DAT and harvest respectively), effective tillers $hill^{-1}$ (13.43) were obtained from L_0 treatment. The maximum non-effective tillers $hill^{-1}$ was achieved from L_3 (2.98) treatment. The maximum panicle length (26.12 cm) and filled grains panicle^{-1} (190.95) were obtained from L_0 treatment. The maximum unfilled grains panicle^{-1} was observed in L_4 (32.70) treatment. The maximum total grains panicle^{-1} (208.73), 1000 grains weight of aromatic rice (25.21 g), grain yield (4.08 t ha^{-1}), straw yield (7.89 t ha^{-1}), biological yield (11.97 t ha^{-1}) and harvest index of aromatic rice (34.04 %) were obtained from L_0 treatment. On the other hand the minimum plant height (37.85, 69.39, 75.46, 91.28 and 107.89 cm at 20, 40, 60, 80 DAT and harvest, respectively), leaves hill^{-1} (31.64, 65.37, 45.19 and 36.56 at 20, 40, 60 and 80 DAT, respectively) was observed in L_3 treatment. Leaf area (9.28, 32.40, 66.25 and 69.06 cm^2 at 20, 40, 60 and 80 DAT, respectively) was observed in L_4 treatment. The minimum tillers hill^{-1} (11.68 and 14.77 at 20 and 40 DAT, respectively) were obtained from L_4 treatment which was statistically similar with L_3 (11.90) treatment at 20 DAT. At 60 DAT, the minimum tillers hill^{-1} (14.88) was observed in L_2 treatment. At 80 DAT and harvest respectively the minimum tillers hill^{-1} (12.56 and 9.31) were obtained from L_4 treatment. The minimum above ground dry matter weight hill^{-1} (2.48, 9.30, 22.10 and 31.13 g at 20, 40, 60 and 80 DAT), the minimum effective tillers hill^{-1} (7.70) was observed in L_4 treatment. The minimum non-effective tillers hill^{-1} was observed in L_0 (0.75) treatment. The minimum panicle length (21.76 cm), filled grains panicle^{-1} (145.56) was observed in L_4 treatment. The minimum unfilled grains panicle^{-1} (17.78) was obtained from L_0 treatment. The minimum total grains panicle^{-1} (178.27), 1000 grains weight (21.40 g), grain yield (3.38 t ha^{-1}) was observed in L_4 treatment. The minimum straw yield of aromatic rice (7.31 t ha^{-1}) was observed in L_2 treatment. The minimum biological yield of aromatic rice (11.00 t ha^{-1}) was observed in L_3 treatment and the minimum harvest index of aromatic rice (30.23 %) was obtained from L_4 treatment.

In respect of combined effect result revealed that the maximum plant height (48.50, 83.33, 95.29, 104.99 and 126.08 cm at 20, 40, 60, 80 DAT and harvest, respectively), leaves hill^{-1} (36.90, 72.87, 51.30 and 43.63 at 20, 40, 60 and 80 DAT, respectively) were achieved from S_0L_0 treatment combination. The maximum leaf area (27.21 cm^2) was obtained from S_1L_1 treatment combination at 20 DAT. At 40 DAT, the maximum leaf area (54.05 cm^2) was observed in S_0L_0 treatment combination. At 60 and 80 DAT respectively the maximum leaf area (80.50 and 101.78 cm^2) were observed in S_1L_0

treatment combination. The maximum tillers hill^{-1} (13.10) was observed in S_1L_0 treatment combination at 20 DAT. At 40 DAT the maximum tillers hill^{-1} (21.40) was observed in S_1L_1 treatment combination. At 60, 80 DAT and harvest respectively the maximum tillers hill^{-1} (17.28, 14.91 and 15.13) was observed in S_1L_0 treatment combination. The maximum above ground dry matter weight hill^{-1} (3.30, 14.22, 23.74, 41.94 and 47.10 g at 20, 40, 60, 80 DAT and harvest, respectively), number of effective tillers hill^{-1} (14.68) were obtained from S_1L_0 treatment combination. The maximum non-effective tillers hill^{-1} (3.56) was obtained from S_0L_3 treatment combination. The maximum panicle length (27.19 cm), filled grains panicle^{-1} (206.07) was obtained from S_1L_0 treatment combination. The maximum number of unfilled grains panicle^{-1} (35.18) was observed in S_0L_4 treatment combination. The maximum total grains panicle^{-1} (221.42), 1000 grains weight of aromatic rice (26.24 g), grain yield (4.52 t ha^{-1}) was obtained from S_1L_0 treatment combination. The maximum straw yield (8.28 t ha^{-1}) was observed in S_2L_4 treatment combination. The maximum biological yield (12.56 t ha^{-1}) and harvest index of aromatic rice (36.11 %) were obtained from S_1L_0 treatment combination. On the other hand the minimum plant height (35.53 cm) was observed in S_2L_4 treatment combination at 20 DAT. At 40 DAT, the minimum plant height (66.17 cm) was observed in S_1L_4 treatment combination. At 60 DAT, the minimum plant height (72.72 cm) was observed in S_2L_4 treatment combination. At 80 DAT, the minimum plant height (88.70 cm) was observed in S_0L_4 treatment combination. Finally at harvest respectively the minimum plant height (103.45 cm) was observed in S_2L_4 treatment combination. The minimum leaves hill^{-1} (30.83, 65.25, 43.95 and 35.50 at 20, 40, 60 and 80 DAT, respectively) were obtained from S_2L_3 treatment combination. The minimum leaf area ((8.41 cm^2) was observed in S_2L_4 treatment combination at 20 DAT. At 40 DAT, the minimum leaf area (31.30 cm^2) was observed in S_0L_4 treatment combination. At 60 and 80

DAT, the minimum leaf area (63.15 and 64.50 cm^2, respectively) was observed in S_2L_4 treatment combination. The minimum number of tillers hill^{-1} (11.43) was observed in S_2L_4 treatment combination at 20 DAT. At 40 DAT, the minimum number of tillers hill^{-1} (13.93) was obtained from the treatment combination of S_0L_4. At 60 DAT, the minimum tillers hill^{-1} (14.21) was achieved from the treatment combination of S_0L_2. At 80 DAT, the minimum tillers hill^{-1} (12.38) was obtained from

S_0L_4 treatment combination and finally at harvest respectively the minimum tillers hill^{-1} (7.80) was obtained from the treatment combination of S_2L_4. The minimum above ground dry matter weight hill^{-1} (2.43 g) was achieved from S_0L_4 treatment combination at 20 DAT. At 40 DAT, the minimum above ground dry matter weight hill^{-1} (8.67 g) was obtained from S_2L_4 treatment combination. At 60 DAT, the minimum above ground dry matter weight hill^{-1} (21.99 g) was obtained from S_0L_4 treatment combination. At 80 DAT, the minimum above ground dry matter weight hill^{-1} (30.82 g) was observed in S_2L_4 treatment combination. Finally at harvest, the minimum above ground dry matter weight hill^{-1} (39.15 g) was obtained from S_2L_3 treatment combination. The minimum effective tillers hill^{-1} (5.44) was obtained from S_2L_4 treatment combination. The minimum non-effective tillers hill^{-1} (0.45) was observed in S_1L_0 treatment combination. The minimum panicle length (20.04 cm) was observed in S_0L_4 treatment combination. The minimum filled grains panicle^{-1} (140.92) was scored from S_2L_4 treatment combination. The minimum unfilled grains panicle^{-1} (15.36) was observed in S_1L_0 treatment combination. The minimum total grains panicle^{-1} (172.27), 1000 grains weight (21.02 g) was observed in S_0L_4 treatment combination. On the other hand the minimum grain yield (3.28 t ha^{-1}) was observed in S_2L_4 treatment combination. The minimum straw yield (7.02 t ha^{-1}), biological yield (10.44 t ha^{-1}) were observed in S_2L_3 treatment combination and finally the minimum harvest index of aromatic rice (28.37%) was obtained from S_2L_4 treatment combination.

CONCLUSION

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

Treatment combination (S_1L_0), 1/3rd seedling clipping along with no leaf clipping is the best management to have comparable maximum growth and yield of aman rice (var. BRRI dhan80).

RECOMMENDATIONS

Further trials with the same treatment combinations on different agro-ecological zone of Bangladesh would be judicial to make a sustainable conclusion before the countrywide dissemination of BRRI dhan80 cultivation management.

REFERENCES

REFERENCES

Abou-Khalifa, A. A. B., Misra, A. N., El-Azeem, A. and Salem, K. M. (2008). Effect of leaf cutting on physiological traits and yield of two rice cultivars. *African J. Plant Sci.* **2**(12): 147–150.

Ahmed, M., Ahmed, F., Molla, M. S. H., Hossain M. D. and Rahman, B. M. Z. (2001). Effect of nitrogen rate and time of leaf cutting on green fodder as well as seed yield of rice. *Pakistan J. Biol. Sci*. **4**(8): 937–939.

Ahmed, M., Hashem, M. A., Molla, M. S. H. and Kamruzzaman, M. (2001). Effect of pre-flowering leaf cutting on forage and seed yield of Transplant Aman Rice. *Pakistan J. Biol. Sci*. **4**(8): 934–936.

Aktaruzzaman, M. (2006). Effect of source-sink manipulation on the yield of rainfed rice (Oryza sativa L.). M.S. Thesis, Department of Genetics and plant breeding, Sher-e-Bangla Agricultural University, Dhaka−1207, Bangladesh.

Anonymous. (1988a). The Year Book of Production. FAO, Rome, Italy.

Anonymous. (1988b). Land resources appraisal of Bangladesh for agricultural development. Report No.2. Agro-ecological regions of Bangladesh, UNDP and FAO. pp. 472–496.

APCAS (Asia and pacific commission on agricultural statistics). (2016). Agriculture Market Information System (AMIS) in Bangladesh. Twenty-sixth session on Asia and Pacific Commission Agriculture Statistics. pp. 15–19.

Ayutthaya, S. (2011). Rice leaf cutting for weedy rice reducing. [Online] Available:http://www.ayutthayadoae.go.th/Knowledge-534ea/%2Oricecut.doc (15/7/2014).

Bardhan, S. K. and Mandal, B. K. (1988). Effect of leaf cutting for herbage in deep water rice. *Intl. Rice. Res. Newsl*. **12**: 16-19.

BBS (Bangladesh Bureau of Statistic). (2013). Year Book of Agricultural Statistics of Bangladesh. Ministry of Planning, Dhaka, Bangladesh. web: www.bbs.gov.bd. pp. 55.

BBS (Bangladesh Bureau of Statistics). (2016). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka, Bangladesh. pp. 67.

BBS (Bangladesh Bureau of Statistics). (2016). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka, Bangladesh. pp. 81.

BBS (Bangladesh Bureau of Statistics). (2019). Statistical Monthly Bulletin of Bangladesh, Bureau of Statistics, Statistics Division, Ministry of Planning, Government of People's Republic. Dhaka, Bangladesh. pp. 79.

Birsin, M. A. (2005): Effects of removal of some photosynthetic structures on some yield components in wheat. *Tarim Bilimleri Dergisi J. Agril. Sci.* **11**: 364–367.

BNNC (Bangladesh National Nutrition Council) (2008). Bangladesh National Nutrition Council, Dhaka, Bangladesh.

Boonreund, C. and Marsom, K. (2015). Effect of rice leaf cutting length on rice yield. Proceedings of the 5th International Conference on Agricultural and Food Industry: Rajamangala University of Technology, Suvarnabhumi, Phra Nakhon Si Ayutthaya, Thailand. pp. 474–481.

Bozorgi, H. R., Faraji, A., Danesh, R. K., Keshavarz, A., Azarpour, E. and Tarighi, F. (2011). Effect of Plant Density on Yield and Yield Components of Rice. *World App. Sci. J.* **12**(11): 2053-2057.

BRRI (Bangladesh Rice Research Institute). (2016). Krishi Projukti Hat Boi. Bangladesh Rice Research Institute, Joydebpur, Gazipur. p. 67.

Chowdhury, I. F., Ali, H. M., Karim, M. F. (2017). Economic weed control strategies in aromatic rice. *App. Sci. Report.* **8**: 21-26.

Daliri, M. S., Eftekhari, A., Mobasser, H. R., Tari, D. B. and Porkalhor, H. (2009). Effect of cutting time and cutting height on yield and yield components of ratoon rice (Tarom Langrodi Variety). *Asian J. Plant Sci.* **8**(1): 89–91.

Das, N. R. and Mukherjee, N. N. (1992). Effect of seedling uprooting time and leaf removal on grain and straw yields of rainy season rice. *Indian J. Agron*. **37**: 167- 169.

Das, S. R., Ali, M. Y. and Islam, M. M. (2017). Effect of Leaf Clipping on Yield Attributes of Modern and Local Rice Varieties. *Bangladesh Rice J*. **21**(1): 101-104.

Das, T. and Baqui, M. A. (2000). Aromatic rices of Bangladesh. *In*: Aromatic rices, Pp.184 -187. Oxford & IBH publishing Co. Pvt. Ltd., New Delhi. Co. Pvt. Ltd., New Delhi, Pp.58.

Dutta, K. R., Baset Mia, M. A. and Khanam, S. (2002). Plant architecture and growth characteristics of fine grain and aromatic rices and their relation with grain yield. *Intl. Rice Comm. Newsl.* Vol.51.

Evans, L. T. and Rawson, H. M. (1970). Photosynthesis and respiration by the flag leaf and components of the ear during grain development in wheat. *Australian J. Bio. Sci*. **23**:245-254.

FAO (Food and Agriculture Organization). (2019). Statistical Database. Food and Agricultural Organization of the United Nations, Rome, Italy.

Fatima, S. (2019). Effect of flag leaf clipping on growth, yield and yield attributes of hybrid rice in Boro season. M. S. Thesis. Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

Ghosh, A. and Sharma, A. R. (1998). Effect of foliage pruning on performance of rice under semi-deep water situation (50-100 cm). *Int. Rice Res. Notes*. 22: 36-37.

Gnanavel, I. and Anbhazhagan, R. (2010). Bio-efficacy of pre and post emergence herbicides in transplanted aromatic basmati rice. *Res. J. Agric. Sci*. **1**(4): 315317.

Gomez, M. A. and Gomez, A. A. (1984). Statistical procedures for Agricultural Research. John Wiley and sons. New York, Chichester, Brisbane, Toronto. pp. 1-125.

Hachiya, K., (1989). Effect of artificial leaf cutting on growth and yield of rice plants in Hokkaido. *Japanese J. Appl. Entomol. Zool*. **33**: 51-56.

Hossain, M. J. (2017). Effect of leaf cutting on growth and yield of modern aman rice varieties. M. S. Thesis, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka−1207, Bangladesh.

Islam, M. S., Sarkar, M. A. R., Uddin, S. and Parvin, S. (2012). Yield of fine rice varieties as influenced by integrated management of poultry manure, urea super granules and prilled urea. *J. Environ. Sci. and Nat. Res.* **5**(1): 129-132.

Islam, M., Rafiqul, B. A. A., Mustafi, A. and Hossain, M. (1996). Socio-economic aspects of Fine quality rice cultivation in Bangladesh Rice Research Prioritization.

Karmaker, B. and Karmakar, B. (2019). Effect of nitrogen rates and leaf clipping on forage and grain yield, and seed quality of transplant aman rice. *Bangladesh Rice J.* **23**(2): 49-57.

Khatun, M. M., Ali, M. H. and Mateo, L. G. (2011). Influences of leaf cutting on growth and yield of rice. *J. bio-sci.* **19**: 99-100.

Maclean, J. L., Dawe, D. C., Hardy, B. and Hettel, G. P. (2002). Rice Almanac. Los Banos (Philippines): International Rice Research institute, Bouake (Cote d'lvoire): West Africa Rice Development Association, Cali (Colombia): International Center for Tropical Agriculture, Rome (Italy). pp. 253.

Mae, T. (1997). Physiological nitrogen efficiency in rice Nitrogen utilization, photosynthesis and yield potential. *Plant and Soil J*. **196**: 201–210.

Mahmood, N. and Chowdhury, M. A. (1997). Removal of green photosynthetic structures and their effect on some yield parameters in bread wheat. *Wheat Info. Ser*. **85**: 14–20.

Mannan, M. A. (1996). A study on the effect of fertilization on grain yield and quality of transplant aman rice. An M.S. Thesis. Dept. Agron. BAU, Mymensingh.

Medhi, A. K., Dey, P. C., Chetia, S. K. and Ghose, T. J. (2015). Effect of foliage pruning on vegetative growth and grain yield of rice under rainfed low land situation (50–100 cm water depth). *Environ. and Ecol.* **33**(3A): 1335–1338.

Misra, A. N. (1987). Physiological aspects of grain formation in sorghum and pearl millet. In: Production technology for sorghum and pearl millet.ICAR/Sukhadia University, Jaipur, India. pp. 1–6.

Misra, A. N. (1986). Physiological aspects of grain yield in pearl millet. In: Production Technology of Sorghum and Pearl Millet. ICAR/Sukhadia University, Jaipur, India pp. 1-6.

Misra, A. N. and Misra, M. (1991). Physiological responses of pearl millet to agro climatic conditions. *In:* Prakash R., Ali. A. (Eds) Environmental Contamination and Hygiene, jagmandir Books, New Delhi, India. pp. 165–175.

Moballeghi, M., Kheyri, N., Hatami, S., Mohaddesi, A. (2018). Effect of source-sink limitation on agronomic traits and grain yield of different lines of rice (*Oryza sativa* L.). *Agron. Res. Semi Desert Regs.* **13**(3): 241-251.

Nasiruddin, M. (1993). Rice in Bangladesh. JIRCAS (Japan International Research Center for Agricultural Sciences). *Intl. Symp. Ser*. **2**: 31-41.

Osunkoya, O. O., Ash, J.E., Hopkins, M. S. and Graham, A. W. (1994). Influence of seed size and seedling ecological attributes on shade tolerance of rain-forest tree species in nothern Queensland. *J. Ecol.* **82**:149–163.

Paez, A., Gonzalez, E., Yrausquín, X., Salazar, A. and Casanova, A. (1995).Water stress and clipping management effect on guinea Grass:I. Photosynthesis and water relations. *Agron. J.* **87**: 760-771.

Prakash, M., Anandan, A. and Kumar, B. S. (2011). Varietal variations in flag leaf area and yield in mutant lines of PY 5 rice. *Karnataka J. Agric. Sci*. **24**: 525526.

Rahimpour, L., Daliri, M. S. and Mousavi, A. A. (2013). Effect of seedling age on yield and yield component of rice cultivars (*Oryza sativa* L.). *Ann. Bio. Res.* **4**(2):72-76.

Rahman, M. A., Haque, M. E. Sikdar, B. (2013). Correlation analysis of flag leaf with yield in several rice varieties, Department of Genetic Engineering and Biotechnology, University of Rajshahi, *J. Life Earth Sci.* **8**: 49-54

Rahman, M. A., Haque, M. E., Sikdar, B., Islam, M. A. and Matin, M. N. (2013). Correlation analysis of flag leaf with yield in several rice cultivars. *J. Life Earth Sci.* **8**: 49–54.

Ray, S., Mondal, W. A., Choudhury, M. A. (1983). Regulation of leaf senescence, grain filling and yield of rice by kinetin and abscisic acid. *Physiol. Plant.* **59**: 343–346.

Ros, C., Bell, R. W. and White, P. F. (2003). Seedling vigour and the early growth of transplanted rice (*Oryza sativa*). *Plant and Soil.* **252**: 325–337.

Roy, S. K. and Pradhan, A. C. (1992). Forage grain yields of oat (*Avena sativa*) as influenced by phosphorus levels and cutting management in soils of West Bengal. *Indian J. Agron.* **37**: 823-825.

Shams, B. S. (2002). Effect of elevated temperature on the growth and yield parameters of modern Boro rice varieties. M. S. Thesis, Dept. of Crop Bot., Bangladesh Agric. Univ., Mymensingh. pp 1-2.

Sherif, M. R., Amany, S. E. and El-Habashy, M. M. (2015). Simulating damage of leafminer, hydrellia prosternalis and its effect on rice growth characteristics and grain yield. *Egypt. J. Agric. Res*. **93**(4): 1105-1150.

Singh, R. K. (2000). Genetics and biotechnology of quality traits in aromaticrices in: Aromatic rice, Oxford & IBH publishing Co. Pvt. Ltd., New Delhi. pp. 58.

Sriseadka, T., Wongpornchai, S. and Kitsawatpaiboon, P. (2006). Rapid method for quantitative analysis of the aroma impact compound, 2-acetyl-1-pyrroline in fragrant rice using automated headspace gas chromatography. *J. Agric. Food Chem.* **54**: 8183-89.

USDA (United States Department of Agriculture). (2021). Foreign Agricultural Service, Bangladesh. pp. 1-2. https://www.fas.usda.gov/regions/bangladesh.

Usman, K., Khan, E. A., Khan, Q., Wakil, A. and Khan, M. U. (2007). Effect of detopping on forage and grain yield of rice under agro-climatic conditions of Agric. Res. Ins., Dera Ismail Khan, Pakistan. *Sarhad J. Agric*. **23**(1): 1–4.

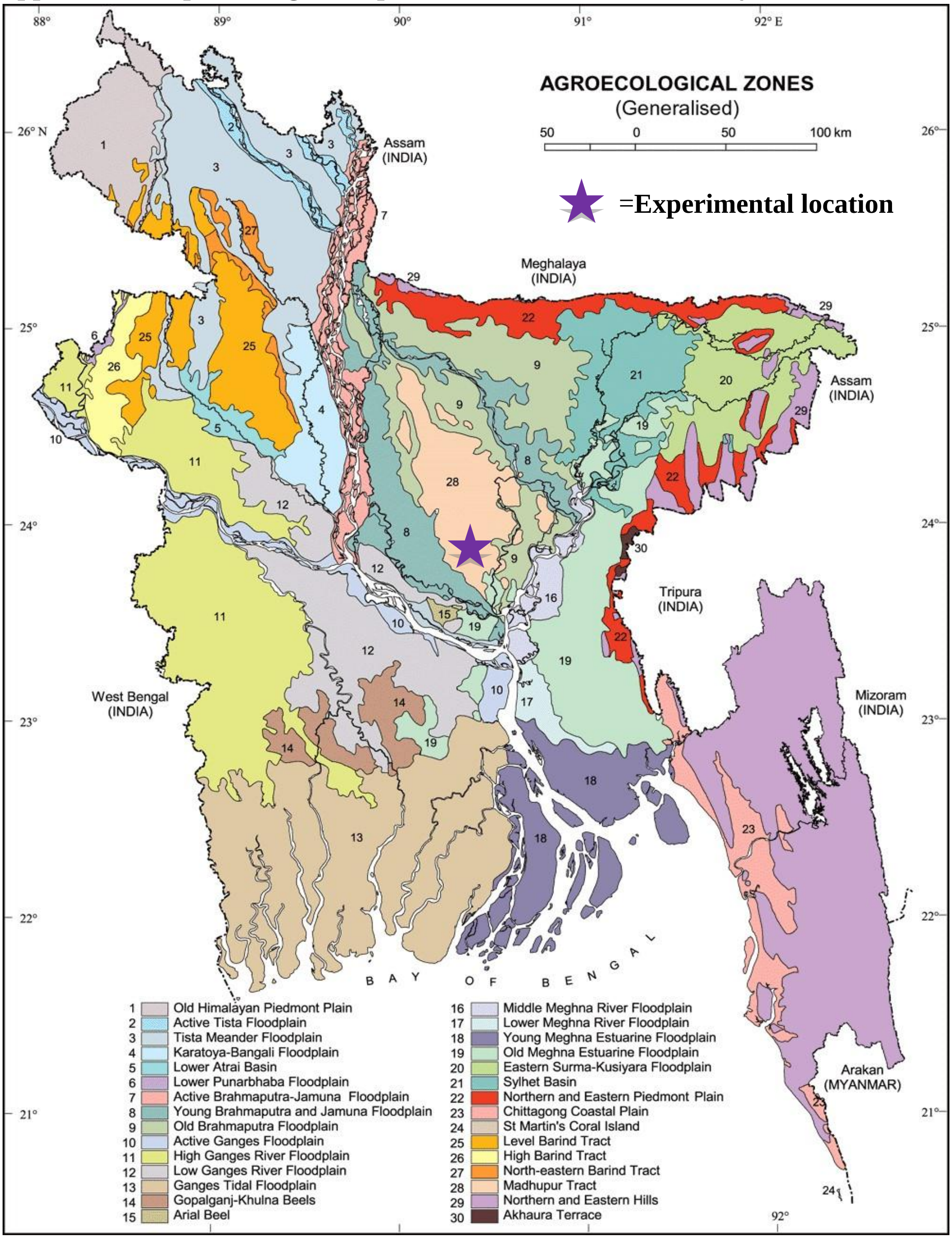
Yoshida, S. (1981). Fundamentals of Rice Crop Science. International Rice Research Institute, Manila, Philippines. Los Baños, Laguna. p. 269.

Yue, B., Xue, W. Y., Luo, L. J. and Xing, Y. Z. (2006). QTL analysis for flag leaf characteristics and their relationships with yield and yield traits in rice. *Acta. Genetica. Scinica*. **2**: 824–832.

APPENDICES

APPENDICES

Appendix I. Map showing the experimental location under study



Appendix II. Soil characteristics of the experimental field

A. Morphological features of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
AEZ	AEZ-28, Madhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

Source: Soil Resource Development Institute (SRDI)

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

Physical characteristics	
Constituents	**Percent**
Sand	26 %
Silt	45 %
Clay	29 %
Textural class	Silty clay

Chemical characteristics	
Soil characteristics	**Value**
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10

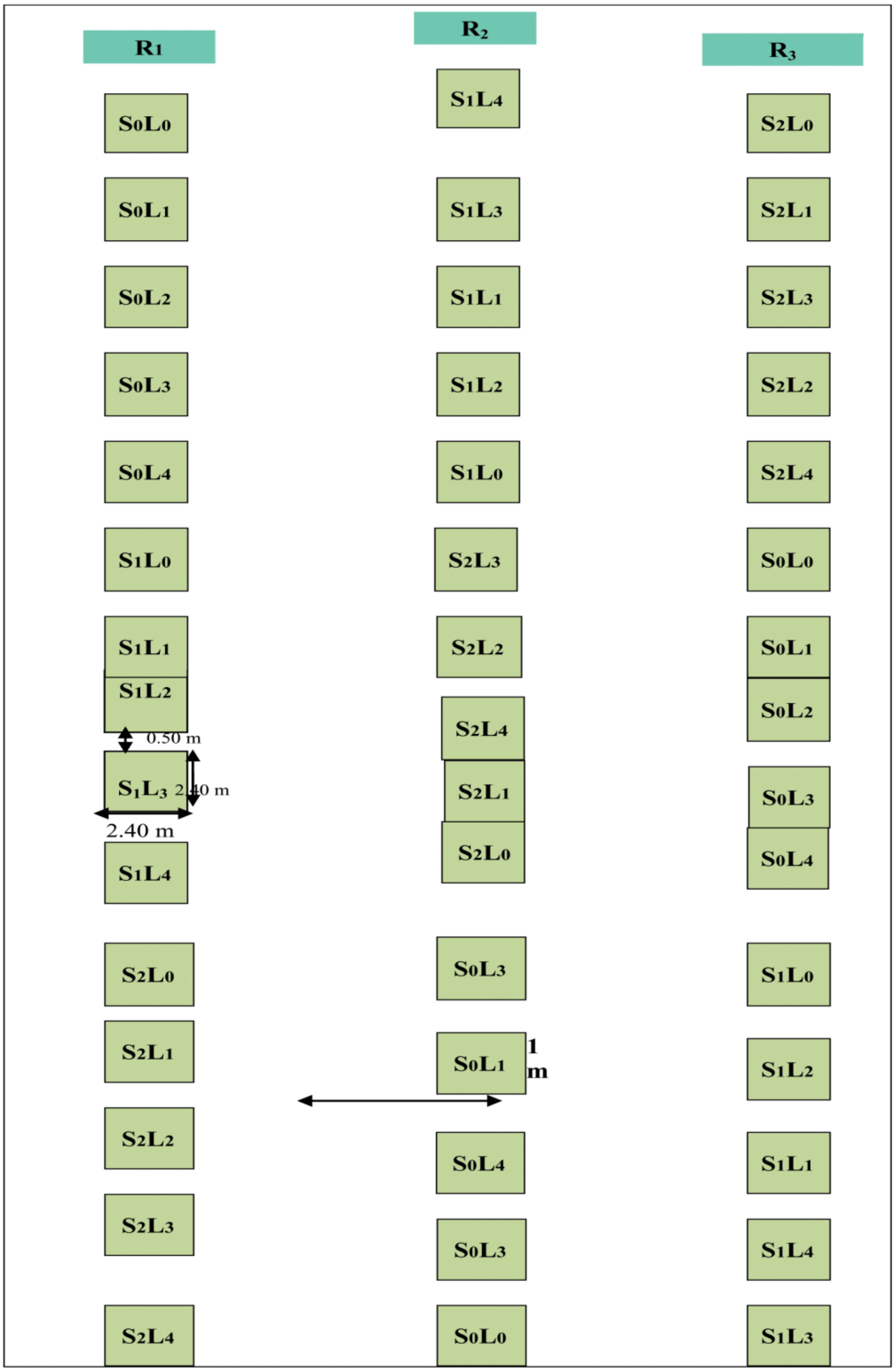
Source: Soil Resource Development Institute (SRDI)

Appendix III. Monthly meteorological information during the period from July 2019 to December 2019

Year	Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2019	July	32.6	26.8	81	114
	August	32.6	26.5	80	106
	September	32.4	25.7	80	86
	October	31.2	23.9	76	52
	November	29.6	19.8	53	00
	December	28.8	19.1	47	00

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Layout of the experimental field



LEGENDS

S_0= Control (no seedling clipping) S_1 =1/3rd clipping

S_2= 1/2nd clipping

L_0= Control (no clipping), L_1= Lower 1+2 leaves,

L_2= Lower 2+3 leaves,

L_3= Lower 3 +4 leaves L_4= Flag leaf clipping.

Appendix V. Analysis of variance of the data of plant height of aromatic rice at different days after transplanting

Mean square of plant height of aromatic rice at						
Source	Df	20 DAT	40 DAT	60 DAT	80 DAT	Harvest
Replication (A)	2	22.36	47.76	0.45	3.47	10.14
Seedling clipping (S)	2	91.27*	86.32NS	209.70*	20.21NS	114.72NS
Error (A×S)	4	12.09	28.18	9.25	19.10	34.10
Leaf Clipping (L)	4	66.17*	92.69*	231.35*	122.52*	156.55*
S×L	8	4.54*	28.02*	35.06*	79.85*	77.23*
Error (A×S×L)	24	5.03	10.66	6.32	26.91	31.67
Total	44					

Ns: Non significant

*: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data of leaves hill^{-1} of aromatic rice at different days after transplanting

Mean square of number of leaves hill^{-1} of aromatic rice at					
Source	Df	20 DAT	40 DAT	60 DAT	80 DAT
Replication (A)	2	1.36	1.40	1.62	1.87
Seedling clipping (S)	2	4.92NS	4.99NS	0.13NS	2.28NS
Error (A×S)	4	1.16	3.40	0.69	2.27
Leaf Clipping (L)	4	34.16*	56.64*	39.43*	69.70*
S×L	8	1.95*	2.66*	5.01*	2.75*
Error (A×S×L)	24	0.89	2.73	1.42	2.13
Total	44				

Ns: Non significant

*: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data of leaf area hill^{-1} of aromatic rice at different days after transplanting

Mean square of leaf area hill^{-1} of aromatic rice at					
Source	Df	20 DAT	40 DAT	60 DAT	80 DAT
Replication (A)	2	0.47	2.82	28.69	1.16
Seedling clipping (S)	2	40.15*	4.13NS	107.43*	313.24*
Error (A×S)	4	0.77	6.42	3.69	6.76
Leaf Clipping (L)	4	464.25*	612.94*	88.22*	1116.56*
S×L	8	26.15*	36.57*	51.75*	46.06*
Error (A×S×L)	24	0.67	5.22	9.52	4.89
Total	44				

Ns: Non significant

*: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data of tillers hill^{-1} of aromatic rice at different days after transplanting

Mean square of number of tillers hill $^{-1}$ of aromatic rice at						
Source	Df	20 DAT	40 DAT	60 DAT	80 DAT	Harvest
Replication (A)	2	0.21	0.19	0.51	0.10	0.21
Seedling clipping (S)	2	0.04NS	7.79*	4.21*	1.73*	17.92*
Error (A×S)	4	0.33	0.31	0.41	0.05	0.33
Leaf Clipping (L)	4	2.78*	47.47*	1.17*	5.05*	33.35*
S×L	8	0.19*	1.03*	1.03*	0.13*	1.89*
Error (A×S×L)	24	0.07	0.33	0.45	0.07	0.29
Total	44					

Ns: Non significant

*: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data of above ground dry matter weight hill^{-1} of aromatic rice at different days after transplanting

Mean square of above ground dry matter weight hill $^{-1}$ of aromatic rice at						
Source	Df	20 DAT	40 DAT	60 DAT	80 DAT	Harvest
Replication (A)	2	0.04	1.65	0.15	1.63	1.13
Seedling clipping (S)	2	0.09*	3.22*	0.38*	53.52*	33.05*
Error (A×S)	4	0.01	0.14	0.053	3.67	0.89
Leaf Clipping (L)	4	0.64*	28.49*	2.56*	69.41*	24.61*
S×L	8	0.16*	0.51*	0.66*	11.79*	7.39*
Error (A×S×L)	24	0.03	0.64	0.11	3.02	0.94
Total	44					

*: Significant at 0.05 level of probability

Appendix X. Analysis of variance of the data of effective and non-effective tillers hill^{-1}of aromatic rice at harvest

Mean square of			
Source	Df	**Effective tillers hill^{-1}**	**Non-effective tillers hill^{-1}**
Replication (A)	2	0.17	0.002
Seedling clipping (S)	2	33.59*	2.53*
Error (A×S)	4	0.27	0.003
Leaf Clipping (L)	4	48.39*	7.29*
S×L	8	2.97*	0.48*
Error (A×S×L)	24	0.31	0.007
Total	44		

* : Significant at 0.05 level of probability

Appendix XI. Analysis of variance of the data of panicle length, filled grains panicle^{-1}, unfilled grains panicle^{-1}, total grains panicle^{-1} and weight of 1000-grains of aromatic rice at harvest respectively

Source	Df	Mean square of Panicle length	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Total grains panicle^{-1}	Weight of 1000-grains
Replication (A)	2	0.54	114.87	3.96	139.91	1.34
Seedling clipping (S)	2	7.28*	824.66*	8.05*	677.49*	10.18*
Error (A×S)	4	0.72	94.34	0.92	78.92	0.95
Leaf Clipping (L)	4	30.73*	2668.23*	389.34*	1096.93*	19.32*
S×L	8	2.26*	224.61*	12.05*	193.70*	3.54*
Error (A×S×L)	24	0.45	62.62	3.44	68.30	1.08
Total	44					

*: Significant at 0.05 level of probability

Appendix XII. Analysis of variance of the data of grain yield, straw yield, biological yield and harvest index of aromatic rice at harvest respectively

Source	Df	Mean square of Grain yield	Straw yield	Biological yield	Harvest index
Replication (A)	2	0.03	0.01	0.08	0.57
Seedling clipping (S)	2	1.31*	0.15*	2.36*	29.14*
Error (A×S)	4	0.02	0.02	0.06	0.30
Leaf Clipping (L)	4	0.61*	0.71*	1.75*	19.57*
S×L	8	0.12*	0.27*	0.53*	3.68*
Error (A×S×L)	24	0.01	0.074	0.07	1.40
Total	44				

* : Significant at 0.05 level of probability