

EVALUATION OF GROWTH AND YIELD OF SELECTED HYBRID AND INBRED RICE VARIETIES GROWN IN NET-HOUSE DURING TRANSPLANTED AMAN SEASON

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Abstract

Pot experiments were conducted during T. *aman* 2001 and 2002 (wet season) at Bangladesh Rice Research Institute (BRRI) in net house. Hybrid variety Sonarbangla-1 and inbred modern variety BRRI dhan-31 were used in both the seasons and BRRI hybrid dhan-1 was used in 2002. The main objective of the experiments was to compare the growth and yield behaviour of hybrid and inbred rice varieties under controlled condition. In 2001, BRRI dhan-31 had about 10-15% higher plant height, very similar tillers/plant, 15-25% higher leaf area at all days after transplanting (DAT) compared to Sonarbangla-1. Sonarbangla-1 had about 40% higher dry matter production at 25 DAT but had very similar dry matter production at 50 and 75 DAT, 4-11% higher rooting depth at all DATs, about 22% higher root dry weight at 25 DAT, but 5-10% lower root dry weight at 50 and 75 DAT compared to BRRI dhan-31. The photosynthetic rate was higher ($20 \mu \text{ mol m}^{-2}/\text{sec}^{-1}$) in BRRI dhan-31 at 35 DAT (maximum tillering stage) but at 65 DAT, Sonarbangla-1 had higher photosynthetic rate of $19.5 \mu \text{ mol m}^{-2} \text{ sec}^{-1}$. BRRI dhan-31 had higher panicles/plant than Sonarbangla-1, but Sonarbangla-1 had higher number of grains/panicle, 1000-grain weight and grain yield than BRRI dhan-31. In 2002, BRRI dhan-31 had the highest plant height at 25 DAT, but at 75 DAT, BRRI hybrid dhan-1 had the highest plant height. Sonarbangla-1 had the largest leaf area at 25 and 50 DAT followed by BRRI dhan-31, but at 75 DAT, BRRI dhan-31 had the largest leaf area. The highest shoot dry matter was observed in BRRI dhan-31 followed by Sonarbangla-1 at all DATs. Sonarbangla-1 had the highest rooting depth and root dry weight at all DATs. BRRI dhan-31 gave the highest number of panicles/plant followed by Sonarbangla-1, BRRI hybrid dhan-1 had the highest grains/panicle followed by BRRI dhan-31 and Sonarbangla-1 had the highest 1000-grain weight followed by BRRI dhan-31. The highest amount of grains/plant (34.6 g) was obtained from BRRI dhan-31.

Key Words: Shoot dry matter, root dry weight, leaf area, photosynthesis, grain yield.

Introduction

Hybrid rice technology is one of the alternative means to meet the challenge of food security for the increasing population in Bangladesh. Chinese rice scientists

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developed and used commercial rice hybrid, which increased rice yield by about 20% over the semi-dwarf varieties (Yuan *et al.*, 1994). Many hybrid rice varieties outyielded the standard check variety with same growth duration by more than are t/ha (Julfiquar *et al.*, 1998).

The heterosis for higher yield in hybrid rice comes from vegetative growth. The life cycles of hybrid and inbred rice are almost similar, but hybrid rice is more vigorous in the vegetative phase, especially at seedling stage. Hybrid rice has higher seedling dry matter content, thicker leaves, larger leaf area and longer root system (BRRI, 2000). Hybrid rice can give 10-15% yield advantage over modern inbred varieties through vigorous growth, extensive root system, efficient and greater sink size, higher carbohydrate translocation from vegetative parts to spikelets and larger leaf area index during the grain filling stage (Peng *et al.*, 1998). However, the physiological basis for heterosis remains unknown. Again the inbred is normally sink limiting and hybrids are source limiting. For high yield of hybrid rice, sink is not the limiting factor as it is in inbred rice (Yan, 1988). Two-step grain filling is observed in hybrid rice, which means that pollinated spikelets stop development for several days but maintain the ability to fill later (Wen, 1990). During vegetative growth, hybrid rice accumulates more dry matter which results in higher spikelets/panicle, whereas inbred rice depends basically on the accumulation of assimilates after heading (Yan, 1988). The main reason for higher yield of hybrid rice is vigorous seedlings with tillers. The tillers that emerge in the seedbed produce more spikelets/panicle than the tillers that emerge after transplanting (Wen, 1990).

The common properties of modern inbred and hybrid rice varieties are, high nitrogen response, erect and thick leaves which remain green till maturity, short statured and high harvest index. Dry matter production at different growth stages shows different patterns for hybrid and inbred rice. While hybrid rice has more dry matter accumulation in the early and middle growth stages, inbred rice has more in the late growth stages (Yan, 1988). High grain yield of hybrid rice is attributed to high vegetative biomass production, high leaf area, large panicles and high tillering capacity in some cases (Peng *et al.*, 1998). The present study was undertaken to evaluate the growth and yield behaviour of a few selected hybrid and inbred rice varieties in wet season under controlled condition.

Materials and Method

Design and treatments

The experiment was conducted using a completely randomized design with 3 replications, where varieties were considered as treatments. The 2 hybrid rice

varieties were Sonarbangla-1 and BRRI hybrid dhan-1 (only in 2002) and an inbred rice BRRI dhan-31.

Number, size and arrangement of pots and condition of the net house

A total of 28 earthen pots in 2001 and 42 in 2002 [14 pots for each variety, 3 pots for each sampling (3 x 3 pots) and 5 pots for yield data] were taken with about 12 kg muddy soil in each pot. The soil was silty clay with O.M 2.1%, pH 6.4-6.7 and total N 0.13%. The pots were kept in the net house. The size of the pots was: 12 inches in height, 20 inches diameter at the top and 9 inches at the bottom. The pots were arranged in the net house in rows variety-wise. The net house was a ware-net covered and well protected chamber. Sunlight and rain could enter easily into the net house.

Fertilization and transplanting in the pots

Considering the weight of top-soil (0-15 cm) of the field (6×10^5 kg/ha), the pots with 10 kg soil were fertilized @ 100-26.4-41.5-10-5 kg N, P, K, S and Zn/ha, respectively. All the fertilizers were applied as basal except urea, which was top dressed in 3 equal splits at 15, 30, and 45 days after transplanting. Single 30-day old healthy seedling was transplanted in the middle of each pot. The pots were irrigated with watering can before crack development on the surface soil of the earthen pots.

Measurement of growth parameters and photosynthesis

The growth parameters e.g., plant height, tillers/plant, leaf area, rooting depth, shoot and root dry matter were measured from destructive samples. To compare the photosynthetic rate of hybrid (Sonarbangla-1) and inbred (BRRI dhan-31) rice varieties, their photosynthetic efficiency was measured in 2001 with a portable photosynthesis-measuring instrument (LiCOR-6200) at 35 DAT (maximum tillering stage) and at 65 DAT (Booting to flower initiation stage) in clear sunshine at 11 to 12 hrs. The SPAD reading of the varieties was also recorded at the same time.

Results and Discussion

Seedling quality

Seedling quality of Sonarbangla-1 was better in terms of all parameters studied i.e., plant height, tiller number, leaf area, rooting depth, shoot and root dry weight, root-shoot ratio and vigour index compared to BRRI hybrid dhan-1 and BRRI dhan-31 (Table 1).

Table 1. Parameters of seedling quality of different transplanted *aman* rice.

2001 (At 30 DAS)										
Variety	Plant height (cm)	Tillers/ plant	Leaf no./ plant	LA/ plant (cm ²)	Root depth (cm ²)	Shoot dry wt (g /plant)	Root- dry wt (g /plant)	Root Shoot ratio	Wt: Height	Vigour index
SB-I	29.6	2	7	23	19.4	0.214	0.087	0.405	0.07	9*
BR-31	28.9	1	7	14	18.0	0.207	0.079	0.308	0.07	8
2002 (At 30 DAS)										
SB-1	33.0	2	6	27	10.0	0.116	0.079	0.681	0.04	9
BH-1	32.2	1	4	25	12.0	0.097	0.051	0.526	0.03	8
BR-31	30.7	1	4	22	10.0	0.087	0.033	0.379	0.03	7

*Visual Score:1= Very poor growth, 3= Poor growth, 5= Medium growth, 7= Good growth and 9 Excellent; SB-I= Sonarbangla-1, BH-I= BRRJ hybrid dhan-1 and BR-31 = BRRJ dhan-31.

Growth parameters

It was observed that plant height and leaf area of BRRJ dhan-31 were higher than those of Sonarbangla-1 at all growth stages, but the number of tillers/plant was almost identical (Table 2). Shoot dry weight (stem + leaf) of Sonarbangla-1 was much higher than that of BRRJ dhan-31 at 25 DAT, but it was very similar at 50 and 75 DAT. Rooting depth of Sonarbangla-1 was about 15% higher than that of BRRJ dhan-31 at all DATs, but root dry weight was 23% higher in Sonarbangla-1 only at 25 DAT. The root dry weight of BRRJ dhan-31 was higher than that of Sonarbangla-1 at 50 and 75 DAT (Table 2) during T. *aman* season of 2001. Lower root dry weight with higher rooting depth might be due to thinner roots.

During T. *aman* 2002, the tallest plant was observed in BRRJ dhan-31 at 25 DAT and in BRRJ hybrid dhan-1 at 50 and 75 DAT. The highest number of tillers/plant was observed in Sonarbangla-1 at 25 DAT, but in BRRJ dhan-31 at 50 and 75 DAT. Sonarbangla-1 had the largest leaf area at 25 and 50 DAT followed by BRRJ dhan-31 but at 75 DAT, BRRJ dhan-31 had the largest leaf area. The highest shoot (stem + leaf) dry weight was observed in BRRJ dhan-31 followed by Sonarbangla-1 at all DATs. Sonarbangla-1 had the highest rooting depth and root dry weight at all DATs (Table 2) during T. *aman* 2002. The results revealed that Sonarbangla-1 had much higher root dry weight at early growth stage (25 DAT) in both the seasons. Similar results were also reported by Yang and Sun (1986), who observed larger and deeper root systems in hybrid rice compared to the conventional varieties. The superficial roots of hybrids were more developed and heavier than those of the inbred.

Table 2. Plant growth parameters of different varieties at different DAT in T. aman season.

Variety	Plant ht. (cm)	Tillers/ plant	LA/ plant (cm ²)	Rooting depth (cm)	Shoot dry wt (g/plant)			Root dry wt (g/ plant)
					Stem	leaf	Total	
25 DAT								
SB-1	60.7±1.5	9±0.33	542±20.5	28.0±0.52	6.5±0.29	4.7±0.31	11.27±0.6	2.17±0.10
BR-31	70.1±1.1	9±0.33	692±29.7	25.1±0.49	4.7±0.15	3.3±0.16	7.93±0.3	1.67±0.14
50 DAT								
SB-1	78.2±0.6	15±0.8	1523±41	32.1±1.05	21.1±0.7	9.9±0.32	31.03±0.9	5.53±0.25
BR-31	80.0±0.8	14±1.0	1647±30	30.5±1.29	23.6±0.6	8.7±0.12	32.00±0.7	6.70±0.45
75 DAT								
SB-1	91.3±1.2	16±0.5	1582±24	34.6±0.91	25.7±0.4	10.2±0.29	35.87±0.7	7.30±0.37
BR-31	99.3±1.1	17±1.0	1853±52	33.3±1.14	25.7±0.5	10.9±0.34	36.60±0.9	8.40±0.35
2002								
25 DAT								
SB-1	70.4±0.8	11.7±0.5	353±10	30.3±0.7	2.35±0.1	1.78±0.05	4.14±0.1	3.50±0.12
BR-1	77.4±0.9	9.7±0.19	269±2.4	28.1±0.5	1.91±0.0	1.72±0.02	3.63±0.0	1.33±0.01
BR31	82.3±1.8	8.0±0.33	323±6.2	28.3±0.6	3.14±0.0	2.44±0.05	5.58±0.0	1.80±0.03
50 DAT								
SB-1	87.4±1.9	18.0±0.7	1854±67	36.0±0.7	16.1±0.7	10.23±0.5	26.33±1	3.36±0.20
BH-1	101.5±1	18.7±1.0	1633±45	31.0±0.7	10.8±0.4	8.41±0.71	19.16±1	2.50±0.15
BR-31	97.3±1.6	20.7±0.5	1759±21	30.5±0.7	17.7±0.5	10.98±0.6	28.70±1	2.62±0.14
75 DAT								
SB-1	102.3±1.0	21.7±0.8	2662±69	35.0±1.7	19.8±0.7	7.9±0.38	27.7±1.1	5.22±0.12
BH-1	121.3±1.4	18.7±0.4	2145±52	34.7±1.9	18.8±0.7	8.8±0.28	27.6±1.0	5.14±0.23
BR-31	116.7±0.5	22.7±1.0	2860±89	32.3±1.2	25.5±1.1	11.0±0.4	36.5±1.5	5.07±0.18

*SB-1= Sonarbangla-1, BH-1= BRRi hybrid dhan-1 and BR-31= BRRi dhan-31; LA= leaf area, ± stands for standard error from the mean value

Photosynthesis

The photosynthetic rate ($\mu\text{ mol m}^{-2}\text{ sec}^{-1}$) in BRRi dhan-31 was higher than hybrid Sonarbangla-1 at 35 DAT (early growth stage), but lower at 65 DAT (flower initiation stage) (Table 3). Results also indicated that photosynthetic rate was higher in the leaves with higher SPAD reading indicating that photosynthetic rate was higher in the leaves where N concentration is higher. Similar results were reported by Peng *et al.* (1998) who observed a strong relationship ($R^2 = 0.84$) between photosynthetic rate and N concentration of the flag leaves. Miah *et al.*

(1997) also reported higher photosynthetic rate, which was associated with higher leaf chlorophyll content (SPAD value basis).

Table 3. Photosynthesis rate of two varieties at different DAT in T. aman season, 2001 35 DAT.

Variety	SPAD value	CO ₂ conc. (ppm)	P (μ mol m ⁻² sec ⁻¹)
SB-1	39.4	387	19.6
BR-31	40.9	387	20.0
65 DAT			
SB-1	47.9	375.3	19.5
BR-31	45.0	384.8	15.8

SB1= Sonarbangla-1 and BR-31 = BRRi dhan-31.

Growth parameters at harvest, yield components and grain yield

At harvest, plant height, tiller number, yield components, grain yield, sterility (%) and HI were measured during T. aman 2001 and 2002. In T. aman 2001, BRRi dhan-31 had higher plant height, number of tillers/plant, and number of panicles/plant than Sonarbangla-1, but Sonarbangla-1 had more number of grains/panicle, 1000-grain weight and grain yield than that of BRRi dhan-31. The sterility (%) of BRRi dhan-31 was much higher than that of Sonarbangla-1, which might be due to genetic character of BRRi dhan-31. Higher sterility of BRRi dhan-31 decreased the HI and ultimately reduced grain yield of this variety (Table 4) in 2001.

Table 4. Growth parameters at harvest, grain yield and yield components of T. aman season 2001.

Variety	Plant ht. (cm)	Tillers/plant	Panicles/plant	Grains/panicle	1000-GW (g)	Yield (g/plant)	Sterility (%)	HI
SB-1	102±0.92	13.6±0.5	11.4±0.4	91±1.96	26.06±0.09	25.96±0.61	20.6±0.8	0.48±0
BR-31	111±1.22	15.0±0.5	13.8±0.4	58±1.44	24.12±0.14	20.09±1.26	40.0±1.9	0.44±0
2002								
SB-1	106±0.88	21±0.84	19±1.16	65±3.79	25.5±0.12	32.2±1.07	22±0.84	0.47±0
BH-1	113±0.51	18±0.51	17±0.33	79±2.04	23.2±0.05	31.2±1.10	24±2.00	0.46±0
BR-31	110±1.07	22±1.64	20±1.26	70±2.01	24.4±0.11	34.6±2.48	37±0.39	0.48±0

SB-1= Sonarbangla-1, BH-1= BRRi hybrid dhan-1 and BR31= BRRi dhan-31, ± stands for standard error from the mean value

In 2002, BRRi hybrid dhan-1 had the highest plant height followed by BRRi dhan-31. BRRi dhan-31 gave the highest number of tillers/plant (22) and panicles/plant (20), which was followed by Sonarbangla- 1. Sonarbangla- 1 had

the highest 1000-grain weight of 26 g followed by BRRI dhan-31. BRRI dhan-31 had the highest grain yield/plant followed by Sonarbangla-I. Again, BRRI dhan-31 had the highest sterility of 37%, which might be its genetic character. Harvest index (HI) was the highest in BRRI dhan-31, which resulted in the highest grain yield of 34.6 g/plant in 2002 (Table 3). Compared to 2001 with high pest infestation, all tested varieties produced 15-30% higher grain yield during 2002.

Conclusion

Sonarbangla-1 produced much higher root dry matter and vigorous shoot growth at seedling stage compared to other hybrid and inbred varieties. The vigorous growth of tested hybrid rice at early growth stage could not increase the grain yield. Poor grain yield of hybrid rice is mainly caused by high pest infestation and grain sterility in *T. aman* (wet) season.

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