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Adjustment in Wet Season Rice Planting for Cropping Intensification in Coastal Bangladesh

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Major constraints to cropping systems intensification in coastal Bangladesh include the lack of fresh water for irrigation, soil salinity, excess moisture in the soils at planting time for dry season (DS) crops and the dominance of long duration wet season (WS) rice cultivars including low yield potential of local cultivars (LCs). This study aimed to find out suitable high yielding, short duration potential wet season rice cultivars to fit into the cropping system to enhance system productivity through timely planting DS non-rice and rice crops in the coastal zone. Thus, varietal trials on seven WS rice cultivars released by BRRI that have high yield potential were conducted at Dacope, Khulna and Amtali, Barguna over three years (2016-2018) to compare the performance of those cultivars with local cultivars. From these trials, BRRI dhan76 was the most preferred variety of farmers in Dacope while BRRI dhan77 was rated second in Amtali because of better performance (0.5-1 t ha^{-1} yield advantage) and environmental suitability at planting and harvesting time. However, BRRI dhan54 was the most preferred variety of farmers in Amtali due to higher yield potential and shorter lifecycle (about 25-30 days) than that of LCs. The key drivers of farmer preference are (i) the cultivar performance in its own right, as well as (ii) how well they facilitate the timely planting of DS crops (Boro rice, sunflower, maize and vegetables). DS crops performed better with early sowing by escaping salinity and moisture stress. Thus, large scale dissemination of the WS transplanted *aman* (T. *aman*) cultivars may create an opportunity for enhancing total system productivity, largely through cropping system intensification. As a result, rice grain self-sufficiency and farm income will be increased notably without adverse impacts on the environment. Thus, there is potential for this approach to be replicated in other areas for cropping intensification in the coastal zone of Bangladesh.

(***Key words:*** *Bangladesh, Coastal zones, Crop intensification, Planting schedule, T. aman rice, Varieties)*

About 2.85 million ha of coastal lands are waterlogged in Bangladesh during wet season. According to PDO-ICZMP (2003a) coastal areas fall under two broad categories *viz*. interior coast and exterior coast. Out of 19 coastal districts (147 upazilas), a total of 48 upazilas in 12 districts (23900 km^2) are exposed to the sea and/or lower estuaries and defined as the exposed coast, and the remaining 99 upazilas are termed interior coast with a total area of 47200 km^2 (PDO-ICZMP, 2003b). The coastal zone of Bangladesh has many rivers and tributaries with complex ecology, and is strongly affected by cyclones, flooding, tidal surges and salinity. The coastline is 734 km long in which region about 50 million people live (Miyan, 2009). The majority of people residing in the coastal zone are dependent on agriculture and aquaculture, especially on rice production, for food security and livelihoods.

More than 30% of the cultivable land in Bangladesh is in the coastal zones and about 1.0 million ha of arable lands are affected by varying degrees of salinity. Farmers grow mostly low-yielding, traditional rice varieties during the wet season and most of the lands remain fallow in the dry season (January-May) because of varying degrees of soil salinity and the lack of good-quality irrigation water (Karim *et al*., 1990; Mondal, 1997). Crop yields, cropping intensity, production levels and people's quality of life are much lower in this region than in other parts of the country. At the same time, food demand in the area is increasing with the steady increase in human population, while extreme events are also increasing due to climate change impacts (Maniruzzaman *et al*., 2018).

The climate of the coastal zone is subtropical, enjoying an average annual rainfall of about 2,000 mm,

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most of which falls from June to October followed by dry season having soil and water salinity problems. Therefore, farmers mostly cultivate tall, stagnant-water tolerant transplanted *aman* (T. *aman*) rice with a yield potential of 2.0-3.5 t ha^{-1} only. These varieties are late maturing and generally harvested during later part of December to early January, leaving little scope for dry season crop production. There has been minimal adoption of modern, high yielding T. *Aman* varieties (HYV) due to shorter height for frequent tidal inundation events during the monsoon.

Bangladesh is currently self-sufficient in rice production, but this is not the case for the coastal zone (MoA-FAO, 2013; Tuong *et al*., 2014). The average national cropping intensity is about 190%, whereas in Khulna region it is only about 134% (BBS, 2016). To improve cropping intensity in coastal areas, specialized crop varieties and smart management practices are needed. This generally can be accomplished in polder areas that provide an excellent opportunity for reduction of waterlogging. But most of the rivers water become saline (>4 d Sm^{-1}) after December, which restrict the cultivation of water-intensive *boro* rice, although moderately saline tolerant varieties (BRRI dhan47, BRRI dhan67 and BINA dhan10) are available. Moreover, many fields remain flooded until December, delaying harvest of T. *aman* and subsequent establishment of *rabi* crops. Thus, large areas of coastal land (approximately 810,000 ha) lie fallow during the dry season (Hasan *et al*., 2013).

The feasibility of increasing productivity in the polder areas has been shown by some researchers (Mondal *et al*., 2010; Mondal *et al*., 2015; Ritu *et al*., 2015). However, there has been little adoption of such improved production systems. By advancing the harvesting time of T. *aman* rice, it creates opportunities for timely establishment of selected non-rice crops in the coastal regions, thus improving total land productivity. Therefore, a study was undertaken to explore the prospects for advancing the T. *aman* harvest to facilitate *rabi* crops cultivation and thus improve land productivity and profitability of the farmers.

MATERIALS AND METHODS

Site characteristics

The study was undertaken in two locations, (i) polder 31 at Dacope, Khulna (22.37°N and 89.30°E) having high salinity, and (ii) in polder 43/1 at Amtali, Barguna (22.02°N and 90.14°E) with medium salinity level environments (Fig. 1). The area has two distinct seasons: a rainy season from June to October and a dry season from November to May. Formerly, the soil was very saline because of the intrusion of seawater during the dry season. To increase agricultural production, in the late 1960's, the area was included in the government's Coastal Embankment Project (CEP), in which the areas were surrounded by a dykes or embankments (called polders), separating them hydrologically from the main river system and offering protection against tidal floods, salinity intrusion and sedimentation (Islam, 2006). The river water salinity varies year-round. The onset of the rainy season makes river water fresh with an average electrical conductivity mostly below 1.0 dS m^{-1} from July to December and after that the river water gradually becomes more saline reaching more than 20 dS m^{-1}, by April-May. Therefore, the rainy season is suitable for crop cultivation from the perspective of water salinity, but there is the problem of waterlogging in most coastal regions.

Soil of the Dacope site is silty-clay to clay and salinity varies from 2-3 dS m^{-1} in July-September and 8-12 dS m^{-1} in April-May. Most arable land (70-75%) in the Dacope area is medium-high to low land and about 25-30% of total area is medium-high to high land. The cropping system is based on a monoculture of wet season rice. Most of the land is under low-yielding local varieties and some areas are under long-duration modern varieties. On the other hand, soil in the Amtali area is of silty-clay type and soil salinity in dry season

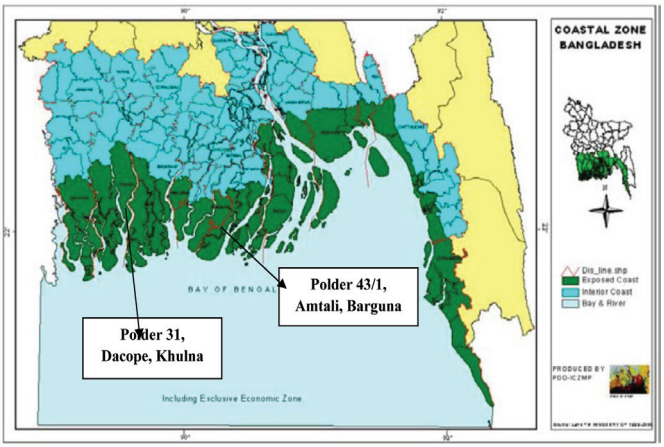

Fig. 1. *Coastal area map showing project sites (Source: Islam and Ahmed, 2004)*

is low to medium (6-8 dS m^{-1}) and decreases to low (1-2 dS m^{-1}) in the wet season. Most arable land (80-85%) in the village is 'medium-high land two' and about 15-20% of total area is 'medium high land-one' (BBS, 2017). In a normal wet season, most of the land is inundated between 0.3 to 0.6 m and to cope with this water depth, farmers use tall rice seedlings. Beside this, every year one or two depressions form in the Bay of Bengal and most of the coastal zone's water depths increase about 0.3-0.5 m above the normal flood level.

Varietal adoption and yield assessment

The experiment was established in a Randomized Complete Block Design (RCBD) at Dacope, Khulna and Amtali, Barguna for three consecutive years, 2016-2018. Tested rice varieties were BR23, BRRI dhan53, BRRI dhan54, BRRI dhan62, BRRI dhan66 and BRRI dhan73 along with popular local varieties (BR11, BR23, BRRI dhan34, Boran, Swarnagota, Tepu, Vogon) as a check for 2016 T. *aman* season based on the availability and suitability of seeds. According to farmers' preferences, some unsuitable varieties were discarded in 2017 and 2018, while BRRI dhan76 and BRRI dhan77 were added. Individual farmer's plots were treated as disperse replications for similar varieties. In the Dacope area, the tested varieties were sown on 10-20 July and 25-30 days old seedlings were transplanted on 10-25 August at 20 cm x 20 cm spacing with 3-5 seedlings per hill. In Amtali, Barguna area, the tested varieties were sown on 15-31 July and 25-30 days old seedlings were transplanted on 10-30 August at 20 cm x 20 cm spacing with 3-6 seedlings per hill. Fertilizer was applied at 75/68-12-53-12 kg NPKS ha^{-1}. Nitrogen fertilizer was used at 68 kg ha^{-1} for short duration (BRRI dhan 62) and 75 kg ha^{-1} for other HYV rice varieties.

Under farmers' practice (FP) in the Dacope area, most cultivated modern varieties and seeds were sown on 14-20 July and transplanted using 25-35 days old seedlings randomly with comparatively wider spacing (25-30 cm x 25-30 cm). In FP at the Amtali site, most of the farmers cultivated local variety and seeds were sown on 1-10 July and transplanted using 30-40 days old seedlings randomly with wider spacing (25-30 cm x 25-30 cm). In Dacope area, most of the farmers apply balanced fertilizer doses for modern varieties, but in Amtali area, most of the farmers used only nitrogen fertilizer with a higher dose (73 - 82 kg ha^{-1}) and a few farmers used other fertilizer with lower doses (5-11 and 7.5-15 kg ha^{-1} for P and K, respectively) than recommendation. The whole amounts of P, K and S were applied at the time of final land preparation, except N fertilizer. One-third N fertilizer was applied basally and the remaining two-thirds were applied in two equal splits at intervals of 25 and 45 days after transplanting (depends upon the tidal and flood water depth in the field). Rainfall and flood/tidal water were sufficient to meet crop water requirements for rice crops during T. *aman*. For yield estimation, 5 m^2 area was harvested from four corners and one from the middle of each rice field, and the yield was adjusted to 14% moisture content. Others input costs and cultivation practice-related economic data were collected and analysed by following the standard procedure (Dillon and Hardaker, 1993).

Preference analysis

Dacope, Khulna under Polder 31, and Amtali, Barguna under Polder 43/1, were selected purposively for this study as researchers managed trials on different wet season (WS) rice varieties. Preference polls were conducted at maturity stage to identify the most preferred rice varieties among farmers.

In the preference analysis (PA), scientists explained to farmers the importance of this activity and step-by-step procedures of voting to identify most desired and the least desired rice varieties. In Dacope, 11 WS rice varieties including four checks were included for preference analysis. Some of the recently released short/medium duration WS rice varieties such as BRRI dhan53, BRRI dhan54, BRRI dhan62, BRRI dhan66 and BRRI dhan73 were considered to represent good potential to enhance cropping intensity in the location and compared with BR10, BR11, BR23 and Baral (a local cultivar). In Amtali, preference analysis was conducted for BRRI dhan39, BRRI dhan53, BRRI dhan54, BRRI dhan62 and BRRI dhan66 against Swarnogota, Vajon, BR11 and BR23.

Each variety had a stake and bag with variety name. All the participants moved to the trial fields and they observed the physical traits of all varieties included in the preference poll. Each participant was provided with four pieces of ballot-paper, two checks and two crosses, and voted for their two most preferred and two least preferred varieties/cultivars. Ballots were colour-coded

to classify male farmers, female farmers and scientists/ researchers. Female farmers voted first, followed by male farmers, and then the researchers last. The regional technicians placed one panicle in the ballot bag of each variety and collected all those bags. Votes were tallied and the preference scores were computed in front of all the participants. The two most preferred and two least preferred varieties were announced, and one of the check varieties was voted top in both the sites.

The preference score was calculated by the following equation:

Preference score = (Positive votes - Negative votes)/ Sum of positive and negative votes (Paris *et al*., 2011).

Correlation analysis was performed to test if there are significant correlations between the preference scores of male and female farmers as well as the preference scores of farmers and breeders.

RESULTS AND DISCUSSION

Weather, salinity and water depth

The maximum temperature varied from 27-34°C and the minimum temperature varied from 16-27°C over the whole T. *aman* rice-growing season at both the study sites (Fig. 2). Both the maximum and minimum temperature gradually decreased from transplanting to harvest. A huge amount of rainfall occurred during the T. *aman* rice growing season, with the maximum in July-August, coinciding with the transplanting time of rice (Fig. 2). Due to the heavy rainfall and tidal water pressure, most of the land became inundated and waterlogged and consequently the transplanting was delayed. The maximum inundation level varied from 0.3 - 0.6 m and in some depressed areas, even more. For that reason, it appeared that most of the varieties with short seedling height are difficult to cultivate in those locations, although river water salinity is very low *i.e*. within the permissible limit during whole T. *aman* growing season in both the study sites (Fig. 3).

Yield performance and advancing harvest date

Yield performance and field duration of the tested and farmers' varieties at both the study locations are shown in Fig. 4 and Tables 1-4. All the tested rice varieties performed well in the coastal region. In the Dacope area, during 2016, BRRI dhan73 produced the highest grain yield (4.53 t ha^{-1}) followed by BRRI dhan66, BRRI dhan53 and BR23 (Fig. 4 and Table 1) and most of the farmers of that locality showed their interest to cultivate BRRI dhan73 and BRRI dhan66 in next T. *aman* season. In the Amtali area, BRRI dhan53 produced the highest grain yield (4.57 t ha^{-1}) followed by BR23 and BRRI dhan66 (Fig. 4 and Table 3) and most of the farmers indicated their interest in growing BRRI dhan53 and BRRI dhan66 in the next T. *aman* season. Though the variety BRRI dhan62 was harvested about 30 days earlier than the other varieties and it created the opportunities for timely establishment of *rabi* crop, its yield was very low (3.82 t ha^{-1}). In Dacope area, among the tested rice varieties BRRI dhan54 and BRRI dhan73 had the similar height of BR23, which was also an important character in terms of the prevailing water management system within the polder area and tillering capacity of BRRI dhan73 was higher compared to others, which was also a strong influencing factor for higher grain yield (Table 1). In FP, most of the farmers cultivated HYV with some local popular varieties in Dacope area and achieved a comparatively

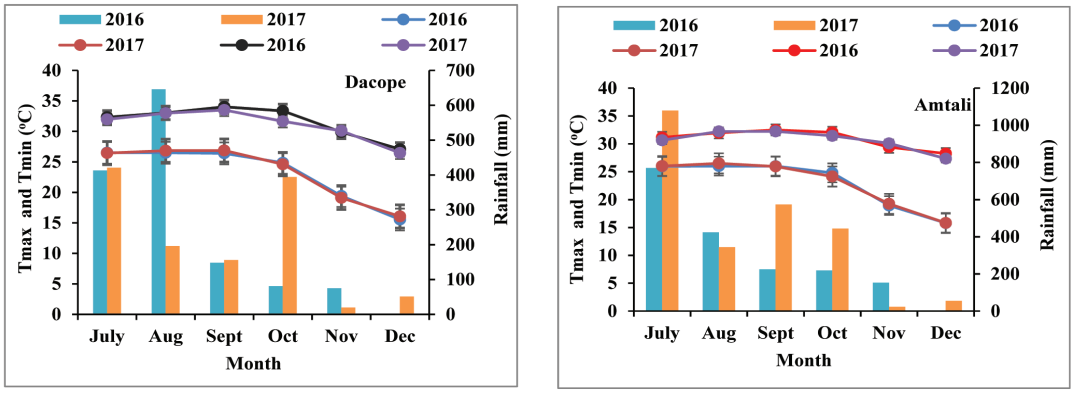

Fig. 2. *Temperature (lines) and rainfall (columns) data of the study locations during the T. aman season of 2016 and 2017. Error bars indicate the standard errors*

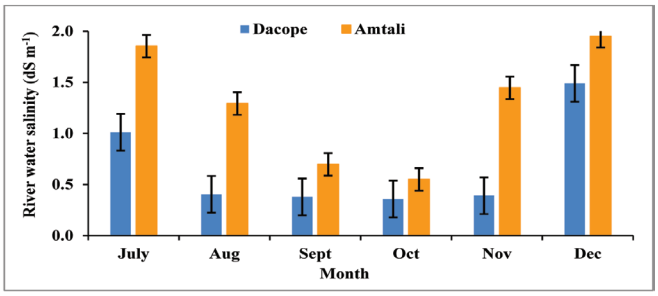

Fig. 3. River water salinity at the study locations during T. aman season. Error bars indicate the standard errors

lower yield compared to the tested varieties (Fig. 4 and Table 2). In the Amtali area, among the tested rice varieties BRRI dhan53 and BRRI dhan66 produced the tallest plants with higher yield compared to the others (Fig. 4 and Table 3). BRRI dhan53 had the highest effective tillers, followed by BR23 and BRRI dhan54 (data not shown), which were the main driving factor for higher grain yield. In FP, most of the farmers cultivated local varieties and achieved comparatively lower yield compared to the tested rice varieties (Fig. 4 and Table 4).

During 2017, we introduced BRRI dhan76 and BRRI dhan77, with similar characters to their local varieties with tall seedling height and bold grain. In both locations, BRRI dhan77 produced the highest yield compared to other varieties (Fig. 4 and Tables 1 and 3). Farmers of both study areas are habituated to use comparatively more seed and imbalanced fertilizer (more N fertilizer with less amount of other fertilizers) in T. *aman* rice cultivation. In both the locations, farmers applied higher amount of urea, because most of the time they lost the effectiveness of urea fertilizer due to flushing out by tidal water. In the Dacope area, farmers used comparatively higher amounts of P and K fertilizers compared to Amtali farmers (data not shown). In the Amtali area, most of the farmers were not using P and K, because of their ignorance. Ritu *et al*. (2016) showed that modern varieties of BRRI dhan46 and BRRI dhan49 yielded 4.2-4.8 t ha^{-1} during T. *aman*

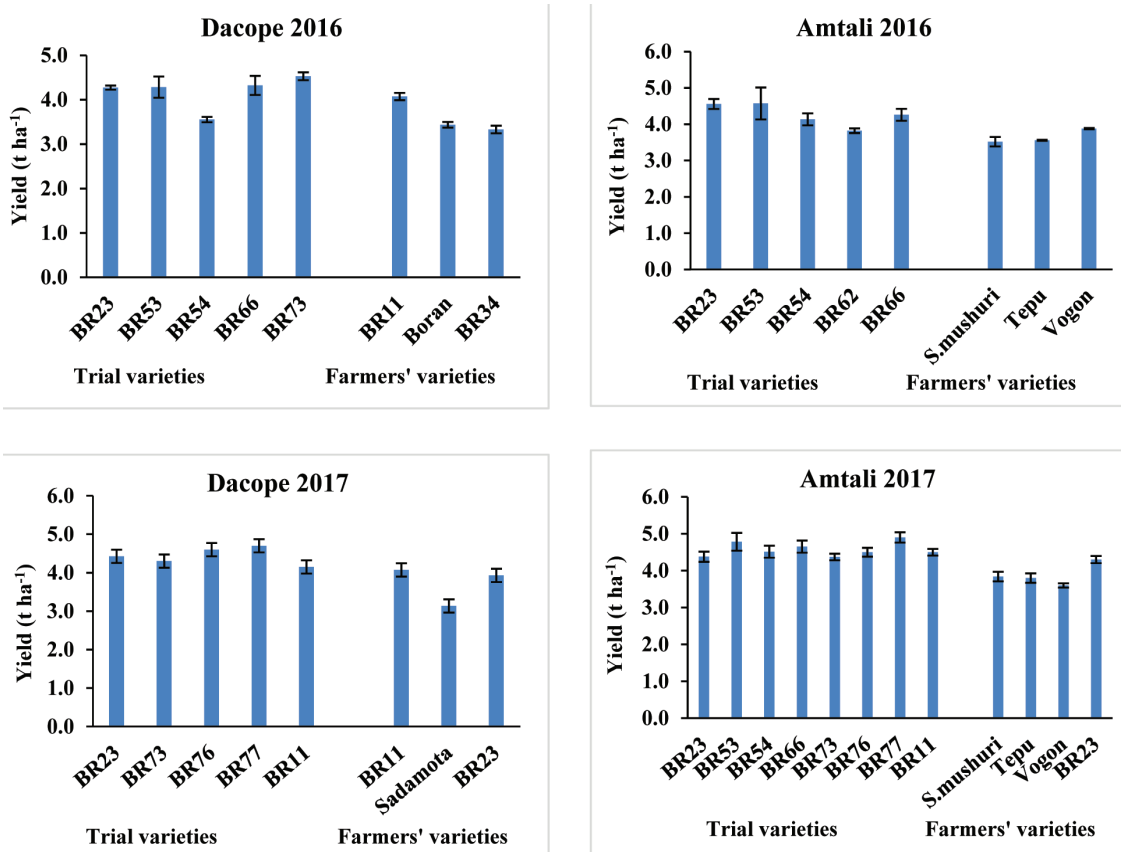

Fig. 4. Performance of T. aman varieties in the study locations during 2016 and 2017. Error bars indicate the standard errors

Table 1. *Field duration and yield of tested varieties, Dacope, Khulna, T. aman, 2016 and 2017*

Variety	Year 2016			Year 2017		
	Transplanting date	Harvesting date	Yield (t ha^{-1})	Transplanting date	Harvesting date	Yield (t ha^{-1})
BR 23	14-23 Aug	10-12 Dec	4.2a	10-23 Aug	12-26 Dec	4.4ab
BRRI dhan53	12-14 Aug	10-17 Nov	4.2a			
BRRI dhan54	8-14 Aug	8-17 Nov	3.5b			
BRRI dhan66	5-13 Aug	9-17 Nov	4.3a			
BRRI dhan73	11-Aug	7 - 9 Nov	4.5a	12-25 Aug	23-24 Dec	4.3ab
BRRI dhan76				10 Aug	2-6 Dec	4.6ab
BRRI dhan77				1 Sep	5 Dec	4.7a
BR11				10-18 Aug	24 Nov	4.15b
CV (%)			8.89			6.6
LSD (P=0.05)			0.57			0.55

Table 2. *Field duration and yield of tested varieties, Dacope, Khulna, T. aman, 2016 and 2017*

Variety	Year 2016			Year 2017		
	Transplanting date	Harvesting date	Yield (t ha^{-1})	Transplanting date	Harvesting date	Yield (t ha^{-1})
BR 23	14-Aug	15-Dec	3.85a	10-25 August	12-25 Dec	3.9a
BRII	05-13 Aug	7-15 Nov	4.07a	10-18 August	18 Nov	4.1a
Boran	12-23 Aug	20-30 Dec	4.03a			
BRRI dhan34	11-12 Aug	30Nov	3.78a			
Sadamota				15-25 August	25-31 Dec	3.1b
CV (%)			6.75			3.3
LSD (P=0.05)			0.44			0.3

Table 3. *Field duration and yield of tested varieties, Amtali, Barguna, T. aman, 2016 and 2017*

Variety	Year 2016			Year 2017		
	Transplanting date	Harvesting date	Yield (t ha^{-1})	Transplanting date	Harvesting date	Yield (t ha^{-1})
BR 23	10-21 Aug	10-22 Dec	4.56a	26-29 August	22 Dec	4.37c
BRRI dhan53	15-27 Aug	10-20 Nov	4.57a	21-27 August	15-25 Nov	4.78ab
BRRI dhan54	10-25 Aug	10-17 Nov	4.13ab	21-26 August	19-21 Nov	4.51bc
BRRI dhan62	10-25 Aug	20-30 Sept	3.82b			
BRRI dhan66	15-27 Aug	10-22 Nov	4.21ab	21-26 August	7-17 Nov	4.65abc
BRRI dhan77				21-26 August	14-18 Dec	4.9a
BRRI dhan76				21-28 August	23-25 Dec	4.5bc
BRRI dhan73				21-29 August	12-20 Nov	4.37c
BR 11				21-26 August	18-21 Nov	4.5bc
CV (%)			10.48			4.6
LSD (P=0.05)			0.68			0.38

Table 4. *Field duration and yield of farmers' varieties, Amtali, Barguna, T. aman, 2016 and 2017*

Variety	Year 2016			Year 2017		
	Transplanting date	Harvesting date	Yield (t ha^{-1})	Transplanting date	Harvesting date	Yield (t ha^{-1})
Swarnamushare	15-30 Aug	10-25 Nov	3.60ab	25-30 Aug	28-30 Nov	4.4ab
Tapu	15-30 Aug	15-30 Nov	3.56b	25-28 Aug	28-30 Nov	3.8b
Vogon	15-30 Aug	15-23 Nov	3.88a	25-30 Aug	27-30 Nov	3.64b
BR23				25 Aug	10 Dec	4.3a
CV (%)			4.68			4.7
LSD (P=0.05)			0.29			0.36

season based on different planting dates. Mondal *et al*. (2015) also showed that yield varied from 4.5-5.5 t ha^{-1} in costal zones of the Barguna area.

Preference study for suitable variety selection

Table 5 presents preference score of the WS rice varieties in Dacope during 2016. Three top-voted varieties were selected as the most preferred WS rice varieties for Dacope. BR11 was the top ranked variety among farmers. Despite some sterility problems and longer growth duration compared to the newly-released BRRI varieties, farmers chose BR11 because of better tillering capacity, moderate panicle length with more grain, consequent good yield, bold grain and good taste, moderate plant height with a strong stem having less/no lodging at maturity stage, reduced fertilizer requirement, less disease and pest infestation, and shorter growth duration compared to BR23 and Boran. BR11 was suitable to cultivate in high to medium-high land and matured for harvesting after drainage out the stagnant water from the fields.

The preference scores indicated that BRRI dhan73 was chosen as the second most preferred WS rice variety in Dacope, but the most preferred one among newly released rice varieties tested. Farmers voted for the variety because of reduced/no lodging (strong stem) despite torrential rain and stormy winds at ripening stage, greater tillering capacity, expectation of higher yield due to long panicles with more grains and less number of unfilled grains, reduced/medium fertilizer response, more tolerant to major diseases and insect pest, medium growth duration which may better facilitate establishment of dry season (DS) crops on time, and an expectation that it would be matured after draining out the stagnant water from the fields. The farmers predicted that the medium bold grain might taste good to eat, with a medium plant height that may survive in moderate flood and produce more straw for livestock feed.

Swarnogota was chosen as the most preferred WS rice variety by the farmers (Table 6) at Amtali during 2016. The key drivers for choosing Swarnogota included a good number of tillers per hill and grains per

Table 5. *Preference score for T. aman rice varieties in Dacope, 2016*

Varieties	Preference score			
	Male	Female	Scientist	Total
BR10	0.013	-0.083	-0.107	-0.041
BR11	0.150	0.233	0.000	0.151
BR23	-0.013	-0.067	-0.071	-0.041
BRRI dhan53	-0.088	-0.050	-0.036	-0.064
BRRI dhan54	-0.125	-0.100	-0.107	-0.110
BRRI dhan62	-0.125	-0.150	-0.143	-0.134
BRRI dhan66	0.100	0.083	0.250	0.116
BRRI dhan73	0.113	0.100	0.286	0.134
Baral	-0.025	0.033	-0.071	-0.012

Table 6. *Preference score for wet season rice varieties in Amtali, 2016*

Varieties	Preference score				
	Male	Female	Farmers	Scientist	Total
BR11	-0.011	-0.045	-0.022	0.000	-0.018
BR23	0.033	-0.023	0.015	-0.071	0.000
BRRI dhan39	-0.011	-0.045	-0.022	0.071	-0.006
BRRI dhan53	0.087	0.045	0.074	0.214	0.098
BRRI dhan54	-0.054	-0.023	-0.044	0.000	-0.037
BRRI dhan62	-0.152	-0.068	-0.125	-0.286	-0.152
BRRI dhan66	0.054	0.068	0.059	0.179	0.079
Swarnogota	0.098	0.182	0.125	0.000	0.104
Vajon	-0.043	-0.091	-0.059	-0.107	-0.067

panicle, medium long panicles, bold grains, good eating quality, higher price (21% higher than locally-available varieties), less sensitivity to abiotic and biotic stresses, suitable for cultivation in medium low to medium-low land, with long duration so that it matured after the drainage of stagnant water with production of more straw which is used as the main feed for livestock.

BRRI dhan53 was ranked second among all varieties, but ranked first among introduced varieties. Farmers voted for BRRI dhan53 due to its homogeneous plant growth, medium plant height, strong stem, reduced/no lodging, medium growth duration which was expected to facilitate establishment of DS crop on time, medium grain size, expectation of good eating quality, with higher number of tillers per hill and long panicles with more grains per panicle and less or no unfilled grains.

Table 7 presents preference score of WS rice varieties in Dacope during 2017. BRRI dhan76 was the most preferred variety of farmers in Dacope, followed by check variety BR23. BRRI dhan73 was the most preferred variety in 2016 but the variety was least preferred among the potential one in 2017. Main reasons why farmers voted for BRRI dhan76 were taller seedling height, long panicle with large number of glossy colour medium bold grains (250-350), higher yield (5.3 t ha^{-1}) than local check BR23 (4.3 t ha^{-1}) and Shadamota (3.2 t ha^{-1}). Besides, the variety matured for harvesting when stagnant water was drained from the fields, with reduced or no lodging susceptibility and reduced susceptibility to pests. There were no bacterial leaf blight (BLB) infestation despite rainfall during their productive phase, and no infestation of other insects and diseases despite no pesticide being applied. Rat's inability to cut the panicle due to taller plant heights was also an important criterion of preference for BRRI dhan76. Farmers reported drawbacks regarding BRRI dhan76, which included reduced tillering capacity, apprehension about potential for lodging as the plants are very tall, and a longer growth duration which might be a barrier to timely rabi crop planting, as well as shattering of the over matured rice.

BRRI dhan54 was the most preferred variety at Amtali followed by BRRI dhan77 in 2017. Similarly, BBRI dhan73 ranked as least preferred variety in Amtali (Table 8). Farmers voted for BRRI dhan54 because of higher yield than the local check varieties. Besides, the variety matured for harvesting about 25-40 days earlier than the check varieties but required drainage of the stagnant water from the fields. In addition, the variety is ready for harvesting during a food- and feed-scarce period so that price of both grain and straw is higher even at harvesting season. Besides, the farmers were attracted to the adequate turnaround time for planting dry season crops within their optimum planting periods, reduced pest infestation, good eating quality, more tillers per hill and long panicles with cylindrical bold grain.

Scope of crop production option

Most of the farmers chose modern varieties which gave higher yield and 15 to 25 days early maturity, compared with their existing varieties in both the study locations. The earliness created an opportunity for the timely establishment of *rabi* crops as well as *boro* rice, in situations where the water resources are available. In both the study locations, farmers cultivated non-rice crops like sweet gourd, maize, and sunflower after early harvest of WS rice and their performance was good. By this approach, farmers were able to increase their land productivity as well as their cropping intensity.

Farmers in the study locations historically cultivate low-yielding local rice varieties during the T. *aman* season because of environmental constraints. Some recent modern rice varieties were tested to facilitate timely sowing of *rabi/boro* crops and for improving land and water productivity in the coastal region. In Dacope, though the farmers used modern varieties in both trial and non-trial plots, the trial farmers achieved comparatively higher grain yield due to balanced fertilizer use and were interested to grow BRRI dhan73 and BRRI dhan66 in coming years. In the Amtali area, most of the farmers cultivate local varieties and some farmers showed an interest in growing BRRI dhan53 in the next T. *aman* season. Most of the farmers in both locations have a tendency to use more seed and a larger amount of urea than is necessary, with fewer amounts of other fertilizers.

In 2016, the check variety BR11 and Sowarnagota were the most preferred WS rice varieties, respectively in Dacope and Amtali, which basically illustrates the typical risk-avoiding tendency of small farmers in the coastal areas. In addition to grain and straw yields, grain quality, stem strength, and other phenotypic features

Table 7. *Preference score for T. aman rice varieties in Pankhali, Dacope, 2017*

Varieties	Preference score					Rank
	Male	Female	Farmers	Scientist	Total	
BRRI dhan76	0.225	0.167	0.308	0.300	0.215	1
BR23	0.083	0.067	0.117	0.100	0.080	2
BR11	-0.150	-0.133	-0.217	-0.150	-0.145	3
Baran	-0.117	-0.067	-0.150	-0.150	-0.105	4
BRRI dhan73	-0.042	-0.033	-0.058	-0.100	-0.045	5

Table 8. *Preference score for T. aman rice varieties in Kallyanpur, Amtali, 2017*

Varieties	Preference score					Rank
	Male	Female	Farmers	Scientist	Total	
BRRI dhan54	0.138	0.109	0.13	0.143	0.131	1
BRRI dhan77	0.113	0.094	0.10	0.214	0.125	2
Sornogota	0.050	0.031	0.04	0.000	0.036	3
BR23	0.013	0.000	0.01	-0.107	-0.012	4
BR11	-0.038	0.000	-0.02	-0.179	-0.048	5
BRRI dhan76	-0.075	-0.094	-0.08	0.071	-0.060	6
Vojon	-0.075	-0.031	-0.06	-0.143	-0.071	7
BRRI dhan73	-0.125	-0.109	-0.12	0.000	-0.101	8

(such as growth duration), the farmers were substantially influenced by BRRI dhan73 and BRRI dhan66 in Dacope, and BRRI dhan53 and BRRI dhan66 in Amtali, because those varieties mature when no stagnant water is found in the fields and they allowed most farmers to establish dry season crops within the optimum seeding windows. Farmers rejected BRRI dhan62 and BRRI dhan54 in part because of high susceptibility of those varieties to lodging and rat-attack, as well as in part because of early maturity when paddy fields are still under stagnant water.

In 2017, BRRI dhan76 was the most preferred variety of farmers in Dacope because of the potential for transplanting the variety in fields with over 30 cm depth of water, the higher growth rate of the plants, a longer growth duration so that it matured for harvesting after drainage of stagnant water from the fields, with reduced or no infestation of disease and long panicles with a large number of grains. On the other hand, BRRI dhan54 was the most preferred variety at Amtali due to higher yield than local check varieties. Besides, this variety matured for harvesting about 25-40 days earlier than check varieties in a food-scarce period and after the drainage of stagnant water from the fields. BRRI dhan77 was the second most preferred variety in Amtali, mainly because of its suitability for planting in fields with stagnant water, maturation for harvesting after drainage and also long panicles that promised higher yield. BBRI dhan73 was least preferred variety both in Dacope and Amtali, while BRRI dhan76 was second least preferred variety in Amtali.

The findings of this preference analysis indicate that environmental compatibility of a variety, especially at maturity stage, is the most crucial consideration of farmers when selecting a new variety for adoption along with high yield potential, taller plants, strong stem, tillers per hills, panicle length and grain size. It was also the case that farmers were not fully aware about the benefits of adopting potential DS crops and/or optimum planting of the crops at the cost of forgoing some yields of WS rice because of adopting short duration WS rice.

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