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EFFECT OF PLANT SPACING AND LEAF CLIPPING ON GROWTH AND YIELD OF RICE

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Abstract

Leaf cutting and spacing plays pivotal role in growth, yield and yield attributing parameters in rice cultivation by reducing different environmental stresses. To assess the effect of leaf cutting and spacing on plant growth and yield, an experiment was conducted with BRRI released *Aman* var. BRRI dhan62. The experiment consisted of two factors where spacing for the experiment were S_1= 30 × 15 cm^2, S_2= 30 × 20 cm^2, S_3= 30 × 25 cm^2 and the leaf cutting were T_0= No leaf cutting, T_1= Cutting of 1st basal leaf, T_2= Cutting of 2nd basal leaf, T_3= Cutting of 3rd basal leaf. The experiment was conducted with Randomized Complete Block Design (RCBD) with 4 replications. Results revealed that there was statistically no change in plant height, flag leaf width and length, panicle length, 1000-grain weight, filled grain panicle^{-1}, and straw yield hill^{-1} at different spacing, leaf cutting, and their combination treatments. Regarding growth and yield parameters, the highest number of effective tillers hill^{-1} was found in combination $T_1 \times S_3$, which was 50% greater compared to control plants. Total tillers hill^{-1} was found higher in combination $T_3 \times S_3$, which was 39% higher than the control plants. Unfilled grain panicle^{-1} was found higher in combination $T_0 \times S_1$, which was 75% higher than the lowest unfilled grain in $T_0 \times S_2$, this indicates that even a minimal change in spacing can significantly impact yield attributes. Harvest index (HI) was found greater in combination $T_2 \times S_2$, which was 15% higher than the control. The lowest number of filled grain panicle^{-1} was spotted at $T_3 \times S_3$ combination indicating that with higher leaf cutting and spacing filled grain number reduced. The growth, yield and yield-contributing parameters showed the best results in 30 × 20 cm^2 spacing in combination with cutting of 2nd basal leaf.

Introduction

Investigating the alternate agronomic options for increasing crop growth and development specially for rice cultivation by reducing different environmental stresses is important. As rice takes 60-70 days for vegetative growth thus leaf clipping plays a beneficial role in regulating photosynthesis as well as carbohydrate segmentation. As leaves act as a source and sink tissue, thus yield serves as a cumulative result of both source and sink strength for photo-assimilates and nutrients as source strength for photo-assimilates which is dominated by both rate of photo-assimilate remobilization from source tissues and average photosynthetic rate thus leaf clipping has a crucial role on overall photosynthesis and production processes (Smith *et al.*, 2018). Therefore, exploring leaf clipping effect on source-sink relationship is significant to improve yield of crops. Mazur *et al.* (2019) reported that the efficiency of photosynthetic activity and productivity of a plant largely depends on the extent of photosynthetic surfaces of a plant, thus leaves have a notable effect on the yield of the plants.

Appropriate plant spacing plays a pivotal role on crop growth, physiology and yield of agronomic crops including rice. The more robust the plants are, the greater the tiller numbers are produced under outspread spacing that enhance photosynthetic potentiality as well as feeding area of soil.

Rice (*Oryza sativa* L.) is one of the important cereal crops globally Apart from its use as the cereal, fodder production has become famous for its income generative and employment source in most of the areas of Bangladesh specially livestock potential area while production of rice is decreasing gradually with growing population (Islam *et al*., 2017). Therefore, appropriate measurements need to be taken to increase the yield per unit area by adopting the modern and improved technologies. Therefore, this study was performed to find out the interaction between spacing and leaf cutting of rice for providing more biomass and regulating both growth and yield.

Materials and Methods

Experimental site and design

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka under the Agro-ecological Zone of Madhupur Tract, AEZ-28 during the period from July to December 2018. The experimental site is geographically situated at 23 77′ N latitude and 90 33′ E longitude at an altitude of 8.6 meters above sea level under the subtropical climate. The experiment was laid out in a randomized complete block design (RCBD) with 4 replications. The high yielding rice variety of BRRI dhan62 was used as planting material The spacing of the experiment were (3): S_1= 30 × 15 cm^2, S_2= 30 × 20 cm^2, S_3= 30 × 25 cm^2 and the leaf cutting were (4): T_0= No leaf cutting, T_1= Cutting of 1st basal l leaf, T_2= Cutting of 2nd basal leaf and T_3= Cutting of 3rd basal leaf. Fertilizers and manure were used for crop cultivation in accordance with the recommendations of fertilizer recommendation guide. Seeds were planted in a seedbed for later transplantation into the main field. Weeds and stubble were removed, leaving a well-prepared and suitable field for seedling transplantation. After 3 weeks seedlings were transplanted. All intercultural operations were practiced properly. Leaf cutting was done at 30 days after transplanting (DAT) when the plant had 5 leaves.

Measurement of growth parameters

The height of plant was measured at the time of harvest for all the entries on 10 randomly selected hill from the middle rows. The height was measured from the base of the plant to the tip of the longest leaf or tip of the longest ear head with the help of centimeters scale; whichever was longer and the average was recorded in centimeters. The effective tillers from ten hills were counted and averaged to have hill^{-1} basis. The panicles which had at least one grain was considered as effective tillers. Total tillers which had at least one leaf visible were counted. It includes both productive and unproductive tillers. Number of tillers hill^{-1} were counted at harvest from ten randomly pre-selected hills and was expressed as number hill^{-1}.To measure flag leaf width and length identify the flag leaf as the last leaf on the stem before flowering, then measure the width across the widest part of the leaf and the length from the base to the tip.

Measurement of yield attributes

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle. Each observation was an average of ten panicles. The total number of filled grains was collected randomly from selected ten plants of a plot and then average number of filled grains panicle^{-1} was recorded. The total number of unfilled grains was collected randomly from selected ten plants of a plot based on no or partially developed grain in spikelet and then average number of unfilled grains per panicle was recorded. For measuring 1000-grains weight (g) one thousand cleaned dried grains were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 14% moisture and the mean weight were expressed in gram.

Measurement of yield and harvest index

Grain and straw obtained from each unit plot were sun-dried and weighed carefully. Final grain yield was adjusted at 14% moisture. Harvest index (HI) denotes the ratio of economic yield to biological yield and was calculated with the following formula:

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

Statistical analysis

Using the statistical analysis tool CoStat v.6.400 (2008), data derived from various parameters were subjected to an analysis of variance (ANOVA). In order to compare the treatments at a 5% level of significance ($p \leq 0.05$), the mean and standard deviation (± SD) from three replications were determined.

Results and Discussion

Plant height

Effect of spacing and leaf cutting observed in case of all the morphological parameters of BRRI dhan62 including plant height, flag leaf width and length and panicle length. For instance, among the three spacings plant height was marked top at S_2 spacing whereas, in case of leaf cutting T_0 showed best result. Plant height was found to be statistically same in all the treatments irrespective of spacing and leaf cutting. But when in interaction highest plant height found in $T_0 \times S_2$ and the lowest in $T_3 \times S_2$ which shows 3 and 1% variation from the control, $T_0 \times S_1$ (Table 1). Different plant spacing had significant influence on plant growth, yield and yield contributing characters might be due to availability of light, air and absorption of nutrient. Bhowmik *et al*. (2012) observed that increase in spacing produced the highest plant height. Similar results were also obtained from Roy *et al*. (2017) that wider hill spacing produced the tallest plant than closer hill spacing. Wider spaced plants received more moisture, light and nutrient which resulted in increase in plant height.

Flag leaf width and length

Among the spacings and leaf cutting plants flag leaf were longest at S_1 and T_0 treatments respectively. There was no statistical difference in case of flag leaf width and length irrespective of spacing and leaf cutting. Yet the longest flag leaf was found in $T_0 \times S_3$ and shortest in $T_3 \times S_2$, indicating 30×25 cm^2 spacing and no leaf cutting treatment combination had longest flag leaf. In case of width highest observed in $T_2 \times S_2$ and lowest in $T_1 \times S_3$. This indicates cutting of 2nd basal leaf with combination of 30×20 cm^2 had wider flag leaf (Table 1).

Panicle length

Spacing, leaf cutting and their combination treatments had varietal panicle length. Among which highest panicle length was recorded in $T_0 \times S_2$ indicating 30×20 cm^2 spacing showed longest panicle, 3% longer than control $T_0 \times S_1$ (30×15 cm^2 spacing with no leaf cutting) (Table 1). Closer spacing produced higher number of grains panicle^{-1} than wider spacing. The number of infertile spikelet's panicle^{-1} increased with wider spacing. A similar result observed from Ahsan (2020) that no leaf clipping produced significantly longer (32.71 cm) panicle.

1000-grain weight

Weight of 1000-grain (g) under different spacing and leaf cutting, exhibited maximum yield at S_1 and T_0 treatments respectively. Among the interaction highest 1000-grain weight was 2% higher than the control at $T_1 \times S_2$ combination indicating 30 × 20 cm^2 spacing in combination of 1st basal leaf cutting recorded maximum yield. 1000-grain weight was lowest at $T_3 \times S_3$ which indicates defoliation of 3rd basal leaf and 30 × 25 cm^2 spacing reduced seed yield (Table 1). Similar results pronounced by Hossain (2017) that the 1000-grain weight was significantly reduced in plants those had the leaves cut compared with the plant in control treatment and no leaf clipping produced highest 1000-grain weight which was 23.21 g. From the findings of Laila *et al*. (2020) spacing had no significant effect on 1000-grain weight may due to genetic character.

Table 1. Effect of spacing, leaf cutting and combination of treatment on plant height, flag leaf width and length, total and effective tiller and 1000-grain weight of BRRI dhan62

Treatment	Plant height (cm)	Flag leaf width (cm)	Flag leaf length (cm)	Panicle length (cm)	1000-grain weight (g)
Spacing					
S_1	104.742 a	1.380 a	35.518 a	24.623 a	21.802 a
S_2	105.402 a	1.383 a	33.937 a	25.318 a	21.858 a
S_3	104.505 a	1.340 a	34.928 a	25.185 a	21.637 a
Leaf Cutting					
T_0	105.911 a	1.367 a	35.411 a	25.778 a	21.951 a
T_1	104.784 a	1.347 a	34.500 a	24.653 a	22.171 a
T_2	104.900 a	1.398 a	34.947 a	25.098 a	21.544 a
T_3	103.936 a	1.360 a	34.320 a	24.640 a	21.396 a
Spacing × Leaf Cutting					
$T_0 \times S_1$	104.227 a	1.353 a	36.033 a	25.373 a	21.913 a
$T_0 \times S_2$	107.313 a	1.360 a	33.620 a	26.027 a	21.807 a
$T_0 \times S_3$	106.193 a	1.387 a	36.580 a	25.933 a	22.133 a
$T_1 \times S_1$	105.093 a	1.427 a	34.847 a	23.940 a	22.133 a
$T_1 \times S_2$	107.167 a	1.367 a	35.473 a	25.307 a	22.353 a
$T_1 \times S_3$	102.093 a	1.247 a	33.180 a	24.713 a	22.027 a
$T_2 \times S_1$	105.720 a	1.393 a	36.127 a	24.553 a	21.580 a
$T_2 \times S_2$	104.053 a	1.447 a	34.853 a	25.180 a	21.693 a
$T_2 \times S_3$	104.927 a	1.353 a	33.860 a	25.560 a	21.360 a
$T_3 \times S_1$	103.927 a	1.347 a	35.067 a	24.627 a	21.580 a
$T_3 \times S_2$	103.073 a	1.360 a	31.800 a	24.760 a	21.580 a
$T_3 \times S_3$	104.807 a	1.373 a	36.093 a	24.533 a	21.027 a

Here, S_1= 30 × 15 cm^2 spacing, S_2= 30 × 20 cm^2 spacing, S_3= 30 × 25 cm^2 spacing, T_0= No leaf cutting, T_1= Cutting of 1st basal leaf, T_2= Cutting of 2nd basal leaf and T_3= Cutting of 3rd basal leaf. The values in a column are presented as the mean ± SD. According to Tukey's HSD test, values labeled with different letters indicate that they are significantly different at $p \leq 0.05$.

Number of tillers

Total and effective tiller number $hill^{-1}$ showed significant difference at different spacing, leaf cutting and their combination treatments. Effective and total tiller number were 40 and 28% greater at S_3 spacing than their respective controls. Maximum number of total tillers was observed at $T_3 \times S_3$ whereas the lowest at $T_2 \times S_1$. The highest number of total tillers was found to be 39% higher than the control $T_0 \times S_1$. In contrary, the lowest total tiller number marked in $T_2 \times S_1$ which is statistically similar to the control (Table 2).

Effective tiller number on the other hand recorded maximum at $T_1 \times S_3$ and minimum at $T_2 \times S_1$ indicating 30 × 25 cm^2 spacing without leaf defoliation alleviated yield growth of rice plants. Due to this spacing $T_1 \times S_3$ combination showed 50% greater effective tiller number compared to control plants. Again, in $T_2 \times S_1$ treatment effective tiller number was reduced by 10% due to the cutting of 2nd basal leaf (Table 2).

Table 2. Effect of spacing, leaf cutting and combination of treatment on effective and total tiller hill^{-1}, filled and unfilled grains panicle^{-1}, and harvest index of BRRI dhan62

Treatment	Effective tiller hill^{-1} (No)	Total tiller hill^{-1} (No)	Filled grains panicle^{-1} (No)	Unfilled grain panicle^{-1} (No)	Harvest index (%)
Spacing					
S_1	10.967 c	12.708 b	84.767 a	22.350 a	43.329 b
S_2	12.518 b	13.533 b	85.733 a	19.033 b	46.313 a
S_3	15.388 a	16.268 a	84.883 a	19.100 b	43.620 b
Leaf Cutting					
T_0	12.880 a	13.947 a	86.378 a	18.222 b	43.982 ab
T_1	13.611 a	14.268 a	87.356 a	20.933 a	44.534 ab
T_2	12.180 a	13.783 a	86.000 a	19.733 ab	46.378 a
T_3	13.160 a	14.682 a	80.778 a	21.756 a	42.789 b
Spacing × Leaf Cutting					
$T_0 \times S_1$	10.547 ef	12.040 c	84.800 a	23.667 a	42.760 b
$T_0 \times S_2$	13.067 a-e	13.930 a-c	87.400 a	13.467 d	45.065 ab
$T_0 \times S_3$	15.027 a-d	15.870 ab	86.933 a	17.533 b-d	44.121 ab
$T_1 \times S_1$	11.760 d-f	13.253 a-c	86.667 a	23.600 a	44.554 ab
$T_1 \times S_2$	13.253 a-e	13.695 a-c	88.267 a	22.533 ab	46.006 ab
$T_1 \times S_3$	15.820 a	15.855 ab	87.133 a	16.667 cd	43.043 b
$T_2 \times S_1$	9.520 f	11.982 c	87.467 a	20.600 a-c	44.807 ab
$T_2 \times S_2$	11.527 ef	12.775 bc	83.933 a	19.667 a-c	49.914 a
$T_2 \times S_3$	15.493 ab	16.592 a	86.600 a	18.933 a-c	44.413 ab
$T_3 \times S_1$	12.040 c-f	13.557 a-c	80.133 a	21.533 a-c	41.197 b
$T_3 \times S_2$	12.227 b-f	13.732 a-c	83.333 a	20.467 a-c	44.265 ab
$T_3 \times S_3$	15.213 a-c	16.757 a	78.867 a	23.267 a	42.904 b

Here, S_1= 30 × 15 cm^2 spacing, S_2= 30 × 20 cm^2 spacing, S_3= 30 × 25 cm^2 spacing, T_0= No leaf cutting, T_1= Cutting of 1st basal leaf, T_2= Cutting of 2nd basal leaf and T_3= Cutting of 3rd basal leaf. The values in a column are presented as the mean ± SD. According to Tukey's HSD test, values labeled with different letters indicate that they are significantly different at $p \leq 0.05$.

Productive tillers unit area^{-1} determined the final yield of rice. The same result was reported by Hossain (2017). Similar findings were reported by Rasool *et al*. (2013) and Mobasser *et al*. (2007).

Number of grains

Highest filled grain panicle^{-1} spotted at $T_1 \times S_2$ and fewer at $T_3 \times S_3$ treatment indicating that with higher leaf cutting and spacing filled grain number reduced. Unfilled grains panicle^{-1} was at $T_0 \times S_1$ that was same to $T_1 \times S_1$ and $T_3 \times S_3$ treatments. This number of unfilled grains was 75% higher than the lowest unfiled grain found in $T_0 \times S_2$ (Table 2). Over exploitation of resources such as water, sunlight and, nutrients etc. may have favored 30 × 20 cm spacing in obtaining the maximum grain yield. The finding agreed with Shinde *et al*. (2011). The result is found more or less similar with the findings of Ahsan (2020) where he observed that the maximum grain yield (5.44 t ha^{-1}) was recorded at no leaf clipping (L_0) treatment. Hossain (2017) also found that the highest number of grains $panicle^{-1}$ was obtained in no leaf cutting (control) treatment. Moreover, the maximum number of unfilled grains $panicle^{-1}$ (16.55) was recorded from no seedling clipping (S_0) treatment from Ahsan (2020) findings.

Harvest index

Harvest index (%) demonstrated difference at diverse spacing, leaf cutting, and their combination. At $S_2 \times T_2$ treatment HI was found to be 7 and 5% higher than their respective controls. Maximum HI was discovered at $T_2 \times S_2$ marking 15% higher yield than control and minimum index at $T_3 \times S_1$ indicating similar result. This scenario shows HI of rice can be accelerated by cutting of 2^{nd} basal leaf in combination with 30 × 20 cm^2 spacing (Table 2). As optimum spacing (S_2) showed highest filled grain $panicle^{-1}$ thus results in maximum HI with no or optimum leaf clipping which is supported by Ahsan (2020). Although unfilled grain $panicle^{-1}$ was highest in lower spacing (S_1) thus results in lowest HI. Mahato *et al*. (2007) also found that grain yield of rice under closer spacing's was significantly higher than wider spacing's which resulted in higher HI.

Grain yield

Grain yield $hill^{-1}$ exhibited difference at spacing, leaf cutting, and their interaction treatments. Maximum grain yield was recorded at $T_2 \times S_2$ marked by 25% rise in comparison with control $T_0 \times S_1$. But least grain yield was recorded at $T_3 \times S_1$ (Fig. 1).

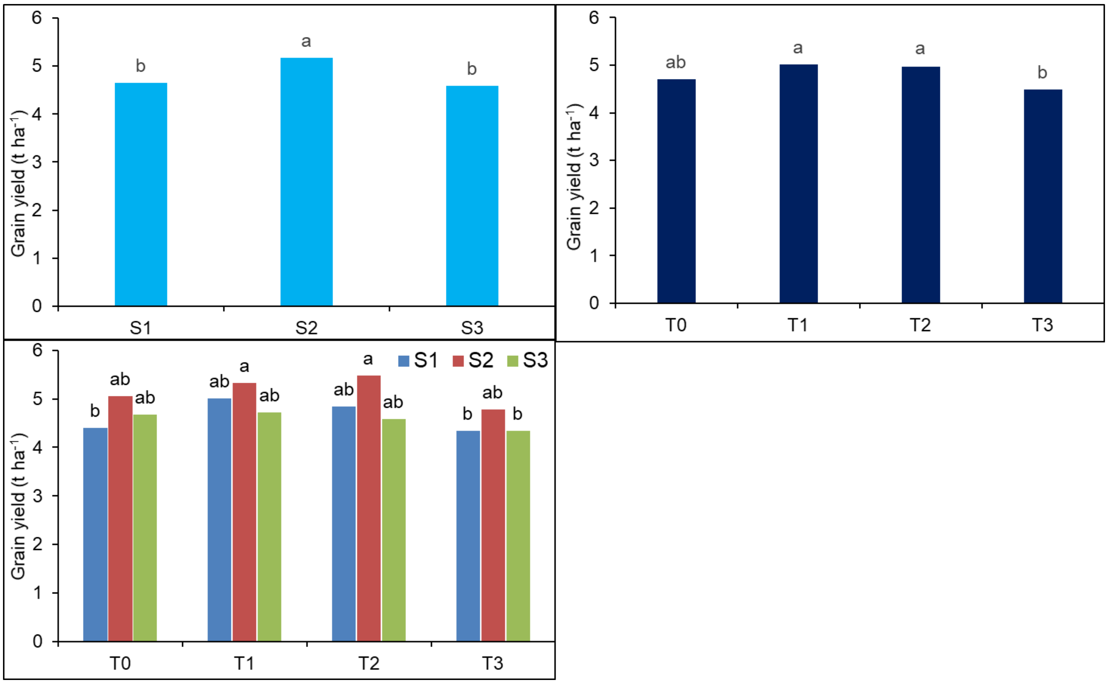

Fig 1. Fig 1. Effect of spacing, leaf cutting and combination of treatment on grain yield (t ha^{-1}) of BRRI dhan62. Here, S_1= 30 × 15 cm^2 spacing, S_2= 30 × 20 cm^2 spacing, S_3= 30 × 25 cm^2 spacing, T_0= No leaf cutting, T_1= Cutting of 1st basal leaf, T_2= Cutting of 2nd basal leaf and T_3= Cutting of 3rd basal leaf. The values in a column are presented as the mean ± SD. According to Tukey's HSD test, bars labeled with different letters indicate values that are significantly different at $p \leq 0.05$.

Straw yield

In case of straw yield, highest straw yield was found at $T_3 \times S_1$ and the least at $T_2 \times S_2$ (Fig. 2) which means no or minimal leaf clipping showed maximum straw yield while optimal leaf clipping does not result in significant changes which is supported by Ahsan (2020). This may be due to the increase in plant height and number of tillers and panicle length. These results are found similar with those reported by Abd El-Hamed (2002) and El-Rewainy (2002).

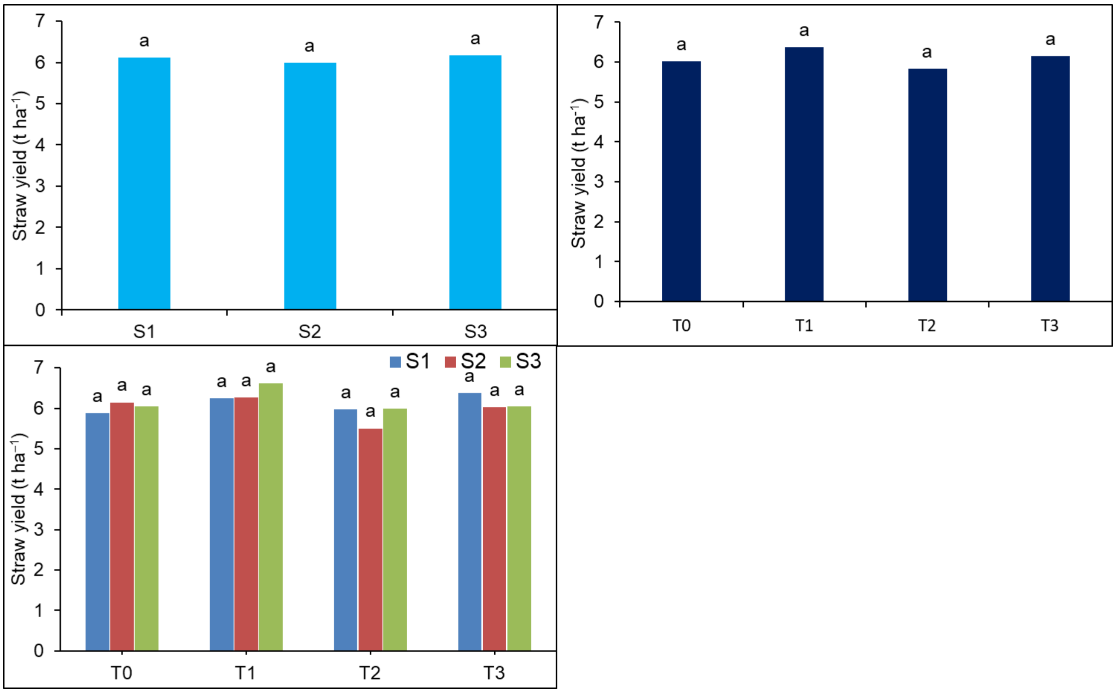

Fig 2. Effect of spacing, leaf cutting and combination of treatment on straw yield (t ha^{-1}) of BRRI dhan62. Here, S_1= 30 × 15 cm^2 spacing, S_2= 30 × 20 cm^2 spacing, S_3= 30 × 25 cm^2 spacing, T_0= No leaf cutting, T_1= Cutting of 1st basal leaf, T_2= Cutting of 2nd basal leaf and T_3= Cutting of 3rd basal leaf. The values in a column are presented as the mean ± SD. According to Tukey's HSD test, bars labeled with different letters indicate values that are significantly different at $p \leq 0.05$.

Conclusion

Proper spacing and leaf cutting can alleviate growth and grain yield of rice. Lower spacing can allow competition among plants for nutrition and growing space whereas wider spacing can make room for weeds and heterozygous plant species. Similarly, removal of leaves at certain growth stage is crucial for plants. Too much pruned or too bushy plants can reduce yield and yield related attributes. From the above findings, it could be concluded that most of the growth, yield, and yield-contributing characteristics of rice gave the best performance with 30 × 20 cm^2 spacing in combination with the cutting of 2nd basal leaf. For this reason, further research needs to be executed for better understanding.

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