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MULTI-ENVIRONMENT VARIETY TESTING (PRE-MET) FOR IRRIGATED ECOSYSTEM IN RICE (*Oryza sativa L.*)

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ABSTRACT

A set of 100 IRRI bred advanced breeding lines were tested at Gazipur (as moderate productive control site) and at Habiganj (as high productive site) following row-column design with 2 replications. The breeding lines were highly variable in days to maturity and plant height but not in grain yield. However the interaction effects between genotype and environment (GXE) were significant for all three traits. At Gazipur, the breeding lines yielded with range between 3.3 to 7.3 t/ha with a growth duration range of 138-154 days, while at Habiganj they yielded 5.1-7.9 t/ha with growth duration of 139-159 days. The highest yielding genotype was IR99092-B-B-78 followed by IR13A390, IR99061-B-B-7, IR14D111, etc at Gazipur, while IR13A390 followed by IR100008-91-B yielded the highest at Habiganj site. Based on yield and growth duration, 22 breeding lines showing better performance at Gazipur, 9 lines at Habiganj and 2 lines for both locations were selected for further evaluation.

Contribution/ Originality: Rice is the major staple food for more than half of the world's population. The study therefore the breeding lines were highly variable in days to maturity and plant height but not in grain yield. However the interaction effects between genotype and environment (GXE) were significant for all three traits.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the major staple food for more than half of the world's total population (Pandey *et al.*, 2010) most of whom live in under developed countries in Asia, Africa and Latin America. In 2050, the world's human population is expected to get to over 9 billion—an addition of two billion people to present estimates (Godfray *et al.*, 2010). To assist guarantee universal food safety and keep pace with the rising require for rice, there is a require to raise rice production by 26% by 2035 (FAO, 2009; GRiSP, 2013; Sayer and Cassman, 2013;Fischer *et al.*, 2014). However, agriculture has been facing vast challenges with shortage of land, water and labor availability (Rosegrant and Cai, 2002; Bouman *et al.* 2007;Lampayan *et al.*, 2015). In addition, agriculture is allied with a number of ecological threats, including climate change, land and water degradation and biodiversity loss (Lobell *et al.*, 2009; Mueller *et al.*, 2012;Phalan *et al.*, 2014). Biological diversity and environmental guilds tend to be much lesser in

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man-altered systems such as monocultural agricultural systems (Liss *et al*., 1986). More diverse ecosystems tend to be extra stable, flexible, and sustainable. In opinion, the quality of diversity determines the point to which it-in conditions of varied guilds or serviceable groups- donate to the solidity and sustainability of the system (Peterson *et al*., 1998). Irrigated rice fields are managed as fenland ecosystems that offer a rich biodiversity of organisms (Thongphak *et al*., 2012). Rice is a excellent protein source as well as a established food in various parts of the world (Poolprasert and Jongjitivimol, 2014).

Grown on 154 million hectares global in a broad range of environments (Babu *et al*., 2012) it is grown below three ecosystems namely irrigated lowlands, rainfed lowlands, and rainfed uplands. Landraces are extensive and trendy among farmers which play an vital role in local agriculture owing to their heritable diversity (Modi, 2004) that represents feral plant populations as genetic resources (Das and Ashesh, 2014). It is doubtless that soil and climate features (rainfall, temperature and relative humidity) precious the show of the twenty genotypes across two environments. According to Hossain *et al*. (2013) fluctuations in the heat and relative humidity can affect rice yield and their factor in a substantial behavior. Ahmed *et al*. (2008) reported that enormously low and high temperatures can affect rice production at all growth stages. The composition of the arthropod communities is identified to modify with the development of the rice crop (Heong *et al*., 1991). Agriculture, which involves about 25-30% of the world land area, is one of the key tricks that involve natural diversity (Factbox, 2011).

Yield of high yielding modern Boro rice varieties has been reached to upland. Scientists across South and South-east Asia have been working since long to address this issue. However, success has been achieved a little. Advanced technologies particularly, DNA markers linked to different high yield traits are being tried to combine in single background. Recently IRRI has made some progress and developed several advanced breeding lines with high yield potential. To determine the suitability of these lines in Bangladesh, a study was undertaken to evaluate a set of IRRI bred advanced breeding lines in high productive Boro area of Bangladesh. Considering all these aspects the research has been conducted for achieving the following objectives: To isolate breeding lines with high yield potential and acceptable grain quality

2. MATERIALS AND METHODS

A total of 100 IR lines (Table 1) were evaluated along with standard check varieties, BRRI dhan28 and BRRI dhan29 at BRRI Gazipur and BRRI Habiganj. BRRI Habiganj was considered as high productive site and BRRI Gazipur was used as moderate productive control site. The trial was conducted in Row-Column Design with 2 replicates. Thirty five-day-old seedlings were transplanted at 20 X 20 cm using single seedling per hill in 5.4 m X 6 rows plots. Gap filling was done within 7 days of transplanting. Fertilizer management was done using 260:100:120:110:11 kg Urea, TSP, MP, Gypsum and $ZnSO_4$/ha. Urea was applied in three equivalent splits at 15 days after transplanting (DAT), 30 DAT and 5 days before PI stage. Total amount of TSP, MP, Gypsum and $ZnSO_4$ were applied at final land preparation. Weed, insect pest and disease management was done as when necessary following standard protocol for Boro rice described in AdhunikDhanerChash (Modern Rice Cultivation) of BRRI. Data on PAcp at maximum tillering and maturity stage, days to flowering and maturity, plant height, panicle length, panicles/hill, yield (t/ha), lodging and disease and insect infestation were recorded.

3. RESULTS AND DISCUSSION

Analysis of variances showed that the breeding lines significantly varied in growth duration and plant height but not in grain yield (Table 2). However, interaction effects between genotype and environment were highly significant for all the traits. The IRRI bred lines matured at 144 and 146 days on average at Gazipur and Habiganj, respectively. Average plant height of the breeding lines at both locations was also almost similar. But slight variation in grain yield though not significant was observed among the lines. Although, the average grain yield of the breeding lines was lower than that of the check varieties, there were still some breeding lines out yielding over

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the check varieties (Table 2). The highest grain yield was 7.3 t/ha and 7.9 t/ha respectively at Gazipur and Habiganj.

Table-1. List of advanced breeding lines and varieties for Multi-Environment Trial (MET), Boro 2015-16

Sl#	Designation	Sl#	Designation
1	IR13A390	52	IR14A185
2	IR14N128	53	IR99085-B-B-77
3	IR09N503	54	IR12A211
4	IR100008-91-B	55	IR99085-B-B-94
5	IR12A136	56	IR99092-B-B-78
6	IR98419-B-B-11	57	IR99092-B-B-91
7	IR12A229	58	IR99046-B-B-28
8	IR13A390	59	IR98418-B-B-4
9	IR100749-63-B	60	IR98418-B-B-9
10	IR14N126	61	IR14D111
11	IR93339:39-B-6-5-B-B-B-24	62	IR98415-B-B-45
12	IR95495-84-1-2-1	63	IR12A238
13	IR09N516	64	IR99086-B-B-8
14	IR100008-88-B	65	IR98417-B-B-27
15	IR99056-B-B-15	66	IR13N142
16	IR99090-B-B-25	67	IR14A151
17	IR99056-B-B-18	68	IR98417-B-B-34
18	IR99090-B-B-62	69	IR14A170
19	IR11A314	70	IR12N274
20	IR99061-B-B-7	71	IR100008-99-B
21	IR98419-B-B-7	72	IR11A294
22	IR99086-B-B-63	73	IR09A235
23	IR100072-30-B	74	IR13A295
24	IR12N235	75	IR14A140
25	IR93339:11-B-23-16-B-B-B-28	76	IR99049-B-B-20
26	IR99085-B-B-52	77	IR99090-B-B-85
27	IR100749-79-B	78	IR14N118
28	IR12A288	79	IR100004-89-B
29	IR98417-B-B-6	80	IR100004-5-B
30	IR99061-B-B-1	81	IR13N179
31	IR13A371	82	IR99062-B-B-16
32	IR99085-B-B-70	83	IR99082-B-B-3
33	IR99090-B-B-8	84	IR99061-B-B-18
34	IR99046-B-B-6	85	IR99085-B-B-25
35	IR100749-56-B	86	IR98413-B-B-5
36	IR98418-B-B-14	87	IR100004-87-B
37	IR98415-B-B-10	88	IR12A185
38	IR12A173	89	IR99119-B-B-94
39	IR99076-B-B-6	90	IR98418-B-B-2
40	IR99062-B-B-1	91	IR99085-B-B-20
41	IR99054-B-B-31	92	IR99085-B-B-63
42	IR14A193	93	IR13N158
43	IR14D155	94	IRRI154
44	IR93339:39-B-6-5-B-B-B-49	95	IRRI174
45	IR14A167	96	IRRI146
46	IR100740-23-B	97	IRRI168
47	IR99046-B-B-30	98	IRRI179
48	IR99053-B-B-3	99	IRRI180
49	IR99049-B-B-16	100	IRRI181
50	IR99086-B-B-34	101	BRRI dhan28 (Ck)
51	IR100008-68-B	102	BRRI dhan29 (Ck)

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Table-2. Average agronomic performance of 100 IRRI bred lines at two locations (Gazipur and Habiganj), Boro 2015-16

Genotype	Statistic	Days to maturity		Plant height (cm)		Yield (t/ha)	
		Gaz	Rang	Gaz	Rang	Gaz	Rang
IRRI bred lines	Mean	144	146	102.2	103	5.5	5.9
	SD	3.2	5.3	7.2	6.0	0.8	0.6
	CV	2.2	3.6	7.0	5.9	14.5	10.6
	Range	138-154	139-159	83-122	90-121	3.3-7.3	5.1-7.9
BRRI dhan28 (Ck)	Mean	141	139	95	92	4.4	6.0
BRRI dhan29 (Ck)		152	155	115	103	5.5	7.1
p – Value (G)		0.0000		0.0000		0.4122	
p – Value (E)		0.0046		0.9977		0.0614	
p- Value (GXE)		0.0000		0.0033		0.0000	

Table-3.Frequency of breeding lines in differential classes of growth duration and yield, Pre-MET, Gazipur, Boro 2015-16

Growth duration / Yield (t/ha)	No. of breeding lines		
	≤140d	141-150d	>150d
>6.5	2	3	0
6.0 -6.5	1	20	0
<6.0	2	70	2

Check variety (GD, Yield): BRRI dhan28 (140d, 4.7t/ha); BRRI dhan29 (152d, 5.7t/ha)

Genotypic discrimination based on growth duration and yield has been shown in Table 3, Table 5 and Table 7 for Gazipur, Habiganj and for both locations, respectively. The breeding lines were categorized into three growth duration classes (>150d, 141-150d and ≤140d) and three yield classes (>6.5 t/ha, 6.0 – 6.5 t/ha and <6.0 t/ha). In case of Gazipur, five breeding lines out of 100 had growth duration up to 140d, 93 breeding lines matured at 141-150 days and only two breeding lines mature at >150d (Table 3). On the other hand in Habiganj, 11 breeding lines matured at ≤140d, 67 breeding lines at 141-150d and 22 breeding lines at >150d (Table 5).

At Gazipur, five breeding lines yielded higher than 6.5 t/ha and 21 breeding lines yielded with a range between 6.0 t/ha and 6.5 t/ha while at Habiganj, 16 breeding lines yielded higher than 6.5 t/ha and 20 genotypes yielded 6.0 t/ha to 6.5 t/ha. Two breeding lines at Gazipur and one breeding line at Habiganj yielded more than 6.5 with growth duration of 140 days or less (Table 3 and Table 5).

Table 4 shows 22 breeding lines that yielded higher than the check varieties contemporary in growth duration were selected from Gazipur site. Among these lines, IR99061-B-B-1, IR99061-B-B-7 and IR12A288 yielded respectively 1.9 t/ha, 1.4 t/ha and 1.9 t/ha higher than BRRI dhan28 with almost similar growth duration. The remaining 19 lines yielded 0.5 t/ha to 2.1 t/ha higher than BRRI dhan29 with 4 to 11 days shorter growth duration. At Habiganj, nine breeding lines yielded at least 0.5 t/ha than the check varieties (Table 6). Among them six breeding lines yielded 6.2 t/ha to 7.4 t/ha which are 0.5 t/ha to 1.3 t/ha higher than BRRI dhan28 with growth duration similar to that of it, while one breeding line, IR13A390 yielded 0.6 t/ha higher than BRRI dhan29 with 12 days shorter growth duration at this location. Also, IR100740-23-B and IR98419-B-B-7 yielded almost similar to BRRI dhan29 with respectively 8 days and 11 days shorter growth duration.

Table 7 shows that only three breeding lines out of 100 yielded more than 6.5 t/ha with a growth duration up to 150 days. Another four lines showing 6.0 t/ha to 6.5 t/ha grain yield matured at ≤140 days. However, the check variety BRRI dhan28 yielded on average 5.4 t/ha with a growth of 139 days and BRRI dhan29 yielded 6.5 t/ha in 153 days. A total of 12 breeding lines of which nine yielded 0.6 t/ha to 1.2t/ha higher than BRRI dhan28 with contemporary growth duration (Table 8). Another three lines, IR13A390, IR99092-B-B-78 and IR98419-B-B-7 yielded 0.2t/ha to 0.6 t/ha higher than BRRI dhan29 with 6 to 10 days shorter growth duration. Importantly, IR13A390 and IR98419-B-B-7 showed better performance at both the location

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Table-4. Agronomic performance of the selected materials from Pre-MET at Gazipur, Boro 2015-16

Sl	Designation	Growth duration (days)	Plant height (cm)	Yield (t/ha)
1	IR13A390	145	104	6.8
2	IR14N128	142	90	6.0
3	IR12A136	147	111	6.2
4	IR98419-B-B-11	143	103	6.2
5	IR14N126	144	96	6.1
6	IR09N516	142	95	6.0
7	IR99056-B-B-15	141	102	6.0
8	IR99090-B-B-62	144	106	6.2
9	IR99061-B-B-7	140	109	6.8
10	IR98419-B-B-7	147	106	6.2
11	IR99085-B-B-52	142	97	6.3
12	IR100749-79-B	143	104	6.1
13	IR12A288	140	102	6.1
14	IR99061-B-B-1	138	103	6.6
15	IR14A193	144	94	6.3
16	IR14D155	142	103	6.2
17	IR93339:39-B-6-5-B-B-B-49	148	115	6.4
18	IR99092-B-B-78	143	94	7.3
19	IR99092-B-B-91	146	118	6.3
20	IR14D111	144	104	6.7
21	IR99061-B-B-18	143	105	6.3
22	IR99085-B-B-25	146	107	6.2
23	BRRI dhan28 (Ck)	140	99	4.7
24	BRRI dhan29 (Ck)	152	118	5.7

Table -5. Frequency of breeding lines in differential classes of growth duration and yield, Pre-MET, Habiganj, Boro 2015-16

Growth duration / Yield (t/ha)	No. of breeding line		
	≤140d	141-150d	>150d
>6.5	1	11	4
6.0 -6.5	0	13	7
<6.0	10	43	11

Check variety (GD, Yield): BRRI dhan28 (139d, 6.1t/ha); BRRI dhan29 (155d, 7.3t/ha)

Table-6. Agronomic performance of the selected materials from Pre-MET at Habigaj, Boro 2015-16

Sl	Designation	Growth duration (days)	Plant height (cm)	Yield (t/ha)
1	IR100008-91-B	141	99	7.4
2	IR13A390	143	104	7.9
3	IR98419-B-B-7	147	107	7.1
4	IR99062-B-B-1	141	103	7.0
5	IR100740-23-B	144	102	7.1
6	IR13N142	142	101	7.0
7	IR09A235	140	106	6.6
8	IR99085-B-B-20	142	97	6.6
9	IRRI174	142	103	6.2
10	BRRI dhan28 (Ck)	139	93	6.1
11	BRRI dhan29 (Ck)	155	101	7.3

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Table-7. Frequency of breeding lines in differential classes of growth duration and yield, Pre-MET, Boro 2015-16

Growth duration / Yield (t/ha)	No. breeding line		
	≤140d	141-150d	>150d
>6.5	1	2	1
6.0 -6.5	4	19	3
<6.0	3	59	8

Check variety (GD, Yield): BRRI dhan28 (139d, 5.4t/ha); BRRI dhan29 (153d, 6.5t/ha)

Table-8. Agronomic performance of the selected materials over two locations of Pre-MET, Boro 2015-16

Sl	Designation	Growth duration (days)	Plant height (cm)	Yield (t/ha)
1	IR100008-91-B	140	97	6.6
2	IR99061-B-B-7	140	111	6.2
3	IR12A288	140	100	6.1
4	IR09A235	140	105	6.0
5	IR99061-B-B-1	139	104	6.0
6	IR99092-B-B-78	146	97	7.0
7	IR13A390	143	101	6.8
8	IR98419-B-B-7	147	106	6.7
9	IR99062-B-B-1	141	102	6.4
10	IR99085-B-B-52	141	97	6.2
11	IR14D155	142	100	6.1
12	IR100008-88-B	141	101	6.1
13	BRRI dhan28 (Ck)	139	96	5.4
14	BRRI dhan29 (Ck)	153	109	6.5

4. CONCLUSION

The breeding lines were highly variable in days to maturity and plant height but not in grain yield. However the effects of GXE were significant for all three traits. At Gazipur, the breeding lines yielded with range between 3.3 to 7.3 t/ha with a growth duration range of 138-154 days, while at Habiganj they yielded 5.1-8.7 t/ha with growth duration of 139-159 days. The highest yielding genotype was IR99092-B-B-78 followed by IR13A390, IR99061-B-B-7, IR14D111, etc at Gazipur, while at Habiganj site IR13A390 followed by IR100008-91-B yielded the highest. Based on yield and growth duration, 22 breeding lines showing better performance at Gazipur, 9 lines at Habiganj and 2 lines for both locations were selected for further evaluation

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