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COMPARATIVE STUDIES OF ROOT GROWTH AND YIELD POTENTIAL OF FIVE BORO RICE VARIETIES

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ABSTRACT

A field experiment was conducted to observe the growth of root, shoot, yield and yield contributing characteristics of five boro rice varieties of which four were local namely Taipe, Pariza, Lafaya and Jirashail and another was BRRI dhan50 (Banglamoti). The morphological traits, yield and yield attributes were significantly variable among the varieties studied. The variety BRRI dhan50 showed superiority in respect of morphological parameters such as tiller numbers, leaf numbers, leaf surface area, root volume, root numbers, root depth, root weight and total dry matter. The BRRI dhan50 was shorter in plant height, having more tillering ability contained higher leaf number which in turn showed superior growth and yield than those of local varieties. Moreover, BRRI dhan50 produced higher number of effective tillers plant^{-1}, number of grains panicle^{-1} and thousand grain weight (TGW) resulted in higher grain yield (5.7 t ha^{-1}) which was statistically similar with pariza and lafaya respectively. Among the all local varieties, lafaya showed the best yield ability than those of other local varieties.

Key words: boro rice, root growth, harvest index and yield

INTRODUCTION

A total of 15.03 million hector of land are used for rice cultivation in Bangladesh which produced 33.83 million tons of rice in the fiscal year of 2012-13 (BBS 2012-13). Rice is the staple food crops of nearly half of the total population of the world and is the main source of calories of almost 40% of the world population (Hoffman 1991). It is the most important crop in Asia as a whole comprises to about 92% of the world rice harvest (IRRI 1995). Among the rice growing countries, Bangladesh rank's 4th on the basis of area and production (FAO 1994) while 39th on yield of rice (IRRI 1995). About 80% of our total cultivated land is used for rice production (AIS 2002). In Bangladesh, average yield of rice is very low (2.83 t ha-1), where as in other countries, average yield is comparatively higher than Bangladesh like 6.3, 6.5 and 6.4 t ha-1 in Japan, Korea and Australia, respectively (Karim 1992).

In Bangladesh, about 10.78 million hectares of land was used for rice cultivation, which produced 25.18 million metric tons of rice but the average yield is only 2.3 t ha-1 (BBS 2003). The productivity of aromatic fine rice is very low compared to that of the HYV coarse varieties (Chandra and Jitendra 1996). Modern and aromatic rice varieties have occupied about 46 and 12.5%, respectively of the total rice growing area of Bangladesh (Jabber and Alam 1993).

Rice production is one of the main income sources of the farmers in Bangladesh. Two types of rice varieties are cultivated in Bangladesh viz., traditional (local) and modern (high yielding) varieties. Local aromatic rice has more demand both in internal and external trade markets. Therefore, the production of aromatic rice in our country is becoming popular due to its high prices and export potentiality (Dutta et al. 2002). It is also preferred by some consumers despite their price and lower yield. There are thousands of local landraces of rice in Bangladesh (Khul *et al*. 1982). On the other hand, the main drawback of these local varieties is their poor grain yield. Although the soil and climate of our country is quite suitable for the production of rice, still it is facing many problems of which the poor yielding inherent capability of our local varieties is the most important one. Poor plant type, such as tall plants, long and droopy leaves, weak culms, susceptible to lodging etc. are the main causes of the low yield of the local varieties. In case of modern varieties possess short and stout culms with dark green, thick and erect leaves and do not lodge. As these local varieties have been under production since long time, there should be a strategy to increase the productive potentials through genetic approach. In order to increase productivity, modern agronomy packages along with higher genetic potential varieties could play an important role obviously. Information on morpho-

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physiological characters plays a vital role in rice breeding. It is important to know the physiological behavior and genetic expression of the selective local and released rice varieties for definite selection process to those varieties. Rice morpho-physiology plays an important role in variety development. Development of rice varieties with a high yielding ability is one of the most fundamental approaches for dealing with the expected increase in the world demand (IRRI 1993). The present research was undertaken to study the growth and yield characteristics of four local rice varieties in contrast with one HYV under modern practices and to find out the potentiality for further improvement of these varieties.

MATERIALS AND METHODS

The experiment was conducted at the Agricultural farm of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during *Boro* season from February to May 2011. The location of the experimental site was at $25^0 38'$ N latitude and $88^0 41'$ longitude and at the elevation of 34.5 m above the sea level. The land was medium high belonging to the Agro-ecological Zone 1 (AEZ-1) named Old Himalayan Piedmont Plain (FAO and UNDP 1988). The soil was sandy loam containing low organic matter and low soil pH (pH 6.2). The five *boro* rice varieties including four local varieties (Taipae, Pariza, Lafaya and Jirasail) and one released HYV namely BRRI dhan50 (Banglamoti) was used as planting materials. The experiment was laid out in a randomized complete block design (RCBD) with four replications. The chemical fertilizers like urea, triple super phosphate, muriate of potash and gypsum were applied @ 217, 180, 100, and 20 kg ha^{-1}, respectively (FRG 2012). As a precautionary measures, to save the crops from the pest attack, admire-200 SL @ 125 mL ha^{-1} was sprayed two times at vegetative and pre flowering stages. Data collections of the following parameters from the experiment on different growth stages viz. plant height (cm), leaf length (cm), single leaf area (cm), number of leaves $hill^{-1}$, total number of tillers, root length (cm), root numbers, root volume (cm^3), root depth (cm) were performed. The shoot parameters i.e. plant height, leaf number, single leaf surface area, tiller numbers were recorded after 7 days interval, and other 3 parameters (root length, root volume, root number) was taken after 20 days intervals. For measuring root length the selected stem was cut above 1 cm from the ground. An augur of 20 cm in diameter was used to collect the layer bagged root sample. The collected plant roots were carefully washed using running tap water to remove soil and blotted to remove the adhering water on them and then roots were weighted carefully. The number of lateral and tap root was counted. The root length was measured using meter scale placing on the square grid paper. The root volume was measured by water displacement method. The root depth was measured by measuring length of root from the place of soil base to longest root tip. Yield and yield components like panicle length, effective tillers $hill^{-1}$, grain numbers $panicle^{-1}$, yield kg $plot^{-1}$ (kg), straw yield kg $plot^{-1}$ (kg), grain yield ha^{-1}, 1000-grain weight and harvest index. Harvest index is the relationship between economic yield and biological yield (Gardner *et al.* 1985). It was calculated by using the Following formula:

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

The data were analyzed using the MSTATC computer software. If the treatments were significant the mean differences between pairs of means were compared by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

The plant height of different rice varieties was varied markedly at all growth stages (Figure 1). The result revealed that plant height increased rapidly till 70 days after transplanting (DAT) followed by slowed growth. After 77 DAT the plant height growth of all varieties studied was not pronounced at all up to harvest. Figure 1 showed that BRRI dhan50 (70.50 cm) were shorter than those of other varieties at all growth stages. Among the cultivar tested, Taipe (121.92 cm) was the tallest. (Munshi 2005) and (Hoque 2004) studied modern and local varieties and reported that modern rice varieties were shorter than local ones due to genetic makeup as well as shorter inter node length, which also supported the present study. Similar findings were also by (Zahan 2011) that local rice varieties were taller than high yield varieties in Bangladesh.

The leaf number of different varieties varied significantly (Figure 2). Among the five varieties Taipe showed the highest number of leaves (5) and the lowest number of leaves (3) was recorded in Jirashail.

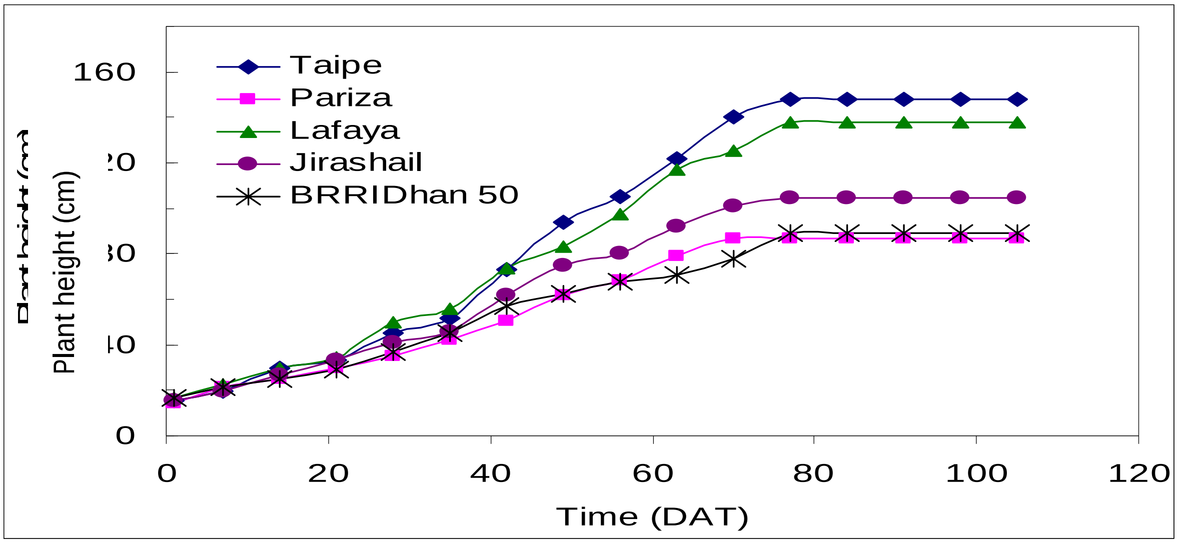

Figure 1. Plant height of five boro rice varieties during experiment time.

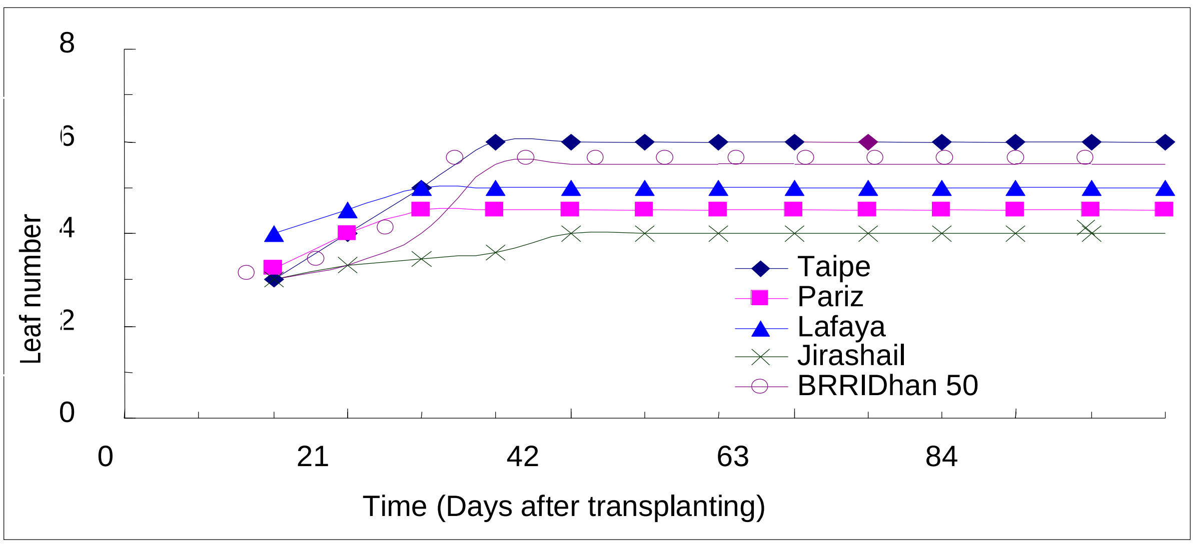

Figure 2. Leaf number of five boro rice varieties during experiment time.

The effect of varieties on single leaf area development at different time of experiment was markedly variable (Figure 3). Figure 3 shows the highest leaf area 20.01 cm^2 was produced by Taipe followed by BRRI dhan50 (19.05 cm^2). Contrarily, Lafaya, Pariza and Jirashail produced the lower leaf area. The variation in leaf area might be occurred due to the variation in leaf length and their expansion and also genetic characteristics the present findings was consistent with the result of (Sharma and Haloi 2001) who stated that variation in leaf area could be attributed to the difference in leaf growth and genotype.

The root depth was recorded at seedling stage and tillering stage of the varieties. There was a remarkable difference in root depth of all varieties at seedling and tillering stages (Figure 4). The root depth of the selected varieties was highest at tillering stage and the lowest at seedling stage. The Taipe showed the highest root depth at seedling stage (14.5 cm) and the Lafaya showed the highest root depth at tillering stage (12.75 cm).

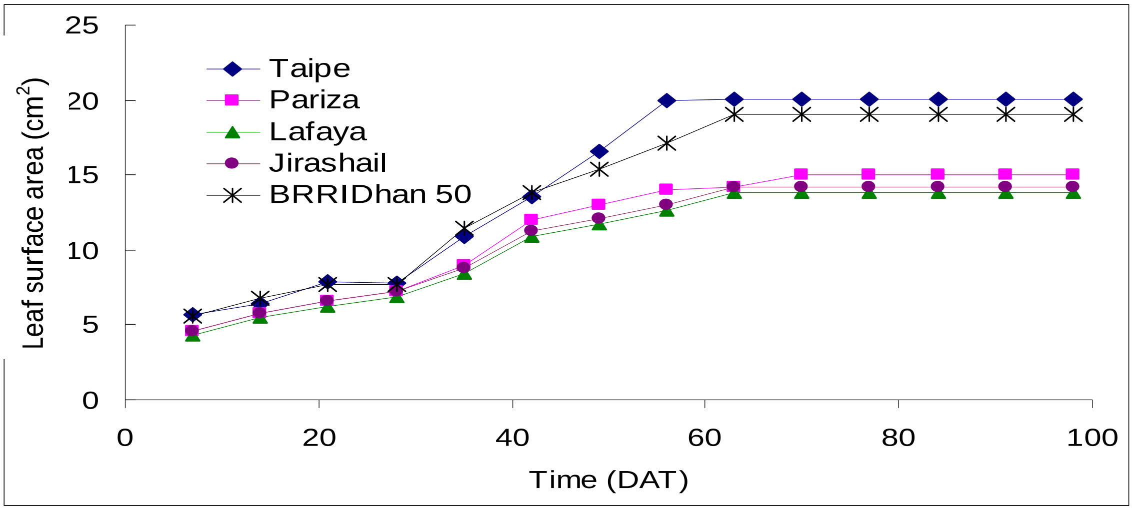

Figure 3. Leaf surface area of five boro rice varieties during experiment time.

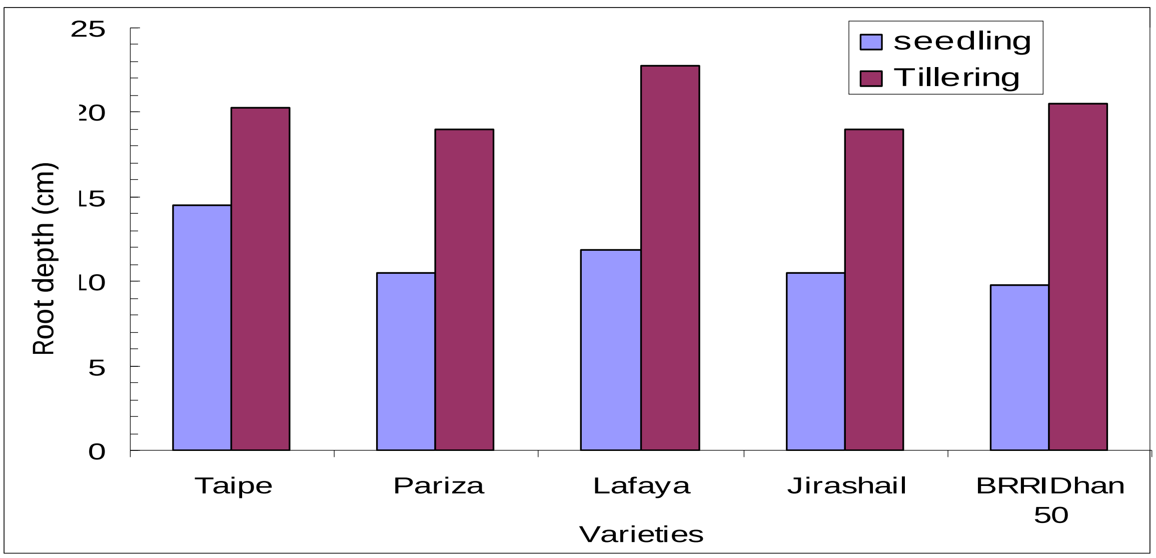

Figure 4. Root depth (cm) of five boro rice varieties at seedling and tillering stages.

The root volume was recorded at seedling and tillering stages at growing time of the varieties shown in figure 5. Root had shown variability amongst the studied varieties (Figure 5). There were remarkable differences in root volume of all varieties at seedling and tillering stages. The root volume of the fine varieties was higher in tillering stage and lower in seedling stage. In the present study, BRRI dhan50 showed the highest root volume (1.05 cm^3) at seedling stage while Taipe showed the highest root volume 1.5 cm^3 at tillering stage. The root number was recorded at seedling and tillering stages of the selective fine rice varieties (Figure 6). There is a remarkable difference in root number of select varieties at seedling and tillering stages. The root number of the varieties was the highest in tillering stage and the lowest in seedling stage. Figure 6 shows that Lafaya had highest root numbers both at seedling stage (33.25) and tillering stage (79.5).

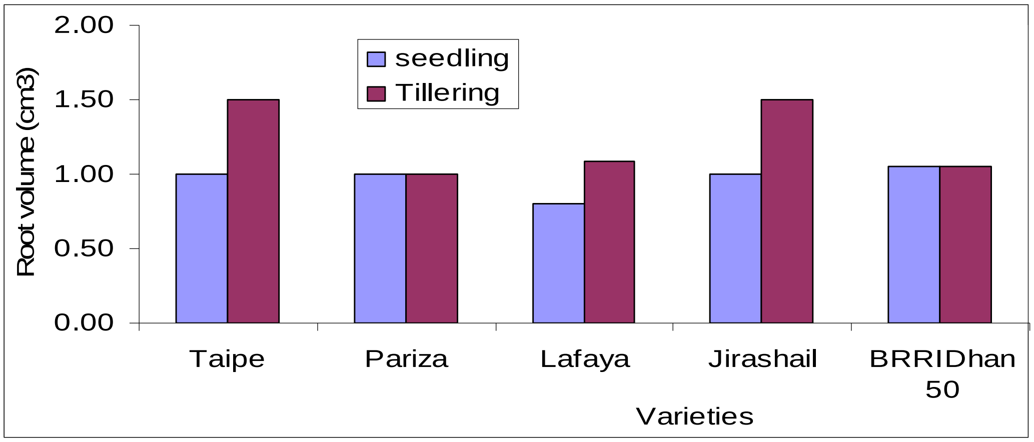

Figure 5. Root volume of five rice varieties at seedling and tillering stages.

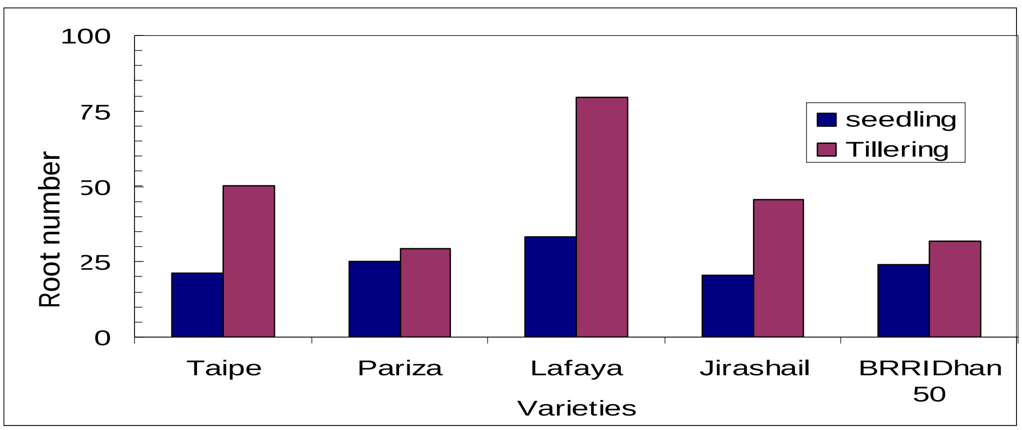

Figure 6. Root number of five rice varieties at seedling and tillering stages.

The dry root weight was also recorded at seedling and tillering stage of the varieties shown in Figure 7. There was a remarkable difference in dry root weight of all varieties at seedling stage and tillering stage. The dry root weight of the varieties was highest at tillering stage and the lowest at seedling stage. The highest dry root weight (0.484 g) was in BRRI dhan50 at seedling stage among the varieties but tillering stage the lafaya showed the highest dry root weight 1.387 g.

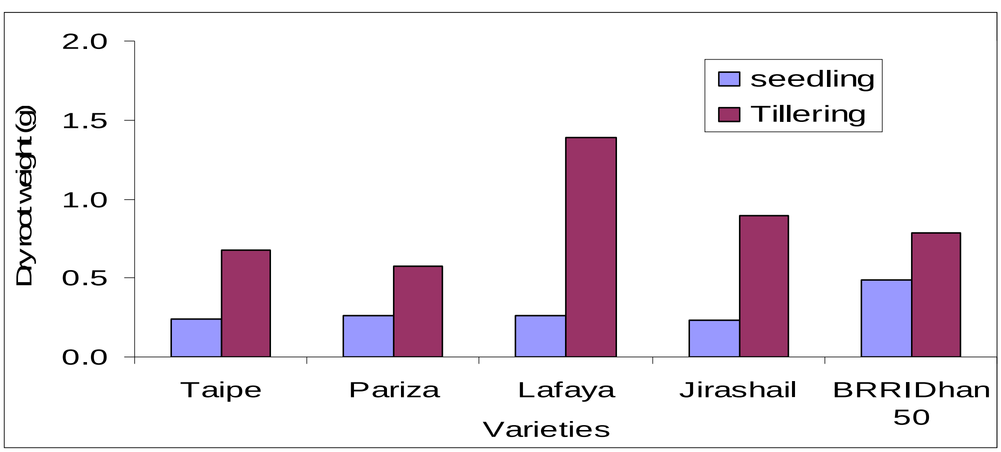

Figure 7. Dry root weight of different rice varieties during experiment time.

Table 1. Yield and yield contributing characteristics of five rice varieties

Varieties	Tiller number hill^{-1}	Effective tiller hill^{-1}	Non effective tiller hill^{-1}	Panicle hill^{-1}	Grain panicle^{-1}	1000 grain wt (g)	Dry matter (t ha^{-1})	Grain yield (t ha^{-1})	HI (%)
Taipe	10.75c	8.75b	2.00c	9.50c	101.50bc	38.92a	17.18ab	5.160ab	30.40c
Pariza	11.50bc	8.75b	2.75b	13.75b	132.50a	22.75bc	16.21ab	5.300a	32.92b
Lafaya	10.00c	7.75b	2.25c	10.00c	103.25b	24.55b	17.61a	5.530a	31.25b
Jirasail	13.75ab	11.75a	2.00c	10.00c	97.50c	21.53c	14.94ab	4.688b	31.32b
BRRI Dhan50	15.75a	12.25a	3.50a	16.00a	136.50a	23.52b	14.75b	5.675a	35.42a

Table 1 shows the variability of tiller production by five studied boro varieties. Result revealed that tiller number increased till 77 DAT followed by a steady on decline at harvest due to death of some undeveloped tillers. Table 1 also revealed that BRRI dhan50 (15.75) produced greater number of tillers hill^{-1} followed by Jirashail (13.75) than those of other varieties. In contrast, Lafaya (10) produced the lowest number of tillers hill^{-1} at the experiment. This study was in agreement with Zahan 2011 that numbers of tillers in case of local varites were low in comparison to modern and released varieties. There was no significant difference between BRRI dhan50 and Jirasail. Similarly, Lafaya and Taipe were statistically similar regarding tiller production per hill.

Number of effective tillers hill^{-1} had shown variability amongst the studied varieties (Table 1). Results revealed that effective tillers hill^{-1} was greater in BRRI dhan50 and Jirashail varieties than others. In rice, the highest number of effective tillers hill^{-1} was recorded in BRRI dhan50 (12.25) followed by and also in Jirashail (11.75). On the other hand, the lowest effective tillers hill^{-1}was observed in other three local varieties viz; Taipe (8.75), Pariza (8.75) and Lafaya (7.75). This result was in agreement with many workers (Yang *et al.* 2001; Dutta *et al.* 2002; Shrirame and Muley 2003 and Munshi 2005). The differential response of tillering in the genotypes could be attributed to its genetic potentiality. With decreasing tillers hill^{-1}, grain yield will be decreased considerably (Hoque 2004). There were marked significant differences among the varieties but no significant difference between BRRI dhan50 and Jirasail. Similarly, Taipe, Pariza and Lafaya were statistically similar.

Numbers of non-effective tillers hill^{-1} amongst the studied varieties were statistically significant (Table 1). Interestingly, the local varieties also showed higher yield performance indicating yield is negatively correlated with non-effective tillers hill^{-1}. In rice, the lowest non-effective tillers hill^{-1} was observed in Taipe (2.0), Lafaya (2.25) and Jirasail (2.0). This result conformed to the result of (Aktar 2005) and (Hoque 2004) in rice. There was a significant difference among the varieties. Taipe (2.0), Lafaya (2.25) and Jirasail (2.0) showed significantly the lowest than the BRRI dhan50 (3.5) and Pariza (2.75). There was no significant difference among Taipe, Lafaya and Jirasail, but between BRRI dhan50 and Pariza.

A significant difference was in number of total panicle hill^{-1} among the varieties (Table 1). Among all the varieties BRRI dhan50 (16) and Pariza (13.75) showed the highest number of panicle hill^{-1} followed by Pariza (13.75). Taipe was the lowest number of panicle hill^{-1} (9.5). There was no significant difference among Taipe, Lafaya and Jirasail but significantly difference between BRRI dhan50 and Pariza.

There was a significant difference in number of grain panicle^{-1} among the varieties (Table 1). Among all the varieties BARI dhan-50 showed the highest number of grain panicle^{-1} (136.5) followed by Pariza (132.5) than the other varieties. On the other hand Lafaya and Taipe produced intermediate grain panicle^{-1} and Jirashai was recorded the lowest number of grain panicle^{-1} (101.5), respectively. There was no significant difference between Pariza and BRRI dhan50 but there was significant difference between Taipe, Lafaya and Jirasail.

The 1000 grain weight had also shown a significant variation among the varieties (Table 1). The local varieties had greater 1000-grain than modern cultivar.

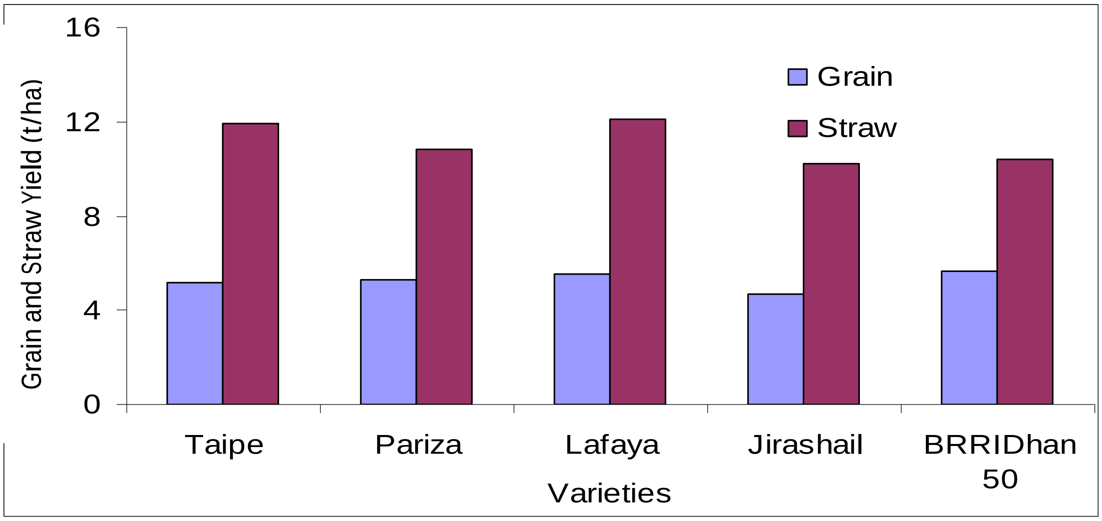

Figure 8. Grain and straw yield of five rice varieties

Taipe showed the highest 1000-grain weight (38.92g) than those of other varieties. While Jirashail produced the lowest 1000-grain weight (21.53 g). (Mondal *et al.* 2005) studied 17 modern varieties of transplant aman rice and reported that 1000-grain weight differ significantly among the varieties which supported the present finding.

There was significant difference in grain yield among the boro rice varieties shown in Table 1 and Figure 8. The highest grain yield was 5.6 t ha^{-1}recorded in BRRI dhan50 and the lowest grain yield was 4.6 t ha^{-1} recorded in Jirashail. The higher yield in BRRI dhan50 might be due to the production of highest number of effective tillers along with highest grain $panicle^{-1}$. (Pruneddu and Spanu 2001) reported that the genotypes; which had higher number of effective tillers $hill^{-1}$ and higher number of grains $panicle^{-1}$ also produced higher grain yield. Similar results were also reported by (Dutta *et al.* 2002; Mondal *et al.* 2005) in rice that conformed the present finding. A statistical difference among the varieties was observed Pariza, Lafaya and BRRI dhan50 showed significantly higher yield than Taipe and Jirashail. There was no significant difference among Pariza, Lafaya and BRRI dhan 50. Taipe and Jirasail are statistically similar but different with the farmer three varieties.

Rice straw yield among the rice varieties shown in Figure 8. The highest straw yield was recorded in Lafaya (12.08 t ha^{-1}) and lowest straw yield was recorded in Jirashail (10.3 t ha^{-1}). There was no significant difference with other varieties. The straw yield in Taipe, Pariza, Lafaya, Jirasail and BRRI dhan50 were statistically similar. (Chowdhury *et al.* 1995) reported that grain yield was positively correlated with biological yield in rice. Similar result was also reported by (Munshi 2005) in rice. In the present investigation, the high yielding varieties also showed higher straw yield in rice.

A significant difference in total dry matter (t ha^{-1}) among the studied boro rice varieties was presented in Table 1. The highest total dry matter was recorded in Lafaya (17.61 t ha^{-1}) and the lowest total dry matter was recorded in BRRI dhan50 (14.75 t ha^{-1}). The above results of differences in total dry matter $plot^{-1}$ were in full agreement with (Hoque 2004). The differential response of dry matter in the genotype could be attributed to its genetic potentiality. There was no significant difference between Taipe, Pariza and Zirashail, but Lafaya and BRRI dhan50 are statistically different.

Harvest index (HI) differed significantly among varieties (Table 1). The highest harvest index 35.42% was recorded for BRRI dhan50 and the lowest harvest index 30.40% was recorded in Taipe. The other varieties showed intermediate values. The result revealed that HYV BRRI dhan50 showed higher harvest index compare to local varieties. HI is the measure of the efficiency of conversion of photosynthate into economic yield of a crop plant (Mondal and Dutta 1999). According to (Poehlman 1991), high yield is determined by physiological process leading to a high net accumulation of photosynthates and it's partitioning into plant and seed. This opinion has been reflected in the present study. In the present investigation, high yielding varieties maintained high HI.

CONCLUSION

BRRI dhan50 along with lafaya and pariza showed superiority in yield contributing characteristics compare to other local varieties due to its high genetic yield potential among the local varieties and resulted in higher grain yield. Among the local varieties, Lafaya had the best yielding ability. Therefore it could be suggested that Lafaya can be selected for cultivation in Northwest Bangladesh by using modern agronomic practices. This study also infers that the high yielding characteristics might be selected biotechnology to improve specific traits or objectives by using gene transformation techniques.

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