Original Research Article

Adaptive trail and Morphological Analysis of two prominent T. Aman rice (*Oryza sativa* L.) Lines under different locations of Bangladesh

ABSTRACT

Two advanced lines: BR8693-8-4-2-1 and BR8693-17-6-2-2, along with BRRI dhan49 (S. Ck) and BRRI dhan33 (R. Ck) as checks were tested at farmers' field in eight locations such ~~-~~as West Byde (BRRI Gazipur), Khulna (Dumuria), Habiganj (Sadar), Chapainawabganj (Gomostapur), Rangpur (Sadar), Feni (Dagonbhuyan), Chattagram (Hathazari) and Barishal ~~-~~(Sadar) during the season T. Aman 2018. The trial~~s~~ ~~were~~ was replicated three times in each location. The unit plot size was 17.94 m^2 (4.6m x 3.9m). Seeding emergence for eight locations varied from 11-17 July 2018. Seedling age varied from 25-30 days among the locations. Seedlings were transplanted at 20 cm x 15 cm spacing. NPKS and Zn fertilizers were applied @90, 15, 50, 12 and 3.6 kg ha^{-1}, respectively. All fertilizers except urea were applied as basal whereas, urea was applied in 3 equal splits at 10, 25 and 40 DAT. Other standard management practices were followed as and when necessary. No insecticide was used because the two advanced lines were insect resistant and diseases were not controlled (to identify susceptibility and tolerance level of lines). Date of seeding, transplanting, flowering and maturity, lodging tolerance, pest and disease incidence, phenotypic acceptance at vegetative and ripening stage, yield and yield components were recorded. The main purpose of the experiment is to recommended insect resistant rice genotype for proposed variety trail. For yield estimation, 9 m^2 sample area from each plot was harvested at maturity and grain yields were adjusted to 14% moisture content.

Keywords: Genotype, insect resistant, disease resistant, growth, yield

INTRODUCTION

The rice (*Oryza sativa* L.) plant belongs to the tribe of Oryzeae under the sub-family of Pooideae in the grass family Gramineae (Poaceae). Recently the genus Oryza divided into several sections and placed Oryza sativa under the series of Sativa in section Sativae. Rice is ~~in~~ indigenous to Asia. For rice plant, root is a fasciculate system and seems at the herbaceous plant, chill and water deficiencies sensitive [8, 7]. [11, 22] reported that the role of the root is extracted and absorption of dissolved minerals and water from the flooded regions.

Rice (*Oryza sativa* L.), one of the major food crops, which is capable of feeding over half of the global population [20]. The people of Asia are dominating regarding rice production as well as its consumption, almost 90% of the global rice production are contributed by them [2]. Rice is the staple food crop in Bangladesh and

Comment [k1]: Please write in international form.

Comment [k2]: What do you mean by that?

Comment [k3]: Explain it for the first time

Comment [k4]: You have to explain the result and conclusion of the study in Abstract. Please summarize the methods as two or three sentences.

Comment [k5]: ?????

Formatted: Font: Italic

occupies about 80% of the country's total cropped area [6]. The total area of the country is 14.86 million ha (147,570 sq. km) [19] and the cultivable area is 8.57 million ha [13]. Rice is cultivating nearly in 11.42 m ha of which Aus, Aman and Boro rice are covered 9.3, 48.9 and 41.8%, respectively [15, 3]. Rice is extensively grown in Bangladesh in the three seasons namely, Aus, Aman (broadcasted and transplanted) and Boro [1]. Among these cropping seasons transplanted Aman is the most important and occupied about 46% of the rice cultivation land in 2019-2020. Area covered by Aman rice is almost 55.3 lac hectares and production is about 131.9 lac metric ton [4]. To increase the cultivation area as well as production, research should be emphasized regarding morph-physiological and genetic characteristics of Aman rice in which a little information ~~have~~has been reported earlier [12, 19]. One of the main constraints to increasing rice production in Bangladesh is the infestation of insects. According to an estimate, annual yield loss due to insect pest alone is 16 percent for rice. Global crop losses in rice due to weeds, animal pests, and diseases at 10.2%, 15.1%, and 12.2% of the attainable yield, respectively [18]. In Bangladesh, chemical control has been the primary method of insect control. Bangladesh needs to increase its rice production on a sustainable basis. Insects continue to cause serious damages to rice crop and the use of toxic pesticides is the main method of pest control and that such continued heavy reliance on chemicals would lead to serious environmental and human health problems, pest resurgence, new pest problems and development of resistance.

Insect pest attacks frequently occur with varying intensities and frequencies possibly induced by the changes in climate and cropping systems in modern rice cultivation. Intensive rice production with the primary goal of achieving high yield is often characterized by the excessive application of fertilizers and pesticides. It has led to many negative environmental effects, such as the reduction of biodiversity and natural biological control, high pesticide residues in rivers, drinking water and agricultural products, rapid and high insecticide resistance in pests, secondary pest outbreaks, environmental pollution and ecological imbalance. These severe negative effects will damage the ecosystem, lead to frequent pest outbreaks and in turn require an increased pesticide dosage, which form a vicious circle [9]. Pesticides used in the paddy fields globally account for nearly 15% of the total pesticides used for crop production.

The breeding of insect resistant cultivar is an effective and economical way to address this problem and some of these cultivars have been released as a variety. However, the conventional breeding progress towards insect resistant rice cultivars has been relatively slow [10, 21 & 5], whereas we need to adopt modern induced breeding which is an effective way to enhance the genetic variability [17, 16]. On the other hand, we have many rice varieties but still we need more suitable rice varieties to address different situation, which can fulfill farmers' demands like higher yield, shorter growth duration with attractive grain quality and also insect and disease resistant rice varieties. We need new insect resistant rice varieties for transplanted Aman, which can replace old varieties to overcome harmful effect of insecticides and can help achieve the target of sustainable and environmentally friendly agricultural production. Bangladesh has achieved self-sufficiency in food, especially in rice [13]. According to the Sustainable Development Goals (SDG) set in 2015 the target is to end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round by 2030 [20].

In the present study, we selected two advanced lines BR8693-8-4-2-1 and BR8693-17-6-2-2 to identify their insect resistant response. Morphological traits, agronomical traits and physical traits were used to evaluate the resistant tolerance advanced lines.

MATERIALS AND METHOD

Comment [k6]: Rewrite in Normal form.

Comment [k7]: ?

Comment [k8]: ?

Comment [k9]: Please write present or % in the same way, in all parts of manuscript.

Comment [k10]: Sentences should be written in the passive form.

Comment [k11]: Passive form

Comment [k12]: Passive form

Two advanced lines: BR8693-8-4-2-1 and BR8693-17-6-2-2, along with BRRI dhan49 (S. Ck) and BRRI dhan33 (R. Ck) as checks were tested at farmers' field in eight locations such as West byde (BRRI Gazipur), Khulna (Dumuria), Habiganj (Sadar), Chapainawabganj (Gomostapur), Rangpur (Sadar), Feni (Dagonbhuyan), Chattagram (Hathazari) and Barishal (Sadar) during the season T. Aman 2018. The trials were replicated thrice in each location. The unit plot size was 17.94 m^2 (4.6m x 3.9m). Seeding emergence time for eight locations varied from 11-17 July 2018. About 20-25 days old seedlings were uprooted from the different locations. Seedlings were then transplanted with 20 x 15 cm spacing. N, P, K, S and Zn fertilizers were applied @ 90, 15, 50, 12 and 3.6 kg ha^{-1}, respectively. All fertilizers except urea were applied during land preparation as basal whereas, urea was applied in 3 equal splits at 10, 25 and 40 DAT. Other standard management practices were followed as and when necessary. No insecticide was used because the two advanced lines were insect resistant and diseases were not controlled (to identify susceptibility and tolerance level of lines). Date of seeding emergence, seedling transplanting, flowering and maturity, lodging tolerance, pest and disease incidence, phenotypic acceptance at vegetative and ripening stage, yield and yield components were recorded. Feedback from farmers and DAE personnel were also recorded. For yield estimation, 9 m^2 sample area from each plot was harvested at maturity and grain yields were adjusted to 14% moisture content.

Comment [k13]: ???

Comment [k14]: ????

RESULTS AND DISCUSSION

Comment [k15]: Where is the discussion?!

The trial site of Barishal (Sadar) was damaged due to ~~4 time~~4-time tidal submergence. On an average, in rest of the seven locations, the tested two entries BR8693-8-4-2-1 and BR8693-17-6-2-2 gave higher yield (4.84 ~~&~~ and 4.89 t ha^{-1}) than the check varieties BRRI dhan49 (S. Ck.) (4.48 t ha^{-1}) and BRRI dhan33 (R. Ck.) (4.06 t ha^{-1}) (Table 1). Among the two advanced entries, BR8693-17-6-2-2 (entry no.2) gave mean 4.89 t ha^{-1}grain yield, ranged from 4.46 to 5.17 t ha^{-1} which was a bit higher than the another advanced line BR8693-8-4-2-1 (entry no.1) which gave mean 4.84 t/ha ranged from 4.42 to 5.20 t ha^{-1}. But, the grain yield of the two advanced lines was statistically similar. The mean growth duration of the advanced line BR8693-8-4-2-1 (entry no.1) was 133 ranged from 131 to 136 days. Whereas, the mean growth duration of another advanced line BR8693-17-6-2-2 (entry no.2) was 135 days ranged from 134-138. Check variety BRRI dhan33 (R. Ck.) was found to be matured within the earliest mean growth duration (120 days), followed by in another check variety BRRI dhan49 (132 days). The highest yielder (entry no. 2) matured within 135 days which was longest among the advanced lines including check varieties. Among the tested advanced lines and check varieties the highest mean plant height (125 cm) was found in entry no. 2 ranged from 120 cm to 132 cm followed by 121 cm in entry no. 1 ranged from 114 cm to 128 cm. However, mean plant height was much lower in both the check varieties (101 cm in BRRI dhan49 and 104 cm in BRRI dhan3e 1). The mean plant height of the check varieties ranged from 98 to 109 cm. Mean 1000-grain weight was found lowest (20.90 g) in the check variety BRRI dhan49, ranged from 20.11 to 21.91 g and it was 23.76g for the another check variety BRRI dhan33 (22.96 to 24.89 g). Whereas, the highest mean 1000-grain weight (26.03 g) was found in the BR8693-17-6-2-2 (entry no.2) varied from 24.89 to 27.27 g. Mean 1000-grain weight of BR8693-8-4-2-1 (entry no.1) was 23.12 g (ranged from 23.06 to 25.80 g) which was a bit lower than the entry no. 2 (Table 2). Highest panicles m^{-2} (231) was observed in BR8693-8-4-2-1 (entry no. 1) followed by BRRI dhan49 (226), BR8693-17-6-2-2 (215) and the lowest panicles m^{-2} was found in the R. Ck., BRRI dhan33. Panicles m^{-} varied from 205-282 for the advanced line BR8693-8-4-2-1 (entry no. 1) and it varied from 182 to 268 for the advanced line BR8693-17-6-2-2 (entry no. 2) (Table 2). Filled grains/panicle of the tested advanced lines and check varieties varied from 99-107 and it was the highest (107)

Comment [k16]: Please write all units in one type.
t ha^{-1} or t/ha

in the check variety BRRI dhan49 (Table 2). Highest yield (entry no. 2) produced a bit lower filled grains panicle^{-1} (101) than the check variety BRRI dhan49 but higher than BRRI dhan33. Sterility (%) of the entries including checks ranged from 19-23 (Table 2).

Table 1. Grain yield (t/ha), Growth duration (days) and plant height of some advanced Lines .

Genotypes / Locations	Gazip WB	Khulna	Habiganj	Chapainawa	Rangpur	Feni	Chattogra	Mean
	Yield (t ha^{-1})							
BR8693-8-4-2-1	5.20	4.70	5.13	4.42	5.02	4.90	4.52	4.84
BR8693-17-6-2-2	4.63	4.46	5.17	5.04	4.83	5.01	5.11	4.89
BRRIdhan49(S.Ck)	5.04	4.75	5.04	4.37	4.82	3.64	3.69	4.48
BRRIdhan33(R.Ck)	4.45	4.37	4.06	4.12	4.19	3.72	3.51	4.06
LSD (0.05)	**0.56**							**0.21**
CV%	**7.37**							
Growth duration (days)								
BR8693-8-4-2-1	136	135	131	132	133	134	133	133
BR8693-17-6-2-2	138	134	134	134	135	134	135	135
BRRIdhan49(S.Ck)	133	132	134	133	129	133	133	132
BRRIdhan33(R.Ck)	117	117	120	120	122	120	121	120
LSD (0.05)	**0.78**							**0.29**
CV%	**0.37**							
Plant height (cm)								
BR8693-8-4-2-1	124	120	128	120	119	114	119	121
BR8693-17-6-2-2	126	123	132	128	122	123	120	125
BRRI dhan49 (S.Ck)	107	105	101	98	99	101	99	101
BRRI dhan33 (R.Ck)	109	107	102	104	101	105	100	104
LSD (0.05)	**2.52**							**0.95**
CV%	**1.30**							

Table 2. Yield components of some advanced lines.

Genotypes / Locations	Gazip WB	Khulna	Habiganj	Chapainawa	Rangpur	Feni	Chattogra	Mean
	1000-grain weight (gm)							
BR8693-8-4-2-1	23.06	23.73	25.03	24.57	25.20	25.07	25.80	23.12
BR8693-17-6-2-2	25.28	24.89	25.51	27.27	27.09	26.35	25.83	26.03
BRRI dhan49 (S.Ck)	20.79	20.11	21.91	21.30	21.69	20.27	20.25	20.90
BRRI dhan33 (R.Ck)	23.98	23.43	23.74	23.22	22.96	24.13	24.89	23.76

LSD (0.05)	**0.85**							**0.32**
CV%	**2.24**							
Panicles/m²								
BR8693-8-4-2-1	248	243	282	209	226	206	205	231
BR8693-17-6-2-2	234	235	268	193	182	198	193	215
BRRI dhan49 (S.Ck)	270	261	245	230	197	191	186	226
BRRI dhan33 (R.Ck)	237	242	245	215	202	131	129	200
LSD (0.05)	**20.74**							**7.83**
CV%	**5.58**							
Filled grain per panicle								
BR8693-8-4-2-1	107	101	95	107	113	110	111	106
BR8693-17-6-2-2	94	92	98	107	104	106	108	101
BRRI dhan49 (S.Ck)	113	105	106	101	126	97	102	107
BRRI dhan33 (R.Ck)	94	92	87	93	104	114	107	99
LSD (0.05)	**8.68**							**3.28**
CV%	**5.20**							
Sterility (%)								
BR8693-8-4-2-1	18	20	22	23	17	17	17	19
BR8693-17-6-2-2	21	25	27	26	28	17	13	23
BRRI dhan49 (S.Ck)	15	17	26	31	24	15	13	20
BRRI dhan33 (R.Ck)	18	21	30	29	26	12	14	22
LSD (0.05)	**5.93**							**2.24**
CV%	**17.61**							

INSECT INFESTATION

Different insects' infestation was found in the different experimental sites. Stem borer (05-15%), Rice bug (05-10%) and Leaf folder (05-15%) were found in some trial locations. However, No insecticide was used because the two advanced lines were insect resistant rice.

Table 3. Insect infestation of some advance rice lines

Genotypes	**Disease infection (%)***				
	Rice bug	**Stem borer**	**Leaf folder**	**Brown Plant Hopper**	**Green Leaf Hopper**
V_1 = BR8693-8-4-2-1	5-8 in 5 loc.	4-10 in 2 loc.	5-12 in 3 loc.	3-4 in 2 loc.	2-4 in 2 loc.
V_2 = BR8693-17-6-2-2	5-10 in 4 loc.	5-12 in 2 loc.	5-15 in 2 loc.	3-5 in 2 loc.	3-4 in 2 loc.
V_3 = BRRI dhan49 (S.Ck.)	4-9 in 5 loc.	5-15 in 1 loc.	4-14 in 2 loc.	4-7 in 3 loc.	2-5 in 3 loc.

V_4 = BRRI dhan33 (R. Ck.)	8-10 in 3 loc.	10 in 1 loc.	4-12 in 2 loc.	5-7 in 2 loc.	3-5 in 2 loc.

DISEASE INFECTION

Different diseases infection was found in the different experimental sites. From Table 4, V_1 = BR8693-8-4-2-1 and V_2 = BR8693-17-6-2-2 both the lines are comparatively less infected by sheath blight, Bacterial leaf blight, leaf blast, false smut, Bacterial leaf streak, Tungro and Grain spot as per checked varieties of V_3 = BRRI dhan49 (S.Ck.) and V_4 = BRRI dhan33 (R. Ck.).

Table 4. Disease infestation of some advance lines

Genotypes	Disease infection (%)*						
	Sheath blight	**Bacterial leaf blight**	**Leaf Blast**	**False smut**	**Bacterial leaf streak**	**Tungro**	**Grain spot**
V_1 = BR8693-8-4-2-1	1-4 in 5 loc.	3-4 in 2 loc.	4-6 in 3 loc.	1in 2 loc.	0	10-15 in 1 loc.	0
V_2 = BR8693-17-6-2-2	1-3 in 4 loc.	2-3 in 2 loc.	3-6 in 2 loc.	1 in 2 loc.	0	10-15 in 1 loc.	1-5 in 2 loc.
V_3 = BRRI dhan49 (S.Ck.)	1-5 in 5 loc.	1-4 in 1 loc.	4-7 in 2 loc.	2-12, in 3 loc.	0	10-15 in 1 loc.	1-2 in 1 loc.
V_4 = BRRI dhan33 (R. Ck.)	3 in 3 loc.	3 in 1 loc.	3-7 in 2 loc.	1-2 in 2 loc.	0	10-15 in 1 loc.	4 in 1 loc.

*****Eye estimation of the number of hills showing the sign and symptom of disease infection. The percentage indicates the disease incidence level of the tested genotypes.

Lodging incidence: The two advanced lines were found lodging tolerant in all locations.

Table 5: PHENOTYPIC ACCEPTANCE

Entry no.	Characteristics						P. acp Score	
	Plant growth	**Uniformity of flowering**	**Uniformity of maturity**	**Wrapping quality of culm**	**Grain type**	**Flag leaf**	**Veg.**	**Mat.**
1	Fair	regular	regular	Well wrapped	Medium bold	Erect	5	5
2	Fair	irregular	irregular	Well wrapped	Medium	Erect	5	7

					bold			
3	Good	regular	regular	Well wrapped	Medium fine	Erect	3	3
4	Good	regular	regular	Well wrapped	Medium bold	Erect	3	5

Phenotypic Acceptability: 1= Excellent, 3= Good, 5= Fair, 7= Poor, 9= Unacceptable

Farmer's opinions:

Comment [k17]: This part has to be as subtitle of result section

Formatted: No bullets or numbering

- Most of the farmers showed their interest about the two advanced lines due to their higher grain yield than the check varieties i.e., BRRIdhan49 and BRRIdhan33. Farmers preferred entry no. 1 due to similar growth duration to BRRIdhan49.
- But most of the farmers dislike bold type grain size of the two advanced lines.

CONCLUSION

In this study, correlative and comprehensive observations of physiological traits were performed including morphological development, agronomic traits. The results showed that both the advanced lines gave statistically higher yield than the check variety BRRIdhan49 and BRRIdhan33. But growth duration of BR8693-8-4-2-1 (entry no. 1) is lower than BR8693-17-6-2-2 (entry no. 2), but similar to BRRIdhan49. Though BR8693-8-4-2-1 (entry no. 1) is statistically significant from BR8693-17-6-2-2 (entry no. 2), BRRIdhan49 and BRRIdhan33 which would be recommended insect resistant rice genotype and considering the above results and following information regarding disease reaction, farmers' opinion, and special character of insect resistant, entry no. 1 (BR8693-8-4-2-1 line) was found to be suitable for Proposed Variety Trial (PVT).

REFERENCES

1. AIS (Agricultural Information Service), Krishi Dairy. Agriculture Information Service, Khamarbari, Farmgate, Dhaka. p. 10-15, 2011.
2. Bandumula N., Rice production in Asia: Key to global food security. The Proceedings of the National Academy of Sciences, India, Section B: Biological Sciences DOI 10.1007/s40011- 017-0867-7, 2017.
3. BBS (Bangladesh Bureau of Statistics), Agriculture statistics of major crops. Statistics and Informatics Division (SID), Bangladesh Bureau of Statistics, Government of the People's Republic of Bangladesh. pp. 21-22, 2018.
4. BBS (Bangladesh Bureau of Statistics), Forty five years Agriculture Statistics of Major Crops (Aus, Amon, Boro, Jute, Potato & Wheat). Bangladesh Bureau of Statistics Division, Government of the People's Republic of Bangladesh. p. 22, 2018.
5. Bernier J, Atlin G N, Serraj R, Kumar A, Spaner D., Breeding upland rice for drought resistance. *Journal of the Science of Food and Agriculture*, **88**, 927–939, 2008.
6. BRRI (Bangladesh Rice Research Institute), Adhunik Dhaner Chash (Cultivation of Modern Rice), Gazipur, Bangladesh. pp. 5-93, 2019.

7. Chun, L., Wang, G., Chen, P., Zhu, H., Wang, S., Ding, Y., Shoot-Root Communication Plays a Key Role in Physiological Alterations of Rice (Oryza sativa) Under Iron Deficiency, Front Plant Sci. 9:757, 2018.
8. Comas, L. H., Becker, S. R., Cruz, V. M. V., Byrne, P. F., Dierig, D. A., Root traits contributing to plant productivity under drought, Front. Plant Sci. 4:442, 2013.
9. Conway G R, Pretty J N., Unwelcome Harvest: Agriculture and Pollution. London: Earthscan Publications Ltd, 1991.
10. Cooper M, Fukai S, Wade L J., How can breeding contribute to more productive and sustainable rainfed lowland rice systems? *Field Crops Research*, **64**, 199–209, 1999.
11. Fageria, N. K, Moreira, A., The Role of Mineral Nutrition on Root Growth of Crop Plants. Advances in agronomy, 110(1):251- 331, 2011.
12. Hossain MS, Monshi FI, Kamal AMA, Miah MF, Grain yield and protein content of transplant aman rice as influenced by variety and rate of nitrogen. Journal of Agroforestry and Environment 3(2): 235-238, 2010.
13. Kabir, M S, M U Salam, A Chowdhury, N M F Rahman, K M Iftekharuddaula, M S Rahman, M H Rashid, S S Dipti, A Islam, M A Latif, A K M S Islam, M M Hossain, B Nessa, T H Ansari, M A Ali and J K Biswas. (2015). Rice Vision for Bangladesh: 2050 and Beyond. Bangladesh Rice J. 19(2):1-18.
14. Karmakar, B, and M A R Sarkar., Optimizing seedling age of promising rice genotypes in rainfed environment. J. Crop and Weed. 11(Special Issue):149-160, 2015.
15. Karmakar, B and M A Ali, Production and Preservation of Quality Rice Seed. 1st Edition, Bangladesh Rice Research Institute, Gazipur. pp.136, 2019.
16. Mondal S, Petwal V C, Badigannavar A M, Bhad P G, Verma V P, Goswami S G, Dwivedi J. (2017). Electron beam irradiation revealed genetic differences in radio-sensitivity and generated mutants in groundnut (*Arachis hypogaea* L.). *Applied Radiation and Isotopes*, **122**, 78–83.
17. Mostafa H A, Wang H P, Shen D, Yang Q, Li X., Sprout differentiation and mutation induction of garlic (*Allium sativum* L.) callus exposed to gamma radiation. *Plant Growth Regulation*, **75**, 465–471, 2015.
18. Oerke EC. 2006. Crop losses to pests. J. Agric. Sci. 144:31-43.
19. Shelley, I J, M T Nosaka, M K Nakata, M S Haque and Y Inukai., Rice Cultivation in Bangladesh: Present Scenario, Problems, and Prospects, J. Intl. Cooper. Agric. Dev. 14: 20-29, 2016.
20. USDA, Rice Sector at a Glance. https://www.ers.usda.gov/topics/crops/rice/ rice-s ector-at-a-glance/, 2020.
21. Wade L J, McLaren C G, Quintana L, Harnpichitvitaya D, Rajatasereekul S, Sarawgi A K, Kumar A, Ahmed H U, Singh A K, Rodriguez R., Genotype by environment interactions across diverse rainfed lowland rice environments. *Field Crops Research*, **64**, 35–50, 1999.
22. Yamauchi, T., Colmer, T. D., Pedersen, O., Nakazono, M., Regulation of Root Traits for Internal Aeration and Tolerance to Soil Waterlogging-Flooding Stress, Plant Physiol., 176, 1118– 1130, 2018.