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PERFORMANCE OF DROUGHT TOLERANT NERICA AND GREEN SUPER RICE GENOTYPES IN DIFFERENT SEASONS AND LOCATIONS OF BANGLADESH

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Abstract

Drought has been recognized as one of the biggest limiting factor to rice production. Effort has been carried out to introduce new rice genotypes tolerant to drought stress with higher yield. An experiment was carried out at BRAC Agricultural Research and Development Centre (BARDC), Gazipur during Aman 2011 and Boro 2012 and in Rajshahi during Boro 2012 to evaluate the performance of NERICA and Green Super Rice (GSR) genotypes under drought condition. NERICA materials are said to be drought tolerant. On the other hand, GSR genotypes are designed in such a way that they are much more capable in drought situation. Hence, artificial drought was created by withdrawing irrigation water at key growth stages. Five drought tolerant rice genotypes were used as experimental materials. These were N4, N10, N20, GSR IRRI I 2 and GSR IRRI I 40. The experiment was laid out in randomized complete block design with 3 replications. The rice genotypes differed significantly ($P<0.05$) with respect to plant height, panicle production, spikelet panicle^{-1}, filled grain panicle^{-1}, spikelet fertility, thousand grain weight and yield. Spikelet panicle^{-1} and spikelet fertility was the highest in GSR IRRI I 40 in both Aman 2011 and Boro 2012 seasons in Gazipur. In Rajshahi, panicle m^{-2} was the highest in GSR IRRI I 40 and spikelet fertility was the highest in GSR IRRI I 2 during Boro 2012. The Highest grain yield was observed in GSR IRRI I 40 in both seasons and locations.

Introduction

Rice (*Oryza sativa* L.) is the staple food for more than three billion people, over half the world's population (FAO, 2004). Rice supplies as much as 80 % of the daily caloric intake of the teeming population of Asia, where two-thirds of the world's impoverished population lives. It is estimated that 2.3 billion farmers and their households depend on rice as their main source of livelihood (Mohanty, 2010). In Southeast Asia alone, about 24 million farmers depend on lowland rice agriculture, whereas, in South Asia, the figures are two to three times higher. Irrigated rice is grown on approximately 50 % of the rice area in Asia and generates approximately 75 % of the total rice production. About half of the world's rice area is under rainfed culture where drought has been recognized as the biggest limiting factor to rice production. Rainfed rice area includes 13 % upland ecosystem, 11 % deepwater ecosystem and 25 % rainfed lowland areas is drastically reduced by drought which often occurs due to unpredictable, insufficient and uneven distribution of rainfall during rice growing seasons. To offset the reduction, a new rice variety with greater adaptability to water-deficit situations is highly essential. There is genotypic variability in rice germplasm with regard to root traits including root penetration ability through compacted soils layers which are related to drought resistance.

The Barind tract situated in the North West region of Bangladesh has the lowest rainfall. It is the driest part of the country where only T. Aman rice is grown mostly using rain water, therefore, the effect of drought is most severe in the Barind tract, which receives the lowest average seasonal rainfall of about 1000 mm during the time monsoon (June to October) months. The pattern of rainfall distribution and drought intensities over the crop season is important in determining crop yield. More than 50 % of the rice land of Bangladesh is rainfed lowland (IRRI, 1993). At present only 30 % of total land has access to some form of irrigation, therefore rice production mainly depends on rainfall. Insufficient and uneven distribution of rainfall in Bangladesh creates drought stress in rainfed ecosystem which eventually reduced rice yield. With these view, an experiment was conducted to find a suitable drought tolerant genotype for rainfed and irrigated ecosystem in Bangladesh under artificial drought situation.

Materials and Methods

The experiment were carried out in two seasons and two locations where one is in Aman 2011 at BRAC Agricultural Research and Development Centre (BARDC), Gazipur and in Boro 2012 at BARDC, Gazipur and another location was Paba, Rajshahi. The experiment comprised of five genotypes viz. N4, N10, N20, GSR IRRI I 2, GSR IRRI I 40. The experiments were laid out in randomized complete block design with three replications. The row to row distance was 20 cm and plant to plant distance was 15 cm where the unit plot size was 20 m^2 (5 m x 4 m) in three locations. Firstly, the land was puddle thoroughly by ploughing and cross ploughing two times by power-tiller followed by laddering. Urea, TSP, MoP, Gypsum and $ZnSO_4$ fertilizer were applied at the rate of 180, 80, 70, 60, and 10 kg ha^{-1} during Aman season and 270, 130,120, 60 and 10 kg ha^{-1} during Boro season. The whole amount of triple super phosphate, gypsum, zinc sulphate, two third of muriate of potash and one third of urea was mixed properly and applied as basal application. The rest amount of MoP was applied before flowering stages for uniform flowering. The remaining urea was applied in two equal splits at 20 DAT and the third dose was applied 5 days before flowering. Gap filling and weeding was done accordingly. In Aman season, no supplementary irrigation was given in the whole crop cycle except before fertilization and in Boro, artificial drought stress was created by withdrawing irrigation till the soil became cracked with visual observation. Irrigation was given two times before urea split application. To avoid the infestation of stem borer at the growth stage and flowering stage, insecticide was sprayed two times in the experimental field. Other agronomic management was taken as and when necessary.

Data recorded

Five hills (excluding border hills) from each plot were selected and tagged after transplanting for taking data at harvest stage. The crop was harvested at maturity. During harvesting, 10 m^2 areas were harvested and crop of each harvested plot was separately bundled, properly tagged and then brought to the threshing floor and threshed by pedal thresher. After winnowing and drying of grains in the sun properly, the weight of grains was adjusted to 14 % moisture content. Finally, the grain was converted to ton per hectare. Data on final plant height (cm), panicle m^{-2}, spikelet $panicle^{-1}$, filled grain $panicle^{-1}$, spikelet fertility (%), 1000 grain weight (g) and grain yield (t ha^{-1}) were recorded. The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and means were adjudged by Least Significant Difference test (LSD) using the statistical computer package program, MSTAT-C (Russell, 1986).

Results and Discussion

Yield and yield components of different NERICA and GSR genotypes during T. Aman 2011 at BARDC, Gazipur is shown in Table 1. Results showed that plant height varied significantly among the studied genotypes. N20 (105 cm) was the tallest genotype at harvest over all other genotypes which is statistically similar to N4 (100 cm) and GSR IRRI I 2 (103 cm). The shortest plant height was recorded at N10 (94 cm) which is similar to GSR IRRI I 40 (95 cm). Plant height is mostly governed by the genetic makeup of the cultivar, but the environmental factors also influence it. Our results are in agreement with data presented by Mohammad *et al.* (2002). Panicle m^{-2} was recorded maximum at harvest for GSR IRRI I 2 (244) and the remaining genotypes were insignificant among each other. Spikelet panicle^{-1} was also recorded maximum at GSR IRRI I 40 (144) while minimum was recorded at GSR IRRI I 2 (93). Filled grain panicle^{-1} was found maximum at GSR IRRI I 40 (119) followed by N20 (80) and minimum was recorded at N10 (53) which is insignificant to N4 (58) and GSR IRRI I 2 (68). GSR IRRI I 40 showed the highest spikelet fertility (82 %) which is similar to GSR IRRI I 2 (73 %) followed by N20 (65 %).On the other hand, regarding thousand grain weight N4 (28.0 g) was recorded the highest over all other genotypes, that is similar to N10 (26.6 g) and GSR IRRI I 2 (26.8 g) followed by N20 (26.0 g). The lowest thousand grain weight recorded at GSR IRRI I 40 (20.7 g). Finally, different genotypes exhibit significant differences in grain yield. GSR IRRI I 40 (5.02 t ha^{-1}) produced maximum yield which is statistically identical to GSR IRRI I 2 (4.31 t ha^{-1}). GSR IRRI I 40 was recorded the highest yield because of the highest spikelet panicle^{-1}, filled grain panicle^{-1} and highest percentage of spikelet fertility. Varietal differences of grain yield were reported by Biswas *et al.* (1998). The genotypes, which produced higher number of effective tillers hill^{-1} and higher number of grains per panicle also showed higher grain yield in rice (Kusutani *et al.*, 2000; Dutta *et al.*, 2002). The second highest yield was recorded at GSR IRRI I 2 (4.31 t ha^{-1}) that is similar to N20 (4.16 t ha^{-1}).

Table 1. Yield and yield components of different NERICA and GSR genotypes during T. Aman 2011 at BARDC, Gazipur.

Genotypes	Plant height (cm)	Panicle m^{-2}	Spikelet panicle^{-1}	Filled grain panicle^{-1}	Spikelet fertility (%)	1000 grain weight (g)	Yield (t ha^{-1})
N4	100	155	111	58	52	28.0	2.66
N10	94	178	102	53	52	26.6	2.94
N20	105	178	123	80	65	26.0	4.16
GSR IRRI I 2	103	244	93	68	73	26.8	4.31
GSR IRRI I 40	95	189	144	119	82	20.7	5.02
$LSD_{(0.05)}$	5.5	50.7	12.1	15.1	12.2	1.5	0.77
CV (%)	2.9	14.3	5.6	10.7	10.0	3.1	10.8

The yield and yield components of different NERICA and GSR genotypes during Boro 2012 at BARDC, Gazipur shown in Table 2. Here the tallest plant height was found at harvest for N4 (85 cm) and N20 (85 cm), which is statistically identical to GSR IRRI I 2 (80 cm) followed by N10 (75 cm) and GSR IRRI I 40 (73 cm). At harvest, panicle m^{-2} was recorded at N20 (333) followed by GSR IRRI I 40 (244) and GSR IRRI I 2 (222). Panicle m^{-2} of GSR IRRI I 40 and GSR IRRI I 2 showed statistically similar with each other. It was observed that, N10 (144) recorded above two times and N4 (100) recorded above three times lower panicle m^{-2} production than N20. Spikelet panicle^{-1} recorded maximum in GSR IRRI I 2 (144) followed by N4 (102). N10 (71) recorded minimum number of spikelet panicle^{-1}. It is generally recognized that the number of spikelets per panicle or number of panicles per unit area determines rice yield depending on the cultivar. Kato *et al.* (2008) made similar observations that in upland conditions where drought occurs sporadically, spikelet's number per unit area contributes immensely to yield. In Gazipur, like T. Aman 2011, GSR IRRI I 40 recorded the highest filled grain panicle^{-1} (92) and spikelet fertility percentage (80 %). Highest filled grain panicle^{-1} was observed at GSR IRRI I 40 (92) followed by N4 (62) and N20 (55). N20 is statistically identical to GSR IRRI I 2 (53). The lowest filled grain per panicle was recorded at N10 (49) which are statistically similar to GSR IRRI I 2. Spikelet fertility percentage was also found maximum at GSR IRRI I 40 (80). N10 (69 %) and GSR IRRI I 2 (68 %) showed statistically similar with each other. N20 showed 64 % spikelet fertility which is statistically similar to GSR IRRI I 2 (68 %) and N4 (61 %) had the lowest spikelet fertility percentage that is again statistically identical to N20. Ramalingam *et al.* (1993) also observed that filled grains showed positive genotypic association as well as it direct effect on rice grain yield. However, N4 (27.6 g) had maximum thousand grain weight followed by N10 (25.2 g). On the other hand, N20 (23.8 g) had the third highest thousand grain weight and statistically identical to GSR IRRI I 2 (23.4 g). Whereas, GSR IRRI I 40 (18.9 g) was observed the lowest. Observation showed that, GSR IRRI I 40 (4.83 t ha^{-1}) yielded the highest among all other genotypes and it is statistically identical to N20 (4.24 t ha^{-1}). GSR IRRI I 40 yielded maximum due to its higher spikelet $Panicle^{-1}$, higher filled grain $panicle^{-1}$ as well as higher spikelet fertility percentage. GSR IRRI I 2 yielded 3.07 t ha^{-1} and it is statistically similar to N4 (2.53 t ha^{-1}) while N10 (1.68 t ha^{-1}) produced the lowest yield.

Table 2. Yield and yield components of different NERICA and GSR genotypes during Boro 2012 at BARDC, Gazipur

Genotypes	Plant height (cm)	Panicle m^{-2}	Spikelet $panicle^{-1}$	Filled grain $panicle^{-1}$	Spikelet fertility (%)	1000 grain weight (g)	Yield (t ha^{-1})
N4	85	100	102	62	61	27.6	2.53
N10	75	144	71	49	69	25.2	1.68
N20	85	333	86	55	64	23.8	4.24
GSR IRRI I 2	80	222	77	53	68	23.4	3.07
GSR IRRI I 40	73	244	114	92	80	18.9	4.83
$LSD_{(0.05)}$	8.5	39.3	8.11	5.36	5.18	1.2	0.64
CV (%)	5.6	10.0	4.8	4.6	4.0	2.6	10.4

In Boro 2012, the same experiment was conducted in the farmer's field in Paba Upazila of Rajshahi district and the results of that experiment is shown in the Table 3. Experiment revealed that, genotype N20 (106 cm) had the highest plant height irrespective over all other tested genotypes followed by N4 (103 cm) and N10 (93 cm). GSR IRRI I 2 (90 cm) and GSR IRRI I 40 (90 cm) were observed the lowest plant height and found similar to each other. In terms of panicle number, highest panicle m^{-2} was observed at GSR IRRI I 40 (298) that is statistically identical to N20 (278). Several studies showed that panicle number per square meter is the most important factor in increasing grain yield of rice and many of researcher found around 89 % of yield changes is due to the effect of this factor (Sonia *et al.*, 1990; Grovois and Helms, 1992). GSR IRRI I 2 (247) had shown statistically identical to N20 (278). Genotypes N4 (164) and N10 (160) performed the lowest panicle number and had shown no significant difference between them. Spikelet $panicle^{-1}$ was also recorded highest at N10 (138) and that was statistically similar to N4 (135), GSR IRRI I 40 (130) and GSR IRRI I 2 (120). The lowest was observed at N20 (95) which is again statistically identical to GSR IRRI I 2. Filled grain per panicle was observed highest at genotype N10 (99) which is statistically similar to N4 (98), GSR IRRI I 2 (96) and GSR IRRI I 40 (95). The lowest filled grain per panicle was observed at N20 (57). Spikelet fertility percentage was observed maximum at GSR IRRI I 2 (80 %) and it is statistically similar to N4 (74 %), N10 (72 %) and GSR IRRI I 40 (71 %). The lowest was observed at N20 (60 %) which is again statistically similar to N10 and GSR IRRI I 40. Genotype N4 (27.7 g) was recorded the highest thousand grain weight followed by N20 (25.3 g), GSR IRRI I 2 (24.9 g) and N10 (24.9 g). Genotype N20, GSR IRRI I 2 and N10 are again similar to each other. GSR IRRI I 40 (21.5 g) had the lowest grain weight among all genotypes. However, GSR IRRI I 40 (5.25 t ha^{-1}) perform better yield among all other genotypes and that is similar to GSR IRRI I 2 (4.88 t ha^{-1}). N20 (2.89 t ha^{-1}) has produced the lowest yield that is identical to N4 (3.04 t ha^{-1}) and N10 (3.24 t ha^{-1}).

Table 3. Green yield and yield components of different NERICA and GSR genotypes during Boro 2012 at Paba Rajshahi.

Genotypes	Plant height (cm)	Panicle m^{-2}	Spikelet $panicle^{-1}$	Filled grain $panicle^{-1}$	Spikelet fertility (%)	1000 grain weight (g)	Yield (t ha^{-1})
N4	103	164	135	98	74	27.7	3.04
N10	93	160	138	99	72	24.9	3.24
N20	106	278	95	57	60	25.3	2.89
GSR IRRI I 2	90	247	120	96	80	24.9	4.88
GSR IRRI I 40	90	298	130	95	71	21.5	5.25
$LSD_{(0.05)}$	1.8	46.1	31.0	17.2	12.0	1.2	1.60
CV (%)	1.0	10.7	13.2	10.3	8.9	2.6	22.0

Conclusions

Genotype GSR IRRI I 40 had the best agronomic performance for grain yield and other yield parameters in both the seasons and locations, whereas lowest yield showed by N4 during Aman 2011 in Gazipur, N10 during Boro 2012 in Gazipur and N20 during Boro 2012 in Rajshahi. As we have shortage of drought tolerance variety, so genotype GSR IRRI I 40 might be a potentials suitable genotype for drought prone areas. However, further investigation is necessary to confirm these findings under different locations and agronomic traits

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