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GROWTH PATTERN OF INBRED AND HYBRID RICE AS INFLUENCED BY CULTIVATION METHODS

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ABSTRACT

A field experiment was conducted at Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during the period from December 2005 to May 2006 to study the influence of cultivation methods on the growth pattern of inbred and hybrid rice in Boro season. The experiment consisted of two level of treatments viz. variety (BRRI dhan 29 and Sonarbangla-1) and cultivation method (P_1, P_2, P_3, P_4, and P_5) and was laid out in a split-plot design with four replications. Growth attributes like plant height, leaf area index and dry matter production of Boro rice at different growth stages and days to flowering and maturity were measured and recorded. The inbred variety under System of Rice Intensification (SRI) showed the largest plant but the nursery seedlings of the same variety resulted the highest dry matter production m^{-2}. The hybrid variety under SRI gave the lowest dry matter. Clonal tillers needed the longest duration and sprouted seeds required the shortest duration to flower and maturity.

Key words: growth pattern, inbred and hybrid rice, cultivation methods

INTRODUCTION

Rice is the most important cereal crop in the world. About 75% of the total cropped area and more than 80% of the total irrigated area of Bangladesh is planted to rice (Hossain and Deb, 2003). The country is now producing about 42.3 million tons of clean rice @ 3.78 t ha^{-1} in 11.2 million ha of land (FAO, 2006). Rice cultivation in Bangladesh is predominantly practiced in transplanting method that involves raising, uprooting and transplanting of seedlings. This is rather a resource and cost intensive method since, preparation of seedbed, raising of seedlings and transplanting are labor and time intensive operations. Labor involvement for these operations consists nearly one third of the total cost of production in Bangladesh. To overcome these difficulties several rice cultivation methods have been developed so far. System of Rice Intensification (SRI), drum seeder technique and clonal tillers are gaining acceptance by the growers day by day.SRI is a set of practices and a set of principles rather than as a "technology package" (Uphoff, 2004). SRI is a system for managing plants, soil, water or nutrient together in mutually beneficial ways, creating synergies (Laulanié, 1993). Vegetative propagation of rice using clonal tillers collected from the mother plant without hampering its yield is also a proven technology especially in adverse environmental situation as well as for expansion of hybrid rice cultivation area (Biswas, 2001). Again, direct wet-seeding is an alternative method of growing rice instead of conventional transplanting (Coxhead, 1984). In this method, sprouted (pre-germinated) seeds are sown on well prepared puddled land (Can and Xuan, 2002). Direct seeding can be done either by hand broadcasting or by using a drum seeder. From the above discussion, the study was undertaken to compare the performance of different cultivation methods using inbred and hybrid rice in Boro season

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MATERIALS AND METHODS

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from December, 2005 to May, 2006. The experimental field belongs to the Madhupur Tract (AEZ-28) with sub tropical climate. Soil pH of the experimental area ranged from 6.1-6.3 with organic matter 1.29%, total N 0.065%, available P 25.2 ppm and exchangeable K 0.12 ml/100 g soil. The experiment was comprised with two varieties viz. inbred variety (BRRI dhan 29)-V_1 and hybrid variety (Sonarbangla-1)-V_2 and five planting techniques viz. sprouted seeds in line (P_1), sprouted seeds broadcast (P_2), nursery seedlings (P_3), SRI (P_4) and clonal tillers (P_5). The experiment was laid out in a split-plot design with four replications having varieties in the main plots and cultivation method in the sub-plots. The size of unit plot was 4.0 m × 3.0 m. The land was fertilized with 120, 80, 80, 20 and 5 kg ha^{-1} of N, P_2O_5, K_2O, S and Zn applied in the form of urea, triple super phosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate, respectively. All the fertilizers except urea were applied as basal dose at final land preparation. Urea was top-dressed in three equal instalments i.e., after seedling recovery, during the vegetation stage and at 7 days before panicle initiation.

Seeds were sown on the seedbed on December 07, 2005 for raising seedlings of nursery seedlings and clonal tillers treatments from which 40 days old seedlings were retransplanted in the same plot on January 15, 2006 with 25 cm × 15 cm spacing. Clonal tillers were separated (30 days after transplanting) from the mother crop by uprooting and splitting and retransplanted on the same plot on February 14, 2006. For SRI, seeds were sown in the portable trays on January 02, 2006, afterwards 14 days old seedlings were uprooted from these trays and transplanted on January 15, 2006 with 40 cm × 40 cm spacing. Sprouted seeds were sown on January 15, 2006 continuously in line with 25 cm row to row distance and in another treatment sprouted seeds were randomly broadcasted on the same day. Two hand weedings were done for every method, first weeding was done at 15 days after direct sowing or transplanting followed by second weeding at 15 days after first weeding. Irrigation water was added to each plot according to the recommended practice. Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting of Sonarbangla-1 was done on April 23, April 26, May 02, May 06 and May 08, 2006 for nursery seedlings, clonal tiller, SRI, sprouted seeds in line and sprouted seeds broadcast, respectively. The harvesting of BRRI dhan 29 was done on May 10, May 14, May 19, May 21 and May 28, 2006 for nursery seedlings, clonal tiller, sprouted seeds in line, sprouted seeds broadcast and SRI, respectively. Ten hills per plot were randomly selected from which plant height and LAI data were collected. Dry matter data were collected by destructive harvest taking 5 hills $plot^{-1}$ in each time. The sample data were oven dried to a constant moisture content and finally converted to g m^{-2}. Data were analyzed following the analysis of variance (ANOVA) technique using MSTAT computer package and the mean differences were adjudged by least significant difference test at 5% level of significance.

RESULT AND DISCUSSION

The plant height of Boro rice varied significantly due to variety at 30, 50 and 70 days after sowing/transplanting (DAS/T) and at harvest (Table 1). The result revealed that at 30 DAS/T, the hybrid variety Sonarbangla-1 produced the tallest plant (46.37 cm) and the inbred variety BRRI dhan 29 gave the shortest plant (39.84 cm). The same trend of plant height of hybrid variety over inbred variety was obtained at 50 and 70 DAS/T. However, at harvest, BRRI dhan 29 produced the tallest

plant (106.31 cm) over Sonarbangla-1 (102.22 cm). The rapid increase of plant height was observed from 30 to 70 DAS/T. Rahman (2001) also observed taller plant in the inbred varieties and shorter plant in Sonarbangla-1.

Significant variation in plant height was found due to different cultivation methods at 30, 50 and 70 days after sowing/transplanting (DAS/T) except at harvest (Table 1). The results revealed that at 30 DAS/T, clonal tillers produced the tallest plant (74.08 cm) followed by the SRI (44.41 cm) which was statistically similar with the nursery seedlings (43.53 cm). Sprouted seeds in line produced the shortest plant (25.89 cm) that was statistically similar with the sprouted seeds broadcast (27.61 cm). The tallest plant (95.47 cm) was recorded at 50 DAS/T from the clonal tillers followed by the nursery seedlings (80.74 cm). Similar trend was also observed at 70 DAS/T. The initial establishment of the transplanted crop depended on seedling vigor and in general, the plants from vegetatively propagated tillers established better as the initial advantage in their height and dry weight resulting in better growth and faster acclimatization to the soil (Sharma, 1995). Sarker *et al.* (2002) observed longer plant in SRI than other studied treatments.

Table 1. Influence of variety and cultivation method on plant height of Boro rice

Treatments	Plant height (cm) at different days after sowing/transplanting			
	30	50	70	At harvest
Variety				
V_1	39.84	69.09	91.94	106.31
V_2	46.37	79.05	95.76	102.22
LSD $_{(0.05)}$	0.64	3.69	2.81	2.76
Cultivation method				
P_1	25.89	60.10	87.27	103.71
P_2	27.61	60.20	88.49	101.98
P_3	43.53	80.74	94.20	106.12
P_4	44.41	73.84	97.24	107.73
P_5	74.08	95.47	102.05	102.15
LSD $_{(0.05)}$	4.21	4.53	3.48	ns
Variety × Cultivation method				
V_1P_1	23.99	54.76	83.67	103.04
V_1P_2	27.04	60.60	87.84	104.47
V_1P_3	40.08	74.28	95.92	109.63
V_1P_4	42.19	64.82	88.43	110.30
V_1P_5	65.88	90.98	103.8	104.13
V_2P_1	27.80	65.43	90.86	104.39
V_2P_2	28.17	59.81	89.14	99.50
V_2P_3	46.99	87.19	92.49	102.60
V_2P_4	46.63	82.85	106.05	105.15
V_2P_5	82.28	99.96	100.25	100.16
LSD $_{(0.05)}$	5.95	6.40	3.48	5.70
CV (%)	9.46	5.92	3.59	3.74

V_1 = BRRI dhan 29, V_2 = Sonarbangla-1, P_1 = Sprouted seeds in line, P_2 = Sprouted seeds broadcast, P_3 = Nursery seedlings, P_4 = SRI and P_5 = Clonal tillers
ns = Not significant

Interaction effect between the variety and cultivation method was significant at 30, 50, 70 DAS/T and at harvest (Table 1). At 30 and 50 DAS/T, clonal tillers of the hybrid variety produced the tallest plant followed by the clonal tillers of the inbred variety and the shortest plant was observed from the sprouted seeds in line of the inbred variety. The higher plant height of clonal tillers at early growth stage might be due to combination of the initial higher weight and the force to quick completion of the life cycle of the clonally propagated crop (Sharma, 1995). At harvest, SRI of the inbred variety produced the tallest plant (110.30 cm) and sprouted seed broadcast of the hybrid variety produced the shortest plant (99.50 cm). Longxing *et al.* (2002) reported that plant height of the hybrid rice with SRI methods was higher than with traditional method.

Leaf area index (LAI)

Varietal effect significantly influenced leaf area index of Boro rice at 50 and 70 DAS/T and at harvest (Table 2). At 50 and 70 DAS/T and at harvest, BRRI dhan 29 produced the maximum leaf area index over Sonarbangla-1. This might be due to production of comparatively lower tillers of the hybrid variety than the inbred variety which consequently decreased the number of leaves plant^{-1} and leaf area index.

Table 2. Influence of variety and cultivation method on LAI matter of Boro rice

Treatments	Leaf area index at different days after sowing/transplanting			
	30	50	70	At harvest
Variety				
V_1	1.09	5.53	7.52	1.75
V_2	1.02	5.49	5.76	1.66
LSD $_{(0.05)}$	ns	0.02	0.75	0.04
Cultivation method				
P_1	0.47	6.34	8.63	1.78
P_2	0.48	6.69	9.58	1.89
P_3	0.83	5.89	5.88	1.72
P_4	0.27	3.00	5.02	1.54
P_5	3.23	5.63	4.09	1.58
LSD $_{(0.05)}$	0.16	0.73	0.78	0.033
Variety × Cultivation method				
V_1P_1	0.46	6.063	8.42	1.84
V_1P_2	0.43	6.76	9.76	1.96
V_1P_3	0.70	5.08	6.46	1.77
V_1P_4	0.31	3.43	6.35	1.56
V_1P_5	3.57	6.33	6.61	1.62
V_2P_1	0.48	6.61	8.84	1.72
V_2P_2	0.52	6.62	9.38	1.83
V_2P_3	0.97	6.70	5.31	1.67
V_2P_4	0.24	2.56	3.69	1.52
V_2P_5	2.89	4.94	1.57	1.55
LSD $_{(0.05)}$	0.23	1.03	1.10	0.046
CV (%)	14.77	12.77	11.37	12.66

V_1 = BRRI dhan 29, V_2 = Sonarbangla-1, P_1 = Sprouted seeds in line, P_2 = Sprouted seeds broadcast, P_3 = Nursery seedlings, P_4 = SRI and P_5 = Clonal tillers

ns = Not significant

Cultivation method significantly influenced leaf area index of Boro rice at 30, 50, 70 DAS/T and at harvest (Table 2). At 30 DAS/T, clonal tillers produced the highest leaf area index (3.23) followed by the nursery seedlings (0.83) and SRI produced the lowest leaf area index (0.27). At 50 and 70 DAS/T

and at harvest, sprouted seeds broadcast produced the highest leaf area index (6.69, 9.58 and 1.89, respectively) that was followed by the sprouted seeds sown in line. This result might be due to higher number of leaves m^{-2} in sprouted seeds. At 50 DAS/T and at harvest, SRI produced the lowest leaf area index (3.00 and 1.54, respectively). However at 70 DAS/T, clonal tillers gave the lowest leaf area index (4.09). Interaction effect of variety and cultivation method significantly influenced leaf area index of Boro rice at 30, 50 and 70 DAS/T and at harvest (Table 2). At 30 DAS/T, use of clonal tillers of BRRI dhan 29 produced the highest leaf area index (3.57) followed by the same treatment of Sonarbangla-1 (2.89). At 50 and 70 DAS/T and at harvest, sprouted seeds broadcast of BRRI dhan 29 produced the highest leaf area index (6.76, 9.79 and 1.96, respectively). At 30 and 50 DAS/T and at harvest, SRI of Sonarbangla-1 produced the lowest leaf area index. However, at 70 DAS/T, clonal tillers of Sonarbangla-1 produced the lowest leaf area index (1.57). Clonal tillers of Sonarbangla-1 required lower duration to complete their life cycle and hence it produced lower leaf area index at 30 and 50 DAS/T and at harvest compared to the other treatments.

Dry matter production

Variety significantly influenced the total dry weight of plant at 30 DAS/T and at harvest (Table 3). At 30 DAS/T, the hybrid variety Sonarbangla-1 produced higher dry matter (99.48 g m^{-2}) compared to the inbred variety BRRI dhan 29 (69.84 g m^{-2}). However at harvest, BRRI dhan 29 produced the highest dry matter (1774.26 g m^{-2}) which was 17.27% higher than Sonarbangla-1 (1512.95 g m^{-2}). The dry matter production of different plant parts was always significantly higher in BRRI dhan 29 compared to Sonarbangla-1 (Table 4).

Table 3. Influence of variety and cultivation method on total dry matter of Boro rice

Treatments	Total dry weight (g m^{-2}) at different days after sowing/transplanting			
	30	50	70	At harvest
Variety				
V_1	69.84	368.62	896.30	1774.26
V_2	99.48	423.69	985.06	1512.95
LSD $_{(0.05)}$	26.72	Ns	ns	251.70
Cultivation method				
P_1	13.55	254.78	934.52	1670.87
P_2	20.54	312.16	905.76	1659.58
P_3	58.75	409.74	887.67	1855.30
P_4	12.79	231.50	702.56	1440.31
P_5	317.66	772.60	1272.89	1591.97
LSD $_{(0.05)}$	22.68	76.72	136.80	136.70
Variety × Cultivation method				
V_1P_1	12.45	211.41	906.22	1785.42
V_1P_2	20.22	275.63	879.36	1737.84
V_1P_3	37.49	359.32	867.98	1863.92
V_1P_4	10.86	206.24	696.42	1742.92
V_1P_5	268.16	790.63	1131.55	1741.23
V_2P_1	14.65	298.15	962.86	1556.32
V_2P_2	20.86	348.73	932.16	1581.33
V_2P_3	80.00	460.19	907.37	1846.68
V_2P_4	14.72	256.82	708.71	1137.71
V_2P_5	367.14	754.56	1414.23	1442.71
LSD $_{(0.05)}$	32.07	Ns	ns	193.34
CV (%)	13.73	12.53	14.09	8.06

V_1 = BRRI dhan 29, V_2 = Sonarbangla-1, P_1 = Sprouted seeds in line, P_2 = Sprouted seeds broadcast, P_3 = Nursery seedlings, P_4 = SRI and P_5 = Clonal tillers, ns = Not significant

Cultivation method significantly influenced the total dry matter production of Boro rice at 30, 50 and 70 DAS/T and at harvest (Table 3). At 30 DAS/T, clonal tillers produced the highest dry matter

(317.66 g m^{-2}) followed by the nursery seedlings (58.75 g m^{-2}) and SRI produced the lowest dry matter (12.79 g m^{-2}). Similar trend of dry matter production was also observed at 50 DAS/T. At 70 DAS/T, clonal tillers produced the highest dry matter (1272.89 g m^{-2}) followed by the sprouted seeds in line (934.52 g m^{-2}). Sharma and Ghosh (1998) also observed highest dry matter in clonally propagated crop compared to the nursery seedlings. SRI produced the highest dry matter (702.56 g m^{-2}). At harvest, nursery seedlings produced the highest dry matter (1855.30 g m^{-2}) and SRI produced the lowest dry matter (1440.31 g m^{-2}). However, Sarkar *et al.* (2003) reported that the crops from anaerobic direct sowing had greater above-ground dry matter than transplanting.

The dry matter production of different plant parts at harvesting time was recorded which showed cultivation method influenced dry weight of all parts (Table 4). Nursery seedlings produced the highest dry matter of grain, stem, leaf and panicle. However, the sprouted seeds broadcast produced the highest dry matter of leaf sheath. SRI produced the lowest dry matter of all plant parts.

Interaction effect of variety and cultivation method influenced the dry matter production of Boro rice at 30 DAS/T and at harvest (Table 3). At 30 DAS/T, clonal tillers of Sonarbangla-1 produced the highest dry matter (367.15 g m^{-2}). At harvest, the nursery seedlings of the inbred variety produced the highest dry matter (1863.92 g m^{-2}) which was similar with the nursery seedlings of Sonarbangla-1 1846.68 g m^{-2}) and sprouted seeds in line of BRRI dhan 29 (1785.42 g m^{-2}), whereas, SRI of Sonarbangla-1 produced the lowest dry matter (1137.71 g m^{-2}).
In case of the dry matter production of different plant parts at harvesting, only dry weight of grain and stem was statistically influenced by the interaction effect of variety and cultivation method (Table 4).

Table 4. Influence of variety on dry matter production of different plant parts at harvest

Treatments	Grain (g m^{-2})	Panicle (g m^{-2})	Leaf (g m^{-2})	Leaf sheath (g m^{-2})	Stem (g m^{-2})
Variety					
V_1	753.22	74.71	310.13	343.92	272.39
V_2	812.03	64.93	201.53	223.56	207.99
LSD $_{(0.05)}$	44.57	4.27	70.45	88.41	58.05
Cultivation method					
P_1	795.20	71.49	283.24	299.07	221.98
P_2	745.96	71.73	275.88	318.95	238.02
P_3	745.96	74.88	305.91	296.34	306.22
P_4	726.91	49.58	175.14	231.11	210.07
P_5	778.91	81.41	238.99	273.24	224.67
LSD $_{(0.05)}$	43.09	12.52	49.46	55.09	60.71
Variety × Cultivation method					
V_1P_1	706.94	77.11	348.68	372.26	280.44
V_1P_2	636.76	80.94	346.39	394.3	281.94
V_1P_3	885.56	71.44	315.93	309.28	281.74
V_1P_4	739.58	57.58	242.02	312.76	289.01
V_1P_5	797.28	86.48	297.64	331.02	228.8
V_2P_1	883.45	65.87	217.8	225.89	163.51
V_2P_2	855.16	62.53	205.36	243.59	194.09
V_2P_3	846.73	78.32	295.90	283.40	330.70
V_2P_4	714.25	41.58	108.27	149.45	131.13
V_2P_5	760.53	76.34	180.34	215.47	220.53
LSD $_{(0.05)}$	60.94	ns	ns	ns	85.86
CV (%)	5.33	7.38	11.73	12.81	14.49

V_1 = BRRI dhan 29, V_2 = Sonarbangla-1, P_1 = Sprouted seeds in line, P_2 = Sprouted seeds broadcast, P_3 = Nursery seedlings, P_4 = SRI and P_5 = Clonal tillers, ns = Not significant

Days to flowering and maturity

The flowering and maturity dates significantly varied between the varieties (Table 5), where the inbred variety BRRI dhan 29 needed longer time for flowering (108 days) and maturity (143 days) compared to the hybrid variety Sonarbangla-1. The hybrid variety matured 17 days earlier than the inbred variety. This might be due to the shortest life span of Sonarbangla-1 compared to that of BRRI dhan 29.

Different cultivation methods affected flowering and maturity dates of both the varieties (Table 5). The clonal tillers needed the longest duration for both flowering (116 days) and maturity (150 days). It required 3 days more for maturity than that of the nursery seedlings. This might be due to regrowth of the clonal tillers. The nursery seedlings needed the second highest duration both for flowering (111 days) and maturity (147 days). In SRI grain matured 13 days earlier than that of the nursery seedlings. Uphoff (2005) reported that SRI required less duration for maturity. Sprouted seeds in line needed the lowest duration both for flowering (83 days) and maturity (119 days). The sprouted seeds in line and sprouted seeds broadcast matured 28 and 26 days earlier than that of the nursery seedlings, respectively. Field duration of the crop was considerably reduced in direct seeded rice might be due to the absence of 'transplanting shock'. Direct seeding enhanced crop establishment and vegetative growth and reduced crop duration by two weeks (Javellana *et al.*, 1988).

Interaction effect of variety and cultivation method significantly influenced the flowering and maturity dates (Table 5). Clonal tillers of BRRI dhan 29 required the longest duration for flowering (125 days) and sprouted seeds broadcast of Sonarbangla-1 needed the shortest duration for flowering (72 days). Similar trend was observed in maturity, where clonal tillers of BRRI dhan 29 needed the longest duration (159 days) and sprouted seeds in line of Sonarbangla-1 required the shortest duration (112 days).

Table 5. Influence of variety and cultivation method on flowering and maturity duration of Boro rice

Treatment	Days to flowering	Days to maturity
Variety		
V_1	108	143
V_2	88	126
LSD $_{(0.05)}$	0.19	0.35
Cultivation method		
P_1	83	119
P_2	83	121
P_3	111	147
P_4	98	134
P_5	116	150
LSD $_{(0.05)}$	0.16	0.33
Variety × Cultivation method		
V_1P_1	93	125
V_1P_2	92	127
V_1P_3	117	155
V_1P_4	112	147
V_1P_5	125	159
V_2P_1	72	112
V_2P_2	73	114
V_2P_3	104	138
V_2P_4	84	121
V_2P_5	106	141
LSD $_{(0.05)}$	0.23	0.46
CV (%)	3.16	5.24

V_1 = BRRI dhan 29, V_2 = Sonarbangla-1, P_1 = Sprouted seeds in line, P_2 = Sprouted seeds broadcast, P_3 = Nursery seedlings, P_4 = SRI and P_5 = Clonal tillers

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