GROWTH AND YIELD PERFORMANCE OF SEVEN RICE VARIETIES UNDER MODERATE SALINITY STRESS

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Abstract

Salinity is a major problem in the Southern part of Bangladesh that reduces the country's rice production. The present investigation was carried out at Bangladesh Institute of Nuclear Agriculture (BINA) Sub-station, Satkhira during Boro season (December-April) of 2020-21to evaluate five hybrid and two inbred salt tolerant rice varieties under moderatesalinity stress . Ontogenetic growth study revealed that all the rice varieties produced the highest number of leaves and tiller at 78 and 64 DAT (Days after Transplanting), respectively. Based on the morphological performance, hybrid rice namely Hira-2 followed by Tejgold and HYV rice namely Binadhan-10 produced the highest grain yield due to increased seed width, 1000 seed weight and total dry matter production. In addition, the seed width showed strong positive correlations with the grain yield and 1000-grain weight indicated an important trait for higher grain yield production in rice. Therefore, further studies are needed in different level of saline areas to identify the potential saline tolerant high yielding rice variety in boro season.

Key words: Morphological parameters, growth, salinity and Bororice.

Introduction

For being a staple food, its production is considered as the key factor for food security in Bangladesh. In the last 30 years, Rice production has doubled with the development of high yielding, short duration, stress-tolerant, resource responsive and semi-dwarf varieties (Chowhan *et. al.,* 2021). However, the threat of a food crisis remains because of increasing population, water insufficiency, shortage of labor, global climate change, pest/diseases infestation, increasing incidences of salinity, uneven distribution of rainfall, soil erosion, soil degradation etc. Above all, salinity is a major problem that hindering the rice production in the world especially in southern part of Bangladesh.

Salinity is most important abiotic stress that directly regulates the plant growth and affects grain yield production in rice. The coastal zone of Bangladesh covers nearly 20% of the total land and over 30% of the cultivable lands of the country and about 53% of coastal soils are salt-affected (Hasan *et. al.,* 2019). However, rice is very sensitive to salinity stress and is currently listed as the most salt sensitive cereal crop with threshold of 3 dSm^{-1} for most of the cultivated varieties (USDA, 2013). In Bangladesh, about 1.06 million hectares of arable lands are affected by soil salinity (SRDI, 2010). Salinity is a year-round problem in the coastal region for agricultural production; it is increasing rapidly in Khulna, Bagerhat and Satkhira districts of Bangladesh (Hasan *et. al.,* 2019).

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The yield performance of the cultivars could be influenced by the environments and to a point by genotype and environment (GE) interaction (Rasyad *et al.*, 2012). Therefore, Rabi crops and Boro rice are mostly affected within the coastal area due to salinity stress. Grain yield is the result of several components that are seriously affected by soil salinity and threatening country's food security (Abbas *et al.,* 2013). Grain yield losses may occur as a result of decreased growth of the vegetative parts and/or as a result of abnormalities in the reproductive process (Reddy *et al.,* 2017; Devi *et al.,* 2022). The degree of the response depends on stress severity and climatic conditions, as well as on the degree of genotype to salinity tolerance. Modern and high-yielding rice cultivars haven't been widely adopted in saline-prone areas where traditional varieties are still being cultivated by farmers because the cultivars can partly stand in waterlog and salt stress conditions; but they're low-yielding, photoperiod sensitive with long duration (Islam *et al.*, 2013).

Rice is moderately susceptible to salinity, since most rice plants are severely injured at an EC 8-10 dSm^{-1}. Yield losses due to salinity are amounted to 30-50 percent and our farmers normally grow local varieties due to unavailability of salt tolerant high yielding varieties (HYV). Therefore, to keep pace with the population growth and food productions, the yield per unit area needs to be increased for minimizing the yield gap. Appropriate salt tolerant high yielding varieties that can fit into the rice-growing ecosystem in the coastal areas of Bangladesh will boost up the country's rice production. Hybrid rice cultivars are getting popular across the coastalarea probably due to the homeostasis effect; earliness and better productivity which made them attractive to farmers; thus, growers became curious about crop diversification to extend their financial gain (Virmani and Kumar, 2004).

In Bangladesh, hybrid rice had higher productivity (20–25%) than HYV rice (Anwar *et al.,* 2021). Higher productivity of hybrid rice can render Bangladesh self-sufficient in rice (Yuan, 2012). Besides, the prices of hybrid rice are 5–10% lower, which resulted in lower profits than HYVvarieties. The farmers stated that the reasons for the decrease in hybrid rice areas were higher seed prices, greater vulnerability to insect infestation, lower market demand, and inferior quality of grain (Anwar*et al.,* 2021). So, farmers are interested to cultivate inbreed varieties that they preserve their seeds and cultivate further season.

The use of tolerant varieties can alleviate salinity problems in salt-affected rice-growing areas but this must be combined with other crop management technologies such as a suitable cropping schedule (Plaut *et al.,* 2013). Thus, it is urgent for the researchers and policy makers to search alternative techniques for better utilization of stress-prone areas, like screening of salt tolerant cultivars might be the best approach to bring salinity prone areas under cultivation and will ensure the country's food security. Moreover, little is known about varietal differences that can be exploited to improve salinity tolerance, especially in rice cropping systems. Screening of salinity tolerance based on agronomical parameters such as growth, yield and yield components has become a reliable method worldwide (Moradi and Ismail, 2007; Cha-Um *et al.,* 2010; El-Hendawy *et al.,* 2009). Thus, this experiment was carried out under moderate saline condition to know the morphological causes of yield variation and select boro rice varieties for higher grain yield production in the southern part of Bangladesh.

Materials and Methods

A field experiment was conducted at the saline prone area, BINA Sub-station farm, Binerpota, Satkhira (22^0 45' N and 89^0 6' E) under natural growth condition during Boro season in 2020-2021. There were7 rice varieties *viz*. 5 Hybrids-SL-8, Syngenta-1203, Hira-2, Tejgold, BRAC Hybrid-777; and 2 HYVs-Binadhan-10 and BRRI dhan67. Salinity level was taken randomly and 3 times in a month using EC meter (ECTestr11+, Spectrum Technologies, Inc.), then the average value was calculated.

The experiment was laid out in a randomized complete block design (RCBD) with 3 replications. The unit plot size was 4m × 3m. The varieties were randomly distributed among the plots. Seeds of all varieties were soaked in water for 24 hours and kept in dark condition for 48 hours. Seedling nurseries for each variety were prepared by pudding the soil. Finally, the sprouted seeds were sown on a well-prepared wet nursery bed on 20 December 2020. The land was prepared by two times ploughing with a power tiller and then all kind of weeds, stubbles and crop residues were removed from the field. The fertilizers were measured and applied according to the fertilizer recommendation guide of BARC (2018). During the final land preparation, the land was fertilized with full dose of TSP, Muriate of potash (MP), Gypsum and Zinc Sulphate. Urea was applied as top-dressing in three equal splits after 20, 35 and 50 days of transplanting. Finally, the forty days old seedlings of all tested varieties were uprooted and then transplanted in the experimental field following the layout. The height was measured from the five randomly selected seedlings of each variety using measuring scale. The single seedling per hill with spacing 20cm × 15cm was used for transplanting. Intercultural operations were done when necessary for ensuring rice growth and development.

The plot was observed regularly and the leaves and tillers number per plant were recorded with 7 days intervals at 50 DAT, 57 DAT, 64 DAT, 71 DAT, 78 DAT and 85 DAT from each experimental plot. For TDM, the single plant of each tested variety was collected from each experimental plot and then corresponding dry weights were recorded after oven drying at 80 ± 2 ºC for 72 hours.Finally, the crops were harvested on 09 May 2021 at 90% of the seeds attained yellow color. Prior to harvesting 5 randomly selected plants per plot excluding border rows were taken from each plot to collect data on yield contributing characters and then the rice of the full plot was harvested. Plot yield was recorded after threshing by a thresher and drying in the sun properly excluding the grains of sample plants. The rice yield adjusted to 14% moisture content and converted to t ha^{-1}. From the randomly harvested five hills, the following data were recorded plant height, total tillers $hill^{-1}$, flag leaf length, flag leaf width, panicle length, filled grains$panicle^{-1}$, unfilled grains $panicle^{-1}$, seed length, seed width, 1000-seed weight and grain yield (t ha^{-1}).

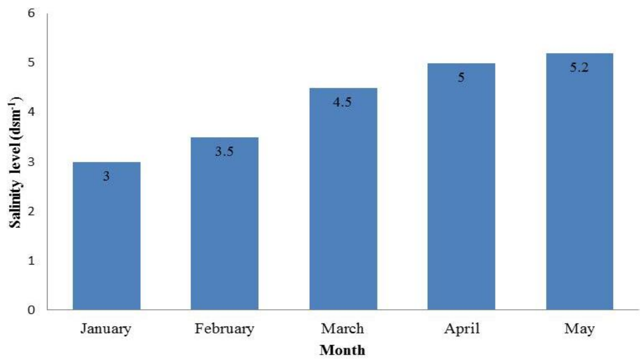

Fig. 1. Level of salinity during crop growing season

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjusted using the statistical computer package program Statistix10 at 5% level of significance was used to compare mean differences among the treatments (Gomez & Gomez, 1984).

Results and discussion

Seedling age and height has important role in the grain yield and yield contributing characters of rice. The seedling height was measured at forty days old and then transplanted in the experimental field. There was a significant difference among the seedling height but apparently the highest seedling height was recorded in BRAC Hybrid-777 followed by Binadhan-10. Besides, the shortest seedling height was observed in Hira-2 (Fig. 2). Similar results were reported by Aslam *et al.*, (2015).

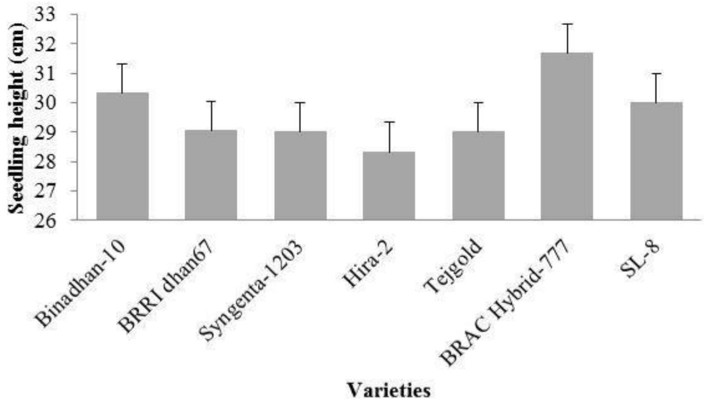

Fig. 2. Seedling height of cultivated varieties

Results indicated that leaves number plant^{-1} increased with age until 78 days after transplanting followed by a decline (Fig. 3). The highest number of leaves was produced at 78 days after transplanting in most of the studied genotypes. Finally, BRAC Hybrid-777 and

Binadhan-10 produced the highest number of leaves compared to other studied cultivars (Fig. 3.). Dissimilarities in leaf numbers may shape individual varietal growth, nutrient use efficiency and genetic traits (Chowan *et. al.,* 2021). This suggests that variations in leaf numbers were noted among the studied varieties at harvest which direct contribute in rice grain yield production (Akter *et al.,* 2019).

The effect of variety on tiller production at 6 growth stages was significant (Fig. 4). The number of tillers was increased with age up to 64 DAT followed by a decline with age due to asynchronous non-effective side tiller mortality. Similarly, Patra and Haque (2011) reported that the lowest number of panicles bearing tillers was found due to non-effective side tiller mortality. However, Binadhan-10 and BRRI dhan67 produced higher number of tillers hill^{-1} and Syngenta-1203 and BRAC Hybrid-577 produced lower number of tillers at harvest (Fig. 4.).

The grain yield-related traits are positively associated with flag leaf area (Ashrafuzzaman, *et al.*, 2009) because it is the most important source of photosynthetic energy during reproduction and grain filling (Rahman *et al.*, 2013). All the varieties had shown significant difference in flag leaf length and width. The longest flag leaf was found in Binadhan-10 followed by Syngenta-1203 andthe shortest in Hira-2. In addition, the highest flag leaf width was noted in Hira-2 and on the other hand, Tejgold produced the lowest flag leaf width (Table 1). In the present study, Syngenta-1203 had the long and narrow leaves that might help in capturing resource and producing sufficient assimilates.

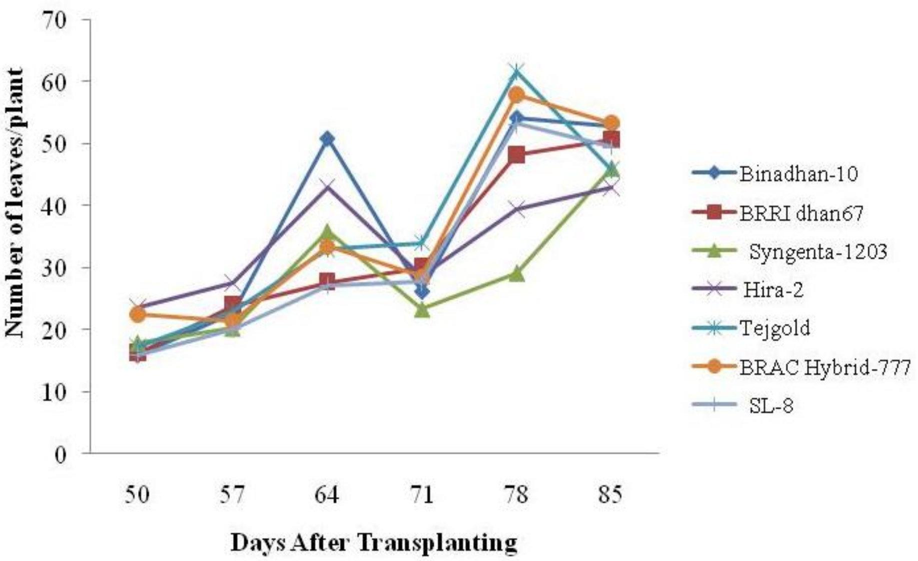

Fig. 3. Leaves production pattern of seven rice varieties in boro season.

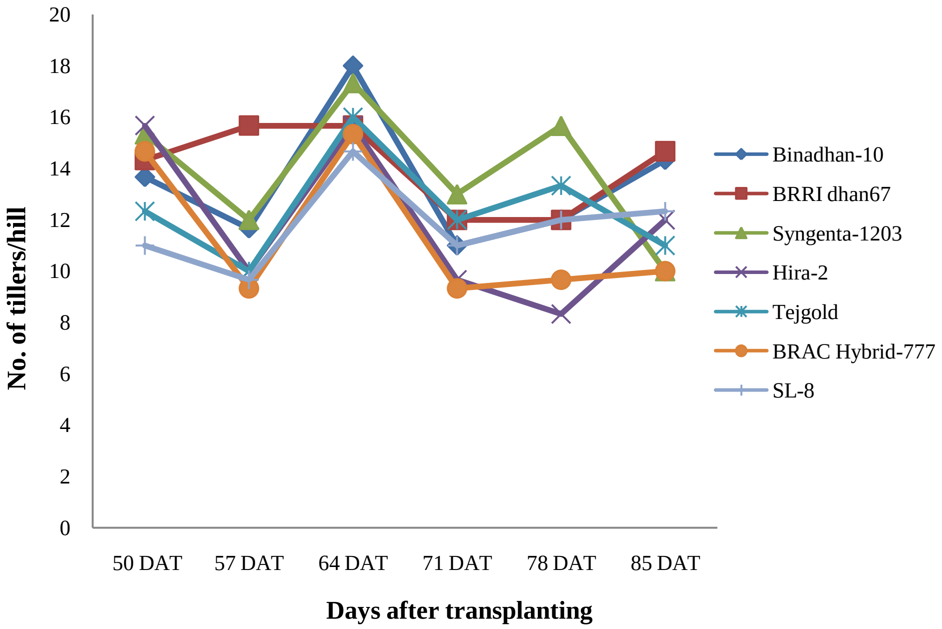

Fig. 4. On to genetic tillering pattern of seven rice varieties in Boro season.

Considering the yield and yield contributing characters; it was observed that the majority of the studied traits showed significant difference among the tested varieties (Table 1). Results revealed that BRAC Hybrid-777 produced the tallest plants (121.6 cm) followed by Binadhan-10 (120.8 cm) and BRRI dhan67 (119.9 cm) with same statistical rank. In contrast, Hira-2 and SL-8 exhibited shorter plant. Plant height is directly affected by genotype and it is an important to nitrogenous fertilizer responses and lodging. Generally, hybrid rice varieties are shorter than inbred HYV varieties and contribute in grain yield (Awal *et al.*, 2007). The number of tillers has a positive association with plant biomass and economic yield in rice (Deng *et al.*, 2015). The highest effective tillers hill^{-1}was recorded in BRRI dhan67 (11.6) followed by Binadhan-10 (11.1) and Syngenta (10.8) with same statistical rank. The lowest number of effective tillers hill^{-1} was observed in BRAC Hybrid-777 (9.0).

Panicle length is an important character which contributes in grain yield production of rice. The highest panicle length (29.0 cm) was recorded in Binadhan-10 followed by BRAC Hybrid-777 (28.8 cm) and the lowest (24.0 cm) was found in SL-8. The other studied varieties showed insignificant difference in panicle length themselves. Gravois and Hilms (1992) reported that the effect of filled grains per panicle and rice yield was positively correlated. The maximum filled grains per panicle (260.2) were counted in Syngenta-1203 and the lowest (163.8) in Binadhan-10. In addition, the highest number of unfilled grains per panicle (35.9) was also found in Syngenta-1203 and the lowest (5.8) in Hira-2 followed by Binadhan-10 (7.4).

Seed size is one of the crucial indicators of seed quality that considered in a crop improvement program. The longest seed was found in BRAC Hybrid-777 (10.3 mm) and the shortest in BRRI dhan67 (8.5 mm) followed by Binadhan-10 (8.7 mm). Besides, the highest seed width was exhibited in Hira-2 (2.8 mm) followed by Binadhan-10 (2.7 mm) and the lowest in BRRI dhan67 (2.1 mm). Considering the grain yield production, Hira-2 produced the maximum grain yield (8.9 t ha^{-1}) followed by Tejgold (8.3 t ha^{-1}), Binadhan-10 (7.9 t ha^{-1}) and BRRI dhan67 produced the lowest grain yield (6.6 t ha^{-1}). The highest 1000-seed weight was recorded in SL-8 (30.9 g) followed by Hira-2 (28.2 g) and lowest was in BRRI dhan67 (21.0 g). These data suggests that the yield can be increased with the increased grains per panicle with bolder grain size in rice which is supported by our previous report (Akter *et al.*, 2019).

Table 1: Yield and yield contributing characters of seven rice cultivars

Variety	Plant height (cm)	Effective tillers $hill^{-1}$ (no.)	Flag leaf length (cm)	Flag leaf width (cm)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)
Binadhan-10	120.8a	11.1ab	41.4a	1.7ab	29.0a	163.8c
BRRI dhan67	119.9a	11.6a	35.0c	1.6b	26.9b	191.7bc
Syngenta-1203	111.7bc	10.8abc	40.9a	1.6b	26.4b	260.2a
Hira-2	107.7c	9.8bcd	29.3d	1.8a	26.2b	192.4bc
Tejgold	116.9ab	9.2cd	36.3bc	1.5b	26.6b	214.2ab
BRAC Hybrid-777	121.6a	9.0d	39.3ab	1.7ab	28.8a	235.1ab
SL-8	108.3c	9.7bcd	38.3abc	1.7ab	24.0c	215.0ab
CV (%)	3.58	9.46	6.09	6.24	3.50	13.05

Variety	Unfilled grains $panicle^{-1}$ (no.)	Seed length (mm)	Seed width (mm)	1000- grain weight (g)	Grain yield (t ha^{-1})
Binadhan-10	7.4cd	8.7cd	2.7ab	27.6abc	7.9b
BRRI dhan67	9.0c	8.5d	2.1e	21.0d	6.6d
Syngenta-1203	35.9a	8.8c	2.4cd	23.1cd	6.9cd
Hira-2	5.8d	8.8c	2.8a	28.2ab	8.9a
Tejgold	16.3b	9.8b	2.4cd	24.3bcd	8.3b
BRAC Hybrid-777	34.0a	10.3a	2.2de	23.3cd	7.0cd
SL-8	7.4cd	9.6b	2.5bc	30.9a	7.2c
CV (%)	9.52	2.10	5.30	10.45	3.44

The grain yield is positively associated with the grain size, which is determined by the grain length, grain width, and grain shape (Duan *et al.*, 2014). All the studied agronomical traits among the varieties were significantly different and showed a varied degree of correlation in either positive or negative direction (Fig. 5). In this present study, grain yield strongly and positively correlated with grain size [width (r = 0.72***) and 1000-seed weight (r = 0.56**)] and the flag leaf length revealed a negative correlation with the grain yield (r = -0.55**) which are supported by our previous study (Akter *et al.*, 2022).

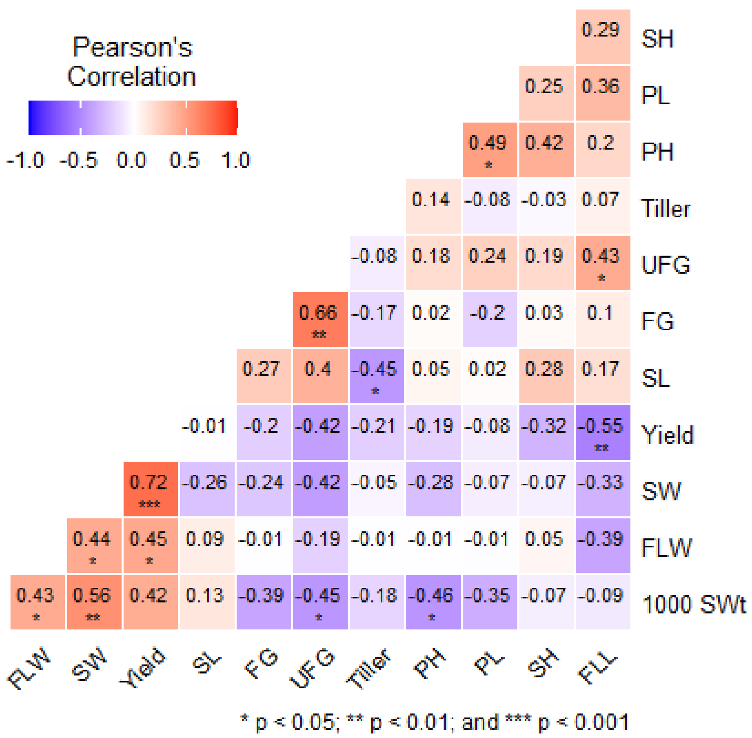

Fig. 5. Correlation among the agronomical parameters of seven rice varieties; where FLW flag leaf width, SW seed width, SL seed length, FG filled grain, UFG unfilled grain, PH plant height, PL panicle length, SH, FLL flag leaf length.

Dry matter accumulation reflects growth and metabolic efficiency of a plant, which ultimately influences the economic yield. Total dry matter production by rice plants increased progressively with the advancement of growth stages and important for higher grain yield in rice. In this present study, total dry matter (TDM) production at various crop growth stages of rice was significantly influenced by different varieties. Most of the studied varieties showed the maximum TDM at 78 DAT. Finally, BRAC Hybrid-777 produced the highest TDM and the lowest TDM was found in Hira-2 (Fig. 6) indicated that good dry matter partitioning of assimilates to the grain in rice. The poor grain filling might be related to poor partitioning of assimilates to the grain in rice (Puteh *et al.*, 2014).

The grain yield increased with increased total dry matter production and grain yield strongly correlated with total dry mass production (Akter *et al.*, 2019) and higher dry matter production during grain filling is helpful for grain filling in rice as previously reported by Yang *et al.* (2002). Results indicated that positive correlation was observed between grain yield and total dry mass production (Fig. 7). The results indicated that higher dry matter production during grain filling is important for grain yield production in rice that supported by (Deng *et al.*, 2015; Bidgoli *et al.*, 2006).

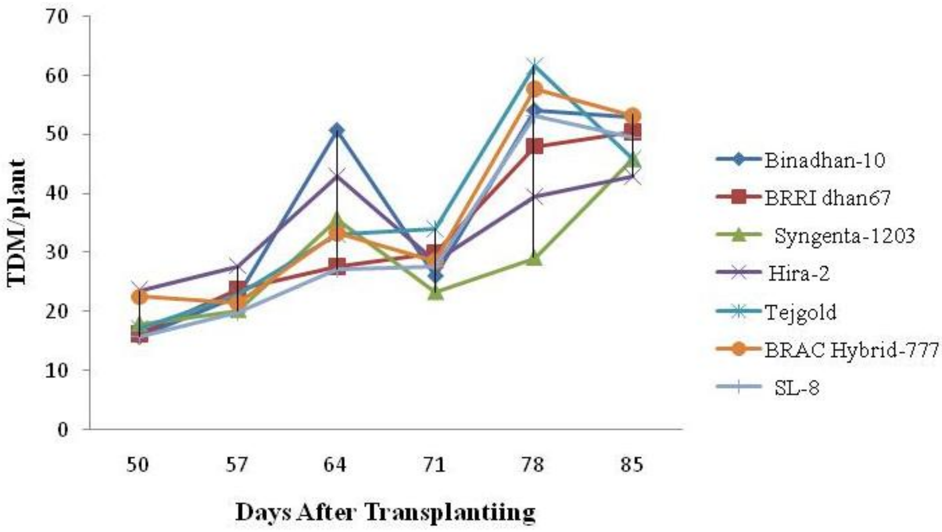

Fig. 6. Total dry mass production (TDM) at different growth stages in seven rice varieties.

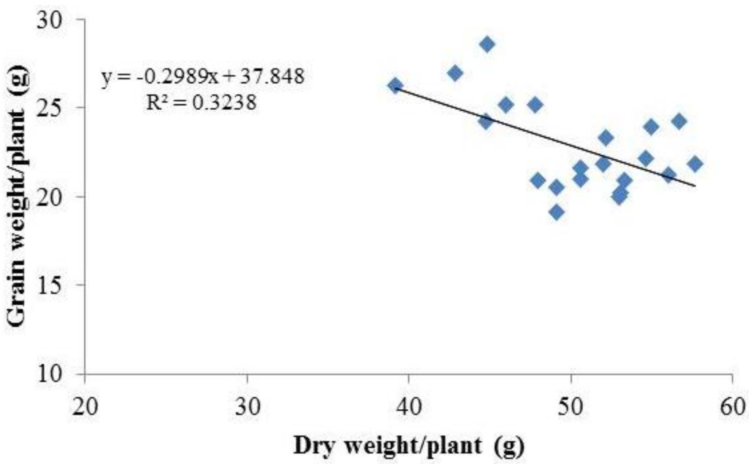

Fig. 7. Relationship between total dry matter (TDM) production and grain weight per plant.

Conclusion

Amongst the studied varieties; hybrid rice Hira-2 followed by Tejgold; and HYV rice Binadhan-10 produced higher grain yield for bolder seed size. Positive correlation between TDM and yield indicated that good dry matter partitioning of assimilates to the grain in rice. Therefore, further studies are needed including varied level of saline areas to identify the highly saline tolerant high yielding rice variety in Boro season.

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