EFFECTS OF WATER STRESS ON GROWTH AND YIELD ATTRIBUTES OF AMAN RICE GENOTYPES

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ABSTRACT

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Transplant aman rice suffers from moisture stress as ceases the reproductive stages in Bangladesh, which contributes to lower the yield of this crop. To identify drought tolerant rice variety, a pot experiment with three T. aman rice genotypes (Basmoti, Binadhan4 and RD2585) was carried out at BINA, Mymensingh during July to December, 2006 to evaluate the effect of water stress at different growth stages of different T. aman rice genotypes. The experiment was conducted in CRD with three replications putting three rice genotypes at three water levels (100%, 70% and 40% FC). Plant height, numbers of tillers/hill, no. of filled grains /panicle, total dry matter/hill, 1000 grain weight , grain yield and harvest index were decreased with increasing water stress levels. Responses of the rice genotypes in different water stress varied significantly. There had been different degree of reduction to the yield contributing characters for the stress. Binadhan 4 performed better in producing tillers, leaves, total dry matter, and yield under stress than the other two genotypes. Basmoti showed the highest plant height but medium total dry matter, 1000 grain weight and yield. RD 2585 showed the lowest total dry matter, 1000 grain weight, and yield under water stress.

Keywords: Effect of water stress, drought tolerance rice varieties, growth and yield attribution

INTRODUCTION

Rice (*Oryza sativa* L.) is the principal food crop in Bangladesh and about 80% of the total arable lands are used for rice (aus, aman and boro) cultivation (BBS, 2002). Among them, T. aman rice covers the largest area (5.71 million hectares) with a production of 11.24 million tons (BBS, 2002). But yield of this crop is low compared to other rice growing countries of the world.

To feed the ever increasing population of Bangladesh rice production must be increased either by increasing arable land or by increasing per hectare yield. However, increase the arable lands in our densely populated country is quite difficult. Rather rice production can be increased by increasing per hectare yield. In this way to increase yield natural calamities are the main barriers .Drought is one of them.

Aman rice is generally cultivated under rain fed condition during June –December. It passes through vegetative stage during August to September when rainfall is sufficient. This crop suffers from moisture stress when the rainfall ceases by the first week of October. It passes through reproductive stages (panicle initiation, booting, flowering and grain filling) in October and November. The total rainfall in these two months is very irregular and often inadequate in Bangladesh which fails to meet the evapotranspirational demand of aman rice consequently water stress develops and affects translocation of assimilates and grain development in rice.

The performance of rice varieties varies under water stress conditions at different growth stages. Islam et al. (1994 b) observed that yield losses resulting from water deficit are particularly severe when drought strikes at booting stage. Water stress at or before panicle initiation reduces potential spike number and decreases translocation of assimilates to the grains, which results low in gain weight and increases empty grains (RRDI, 1999).
Physiological potentiality of drought tolerance of different rice varieties should be studied so that tolerant varieties may be identified. To identify drought tolerant rice variety the present study was undertaken to evaluate the effect of water stress at different growth stages of different T aman rice varieties.

MATERIALS AND METHODS

The pot experiment was carried out with three transplanted aman rice genotypes (Basmoti, Binadhan 4 and RD 2585) at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during July to December 2006, putting them at three different soil water level (100%,70% and 40% FC). The experiment was two factorials (three water levels and three rice genotypes) and laid in completely randomized design (CRD) with three replications. A total of 81 pots (21 cm deep with 24 cm diameter at top) were prepared with each of 8 kg of non-calcareous dark grey floodplain loamy textured soil collected from BINA farm. Field capacity (100%) of the soils was determined through gravimetric methods before use. 25 days old seedling was transplanted in the puddle pot and each pot contained one seedling.

Three water levels were maintained until maturity adding required amount of water. Measured amount of water for (100% FC) was multiplied by 1.00, 0.7 and 0.40 to know their amount of water required to maintain 100% FC, 70% FC and 40%FC, respectively. The pots were placed under polythene sheet. The pots were fertilized with cow dung 40g/pot, urea 1.72g/pot,TSP 1.44 g/pot, MP 0.8g/pot corresponding to 15 ton/ha cow-dung, 215 kg urea/ha, 180 kg TSP/ha and100kg MP/ha. All TSP, MP and one- third of the Urea were applied as basal dose. The remaining two third of the Urea were applied in two equal splits in each pot at 30 and 50 days after transplanting (DAT). Other intercultural operations were done as and when necessary.
Data on some morphological parameters such as plant height, no. of tillers/ hill, no. of leaves/ hill, leaf area/ hill and total dry matter/hill were recorded at booting (81 DAT) flowering (94DAT) and maturity stage from 27 pots in each stage out of 81 pots. Yield attributes and yield were recorded at maturity only.
The data were analyzed statistically following MSTAT-C computer (soft ware) packages and the mean differences were adjusted by Duncan's Multiple Range Test (DMRT) (Gomej &Gomej, 1984).

RESULT AND DISCUSSION

Plant height

The interaction effect of different soil moisture levels and rice genotypes on plant height at booting, flowering and maturity stages was found significant at 1% level (Table 1). At booting stage, the highest plant was found at 100% FC (139.2 cm) followed by 70%FC and the shortest plant was found at 40% FC (117.1 cm) in all rice genotypes. The flowering and maturity stage showed the similar pattern of plant height. Among the genotypes, the highest plant height was observed in Basmoti followed by Binadhan 4 and RD 2585 at all growth stages (Table 1). At booting stage, the highest plant height(164.0 cm) was observed in the treatment combination of Basmoti X 100% FC which is statistically similar to Basmoti X70% FC (160.3 cm) which was followed by the treatment combination Binadhan 4X 100% FC(152.9) . But RD 2585X40% FC showed the shortest plant (88.0 cm). The flowering and maturity stages also showed more or less similar pattern in plant height (Table1).The results indicate that plant height decreased with increasing soil moisture stress. It might be due to inhibition of cell division or cell enlargement under water stress. Variation in plant height among the genotypes also indicates that different genotypes had different water requirement.

Number of tillers per hill

Soil moisture level and genotypes interacted significantly on number of tillers per hill. At all growing stages (booting, flowering and maturity), the highest number tillers per hill were obtained from 100% FC and the lowest number of tillers per hill was obtained from 40% FC. Number of tillers / hill varies due to different genotypes. Binadhan 4 produced the highest number of tillers per hill, Basmoti and RD 2585 produced the medium and the lowest number of tillers per hill, respectively. At booting, flowering and maturity stages, the highest number of tillers was observed the treatment combination of Binadhan 4X 100% FC showed significantly the lowest number of tillers per hill.
The results showed that the number of tiller per hill was decreased with decreased soil moisture level. Reduced tiller production under lower soil moisture levels might be the fact that under water stress, plants were not able to produce enough assimilates for inhibited photosynthesis. It might be also happened for less amount of water uptake to prepare sufficient food and inhibition of cell division of meristematic tissue. The results agree with Murty(1987), Castilo(1987), Cruz *et al* (1986), IRRI (1974) and Islam *et al* (1994 a) .

Number of leaves per hill

The number of leaves per hill varied significantly under different moisture levels (Table1). At booting (106.8), flowering (85) and maturity (58.11) stage, the highest number of leaves was found in 100% FC. The number decreased gradually with increasing soil moisture stress and 40%FC produced the lowest number of leaves per hill in all growing stages.
At booting stage, Binadhan 4 produced the highest number of leaves per hill (100.40) followed by Basmoti (91.11) and RD 2585 (80.11). Also at another two stages, Binadhan 4 produced the highest number of leaves per hill followed by Basmoti RD 2585.
The treatment combination Binadhan 4 X1k00 %FC produced the highest number of leaves per hill and the RD l2585 X 40% FC produced the lowest number at booting, flowering and maturity stages. Water stress might inhibit photosynthesis and produce less amount of assimilates which resulted in lower number of leaves. The results of the experiment are in agreement with Hossain (2001). The results also indicate that different genotypes had different requirements for leaf production.

Leaf area per hill

The interaction effect of different moisture levels and rice genotype of leaf area per hill at all growth stages was significant (Table 2). At booting stage, the highest leaf area was found at 100% FC in all the rice genotypes. The leaf area was reduced with the reduction of moisture levels but the degree reduction was higher in Basmoti (14.7 for 70%FC and 53.2% for 40%FC) cm. RD 2585 than in Binadhan 4 (5.6% for 70%FC and 43.4% for 40% FC). At flowering and maturity stages, similar trend were found for producing leaf area per hill. The results also showed that the flowering stage more critical than other stages. Reduced soil moisture levels produced lower leaf area; it might be due to inhibition of cell division of meristematic tissue under water starved condition. The results of the experiment are in agreement with Aggarwall and Kodundal (1988), and Hossain (2001).

Total dry matter per hill

Different moisture levels and rice genotypes interacted significantly for producing total dry matter per hill. Total dry matter per hill was maximum at 100% FC followed by 70%FC and it was lowest at 40% FC in all the rice genotype at all growing stages. So, total dry matter production was decreased with decreasing soil moisture levels. Decreased total dry matter under lower soil moisture might be due to inhibited photosynthesis. The results confirm with Hossain (2001). But the degree of reduction was different in different genotypes. At booting stage, it was higher for Basmoti (15.28% for 70% FC and 30.86% for 40% FC) and RD2585 (18.79% for 70%FC and40.21% for 40%FC) than for Binadhan 4 (11.82% for 70% and 27.27% for 40% FC). Flowering and maturity showed similar pattern in production total TDM. The results also showed that water stress affects more at flower and maturity stages than that at booting stages.

Number of filled grains per panicle

Different soil moisture levels and rice genotypes interacted significantly in producing filled grains per panicle (Table 3). The highest number of filled grains per panicle was found at 100% FC followed by 70% FC and the lowest number of filled grains per panicle was observed at 40%FC in all the genotypes. As s whole the treatment combination, Binadhan 4 X 100% FC produced the highest number of filled grains per panicle and the lowest was obtained from the treatment combination, RD2585X 40%FC. The results showed that the number of filled grains per panicle decreased under lower soil moisture level but the degree of reduction in different genotypes did not indicate the tolerance level of the genotypes. Decreased filled grains per panicle under lower soil moisture levels might be due to inhibition of translocation of assimilate to the grains due to moisture stress. These results agree with Hossain (2001), O' Toole and Moya (1981).

Number of unfilled grains per panicle

The interaction effect of soil moisture levels and rice genotypes on the number of unfilled grains per panicle was significant (Table 3). In all the rice genotypes, number of unfilled grains was increased with reduced soil moisture levels. But the degree of increment was different in different genotypes. Binadhan 4 produced relatively more unfilled grain (33.13% for 70%FC and 77.21% for 40%FC) than Basmoti and RD 2585 under water stressed condition. Increased unfilled grains per panicle under lower soil moisture level might be due to inactive pollen grain for dryness, incomplete development o f pollen tube; insufficient assimilates production and its distribution to grains. The results agree with Hossain (2001), Yamboo and Ingram (1988), Begum (1990) and Islam et al (1994a).

Grain weight

In all rice genotypes, the largest grain was found at 100% FC, followed by 70% FC, and the smallest was found at 40% FC. The results showed that 1000 grain weight was reduced with reduced soil moisture levels. Lower soil moisture might decrease translocation of assimilates to the grain which lowered grain size .But the degree of reduction in 1000 grain size weight was different in different genotypes. Percent reduction was lower in Binadhan 4 (4.14 to 6.37%) than in Basmoti (6.75to 12.5%) and RD 2585 (4.57 to 14.64%). Islam et al (1994b), RRDI (1999), O'Toole et al (1979) and Tsuda and Takami (1991) also stated that water stress reduced grain weight.

Grain yield

Different soil moisture levels and rice genotypes interacted significantly for grain yield per hill (Table 3). All the genotypes produced the highest grain yield per hill at 100% FC followed by 70% FC and the lowest yield per hill was obtained at 40%FC. So, it was observed that grain yield per hill decreased in decreasing soil moisture level. Reduced grain yield under lower soil moisture levels might be due to inhibition of photosynthesis and less translocation of assimilates towards grain due to soil moisture stress. The results also agree with Castilo et al (1987) and Hossain (2001).

The results also showed that the amount of reduction under lower moisture level was higher in Basmoti 926.25 to 53.08%) and RD 2585 (32.51 to 48.84%) than that in Binadhan 4 (20.74 to 45.34%).

Harvest index

Harvest index was significantly influenced by the interaction effect of soil moisture level and rice genotype (Table 3). Harvest index of all rice genotypes was reduced with reduced moisture level. It might be due to the fact that water stress affects the translocation towards the grain. But the degree of reduction in HI value under lower moisture level was different in different genotypes. It was higher in Basmoti (13.15 to36.84%) and RD2585 (12.5 to 28.12%) than that in (11.11 to 20.0 %).

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Table 1: Effects of different moisture levels and genotypes on plant height and number of tillers per hill of T- aman rice

Genotypes	Moisture level (% FC)	Plant height(cm)			Number of tiller/hill			Number of leaves /hill		
		Booting stage	Flowering stage	Maturity stage	Booting stage	Flowering stage	Maturity stage	Booting stage	Flowering stage	Maturity stage
Basmoti	100	164.0 a	170.00 a	166.00 a	33.00c	35.00 c	32.0 c	101.30 b	91.67 b	53.00 b
	70	160.3 a	163.90 b	159.30 b	31.67 cd	34.00 cd	30.00 d	95.67 c	81.00 c	45.33 c
	40	133.7 d	141.3 d	135.7 d	26.33 e	28.30 e	20.33 f	76.33 d	63.33 d	36.67 d
Binadhan 4	100	152.9 b	161.00 b	155.3 b	40.33 a	43.30 a	37.19 a	119.3 a	97.67 a	68.33 a
	70	145.0 c	152.30 c	147.00 c	38.00 b	40.00 b	35.30 b	102.7 b	81.33 c	62.67 a
	40	129.7 d	131.70 f	124.9 e	30.00 d	32.50 d	25.90 e	79.33 d	66.33 d	45.00 c
RD2585	100	100.7 e	113.30 f	103.7 f	27.67 e	28.10 e	24.30 e	99.67 bc	65.67 d	53.00 b
	70	97.67 e	102.70 g	98.00 g	24.33 f	26.07 f	21.12 f	81.33 d	55.67 e	41.00 cd
	40	88.00 f	92.010 h	89.70 h	18.67 g	20.61 g	15.19 g	56.33 e	40.33 e	36.00 d
level of significance		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 2: Effects of different moisture levels and genotypes on leaf area and total dry matter / hill of T- aman rice

Genotypes	Moisture level (% FC)	leaf area / hill (cm^2)						Total dry matter / hill (g)					
		Booting stage		Flowering stage		Maturity stage		Booting stage		Flowering stage		Maturity stage	
		leaf area	Reduction %	leaf area	Reduction %	leaf area	Reduction %	Dry matter	Reduction %	Dry matter	Reduction %	Dry matter	reduction %
Basmoti	100	40.67 b		32.33 b		28.42 a		29.90 c		40.22 c		48.33 b	
	70	34.68 c	14.7	21.09 c	34.76	20.33 c	28.46	25.33 f	15.28	32.33 d	19.61	39.69 e	17.87
	40	19.05 e	53.2	15.10 d	53.3	11.33 fg	60.13	20.67 h	30.86	26.29 f	34.63	32.33 h	33.10
Binadhan 4	100	46.18 a		37.41 a		26.73 a		36.67 a		47.33 a		54.29 a	
	70	43.60 ab	5.6	28.99 b	22.5	22.52 b	15.57	32.33 b	11.83	42.67 b	9.84	47.65 c	12.23
	40	26.16 d	43.4	20.95 c	44.0	17.58 d	34.23	26.67 e	27.27	31.43 d	33.59	36.67 f	32.45
RD 2585	100	25.68 d		21.16 c		20.66 c		27.13 d		39.33 c		43.67 d	
	70	18.59 ef	27.6	14.67 d	30.67	12.17 f	41.09	22.03 g	18.79	29.07 e	26.08	34.33 g	21.38
	40	13.35 f	48.0	11.10 d	47.54	10.17 g	50.77	16.22 i	40.21	22.67 g	42.36	29.33 i	32.83
level of significance		0.01		0.01		0.01		0.01		0.01		0.01	

Table 3: Effects of different moisture levels and genotypes on yield and yield contributing characters of T- aman rice

Genotypes	Moisture level (% FC)	Filled grain		unfilled grain		grain weight		grain yield		Harvest index	
		No./ Panicle	Reduction %	No./ Panicle	Reduction %	1000 grain weight	Reduction %	grain yield/ hill	Reduction %	Harvest index	Reduction %
Basmoti	100	62.0 c		22.33 f		24.00 a		17.67 b		38.00 c	
	70	58.83 c	5.10	28.66d	28.30	22.33 ab	6.95	13.03 c	26.25	33.00 e	13.15
	40	41.66 e	32.80	39.33 b	76.13	21.00 b	12.5	8.29 d	53.08	24.00 g	36.84
Binadhan 4	100	77.30 a		19.00 g		22.43 ab		24.39 a		45.00 a	
	70	69.33 b	10.31	25.33 e	33.31	21.50 b	4.14	19.33 b	20.74	40.00 b	11.11
	40	46.33 de	40.06	33.67 c	77.21	21.00 b	6.37	13.33 c	45.34	36.00 d	20.00
RD2585	100	50.33 d		35.33 c		18.16 c		14.33 c		32.00 e	
	70	43.33 e	13.90	39.00 b	10.38	17.3 cd	4.57	9.67 d	32.51	28.00 f	12.5
	40	32.00 f	36.26	47.33 a	33.96	15.50 d	14.64	7.33 d	48.84	23.00 g	28.12
level of significance		0.01		0.01		0.01		0.01		0.01	