Study on the dry matter accumulation and distribution in BRRIdhan 29 as affected by planting density

M. Shahaduzzaman, M.N. Bari, M. E. Haque[1], R.C. Dey[1] and F. Ahmed[1]
Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur,
and [1]Department of Agricultural Extension, Khamarbari, Dhaka.

Abstract: A field experiment was conducted at the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during *boro* season (2009-10) to study the dry matter accumulation and distribution in BRRIdhan29 as affected by planting density. taking two hybrid varieties viz. IR68877H and IR696960H for comparison seven planting densities which constituted the experimental variables are T_1; IR68877H at 27 hills m^{-2} (25 cm x15 cm), T_2; IR69690H at 27 hills m^{-2} (25 cm x15 cm), T_3; BRRI dhan 29 at 27 hills m^{-2} (25 cm x15 cm), T_4; BRRIdhan 29 at 40 hills m^{-2} (25 cm x10 cm), T_5 ; BRRIdhan 29 at 50 hills m^{-2} (20 cm x10 cm), T_6 ; BRRIdhan 29 at 67 hills m^{-2} (15 cm x10 cm) and T_7; BRRIdhan 29 at 111 hills m^{-2} (15 cm x 6cm). The experiment was laid out in a complete block design (RCBD) with three replications where unit plots were 5m x 3m with a distance of plot to plot 1m and block to block 1.5 m. Destructive plant samplings were done at 15 days interval starting from 21 DAT to maturity. Data revealed that Total dry matter (TDM) accumulation over time varied considerably due to variety as well as population density. Among the rice varieties at standard population density, TDM production at maturity was the highest in BRRIdhan 29 (1497.17 g m^{-2}). Among the density treatments of BRRIdhan 29, T_5 (50 hills m^{-2}) treatment produced the highest TDM (2032 g m^{-2}) which was followed closely by T_7 (111 hills m^{-2}) treatment (1977.6 g m^{-2}).
Key words: Dry matter, rice varieties, planting density, distribution.

Introduction

Rice is the highest growing crop in Bangladesh in respect of area and production. The past increase in rice production came mainly from allocation of land from local varieties to modern varieties. Since the land is constant as well as a gradual decline in per capita land area is fact, the only option remaining is to increase production per unit area. Among cultural technology application, the best planting space is the important one (Barari *et al.,* 2007). When the plant density exceeds an optimum level, competition among plants for light above ground or for nutrients below the ground becomes severe, consequently the plant growth slows down and the grain yield decreases. Therefore, it is necessary to determine the optimum plant spacing and the number of seedlings per hill for high yield (Hasanuzzaman *et al.,* 2009). Omidi (1998) applied source restriction and different planting density on commercial long-duration corn hybrids and asserted that dry matter remobilization rate of crop's aerial organs (leaf, stem and husk) plays a crucial role in grain filling of corn hybrids. He stated that their combinations to dry matter remobilizations in grain filling are different and stem plays a more important role in this regard. Tahmasebi Sarvestani and Pirdashti (2001) reported that dry matter remobilization of shoot (stem + flag leaf + other leaves) had an important effect on grain dry matter accumulation. Improvement in yield of crops can be achieved either by increasing the amount of total dry matter or by raising the proportion of economic portion. A high positive correlation between above ground dry matter and yield was observed by Yoshida (1972). Tanaka (1983) further mentioned that total dry matter produced crop growth rate, plant density and growth duration and was positively correlated with leaf area. Murty and Murty (1981) again found that the closer spacing increased dry matter production per square mater area. Actually the yield was approximately the product of total dry matter and the panicle straw ratio. Spacing determines not only the intensity of intra-varietal competition for light, water and nutrient but also the dry matter partitioning between the organs. The current research is intended to assess the effects of planting density on grain and biological yield and also dry matter remobilization in different rice varieties.

Materials and Methods

The field experiment was conducted at the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur under wet land condition during *boro* season (2009-10) to study the dry matter accumulation and distribution of three rice varieties as affected by planting density. The rice varieties were BRRI dhan 29, hybrid IR68877H and IR69690H and five planting densities constituted the experimental variables as T_1; IR68877H at 27 hills m^{-2} (25 cm x15 cm), T_2; IR69690H at 27 hills m^{-2} (25 cm x15 cm), T_3; BRRIdhan 29 at 27 hills m^{-2} (25 cm x15 cm), T_4; BRRIdhan 29 at 40 hills m^{-2} (25 cm x10 cm), T_5 ; BRRIdhan 29 at 50 hills m^{-2} (20 cm x10 cm), T_6 ; BRRIdhan 29 at 67 hills m^{-2} (15 cm x10 cm) and T_7; BRRI dhan 29 at 111 hills m^{-2} (15 cm x 6 cm). The soil was silty clay of shallow red brown terrace type under Salna Series of Madhupur Tract containing a p^H of 6.5. The experiment was laid out in a complete block design (RCBD) with three replications where unit plots were 5m x 3m with a distance of plot to plot 1m and block to block 1.5 m. At the time of final land preparation cowdung was added @ 10 t hac^{-1} and K, S and Zn were applied @ 60, 12 and 3 kg ha^{-1} respectively. The rates of N were 124, 184, 230, 308 and 510 for the plant population of 27, 40, 50, 67 and 111 hills m^{-2} respectively and it was applied in four equal installments at basal, maximum tillering, panicle initiation and flowering stage. Thirty five days old one rice seedling was transplanted in each hill and gap filling was done after two weeks of transplanting with the same aged seedlings. Adequate intercultural practices were done to keep weed, insect-pest infestation at minimum level and a 2 to 4 cm standing water was maintained in the field until the varieties attained at hard dough stage. Destructive plant samplings were done at 15 days interval starting from 21 DAT to maturity and at each sampling; ten plants per plot were uprooted sequentially from second or third rows of each variety to avoid border effect. Sampled plant parts were separated as green leaf, dead leaf, leaf sheath, stem and panicles and oven dried at 70° C for 72 hours, weighted and then calculated the mean of ten hills in every cases. Data recorded for different parameters were put to analysis of variance (ANOVA) and the means were compared using the Least Significant Different (LSD) test.

Results and Discussion

Dry matter accumulation: Total dry matter accumulation over time varied considerably due to variety as well as population density. Among the rice varieties at standard population density, TDM production at maturity was the highest in BRRIdhan 29 (1497.17 g m^{-2}) which was closely followed by IR69690H (1418 g m^{-2}), while IR68877H lagged behind considerably with 1205 g m^{-2}.

In BRRI dhan29, however, TDM did not increase linearly with increasing population density. Rather, only T_5 (50 hills m^{-2}) treatment produced the highest TDM (2032 g m^{-2}) which was followed closely by T_7 (111 hills m^{-2}) treatment (1977.6 g m^{-2}) (Table1). Although contribution of dense stand to higher dry matter accumulation is well recognized (Talukder, 1998), in this study, it was revealed that population density up to a certain limit (50 hills m^{-2}) contributed to higher TDM accumulation beyond which TDM production declined. It might be due to that in highly dense stands sunlight could not penetrate sufficiently to the lower canopy for photosynthetic activities and led to poor dry matter production.

Dry matter distribution

Green leaf dry matter: Green leaf dry matter increased gradually reaching a peak at around flowering stage and the rate of growth varied with rice varieties. In this regard, BRRIdhan 29 (206.6 g m^{-2}) and IR69690H (191.4 g m^{-2}) required 81 days after transplanting to attain peak in green leaf dry matter, while IR68877H needed only 66 days (105.6 g m^{-2}) (Table 2).Green leaf dry matter declined gradually after the flowering stage and continued till maturity. Among the varieties IR69690H showed the highest decline in green leaf mass during the period of maximum growth and maturity (-32.16%) at standard density and the least was observed in IR68877H (-23.41%). Among the population density treatments of BRRIdhan 29, the highest rate of decline (-71.66%) was incurred by the T_7 treatment (111 hills m^{-2}), while the least and lowest loss (-14.85%) was incurred by the treatment T_4 treatment (40 hills m^{-2}). Results revealed that higher population densities up to 67 hills m^{-2} contributed to lower loss of green leaf mass till maturity which might be indicative to continued photosynthetic activity.

Table 1. Total dry matter (g m^{-2}) accumulation over time as affected by variety and population density

Treatment	Total dry matter (g m^{-2})							
	21 DAT	36 DAT	51 DAT	66 DAT	81 DAT	96 DAT	111 DAT	126 DAT
T_1	2.78	23.60	169.4	335.0	744.0	935.1	1204.5	-
T_2	1.93	15.67	175.5	425.0	809.2	1055.2	1405.3	1418.2
T_3	1.36	13.72	122.7	350.3	669.0	953.1	1391.0	1497.2
T_4	2.71	23.03	207.8	521.9	924.96	1250.0	1710.0	1859.0
T_5	3.25	25.98	281.9	609.4	1090.7	1290.7	1758.3	2032.0
T_6	3.88	28.47	306.4	751.4	1220.2	1405.1	1808.0	1987.1
T_7	6.86	69.90	479.1	1023.4	1520.1	1590.0	1896.9	1977.6
LSD (0.05)	0.67	2.59	27.84	48.34	81.37	160.4	210.8	125.1
CV (%)	11.58	5.08	6.29	4.68	4.59	7.44	7.42	4.52

T_1 = IR68877H at 27 hills m^{-2}; T_2 = IR69690H at 27 hills m^{-2}; T_3, T_4, T_5, T_6 and T_7 = BRRIdhan 29 at 27, 40, 50, 67 and 111 hills m^{-2} respectively.

Table 2. Green leaf dry weight (g m^{-2}) of three rice varieties at different days after transplanting

Treatment	Green leaf dry weight (g m^{-2})							
	21 DAT	36 DAT	51 DAT	66 DAT	81 DAT	96 DAT	111 DAT	126 DAT
T_1	1.430	12.63	57.38	105.6	104.5	84.20	80.04	0.00
T_2	1.028	8.338	62.42	108.4	191.4	221.4	155.2	151.2
T_3	0.7596	7.645	49.34	131.4	206.6	187.4	159.8	145.4
T_4	1.659	12.77	77.92	136.4	211.0	253.9	229.9	216.2
T_5	1.917	14.52	103.5	190.1	268.1	276.3	266.7	227.7
T_6	2.202	15.94	104.00	190.0	312.2	298.6	295.4	250.2
T_7	3.870	37.73	194.9	342.6	536.3	439.9	286.2	152.0
LSD (0.05)	0.5396	1.606	25.03	41.50	63.56	46.28	43.90	26.90
CV(%)	16.50	5.77	15.16	13.41	13.66	10.33	11.72	9.26

Leaf sheath dry matter: Dry matter accumulation in leaf sheath continued to increase beyond flowering stage (81 DAT) in all the rice variety. At 81 DAT the highest amount of leaf sheath dry matter was found in IR69690H (385.5 g m^{-2}) which was followed by BRRIdhan 29 (313.7 g m^{-2}) and the least was in IR68877H (232.2 g m^{-2}). In case of BRRIdhan 29, leaf sheath mass was found to increase with increasing population density with the highest being in the T_7 (111 hills m^{-2}) treatment (Table 3). Leaf sheath dry matter decreased from 81 DAT onwards. It might be due to the translocation of assimilates towards panicle, since leaf sheath works as a major transition store house of carbohydrate towards panicle (Bonnet and Incoll, 1992). Among the rice varieties, the highest loss in leaf sheath mass up to maturity was observed in (-38.16%) with the least in IR68877H (-8.05%). Considering the different plant densities of BRRIdhan 29, the highest loss in leaf sheath dry matter was incurred by the treatment T_7 (111 hills m^{-2}) (-36.66%) and the least was by T_5 treatment (40 hills m^{-2}) (-2.48%) (Table 6). Results revealed that increasing population density did not necessarily contributed to higher or equal translocation of dry matter from the leaf sheath.

Table 3. Leaf sheath dry weight (g m^{-2}) of three rice varieties at different days after transplanting

Treatment	Leaf sheath dry weight (g m^{-2})							
	21 DAT	36 DAT	51 DAT	66 DAT	81 DAT	96 DAT	111 DAT	126 DAT
T_1	1.349	10.97	99.03	184.3	232.2	222.7	213.5	0.00
T_2	0.8997	7.394	100.2	151.2	385.5	424.8	276.1	262.7
T_3	0.6030	6.080	66.58	156.0	313.7	365.9	287.4	278.5
T_4	1.053	10.26	122.3	161.8	338.6	396.8	353.9	314.6
T_5	1.330	11.46	159.0	220.7	380.3	395.6	387.6	385.8
T_6	1.679	12.52	185.0	234.9	426.6	418.1	382.4	333.0
T_7	2.990	32.17	256.9	324.2	543.9	494.9	388.2	307.1
LSD (0.05)	0.2977	1.638	20.09	15.20	46.39	59.77	87.00	62.40
CV(%)	11.75	7.10	7.99	4.17	6.96	8.65	14.95	12.77

Table 4. Dead leaf and panicle dry weight (g m^{-2}) of three rice varieties at different days after transplanting

Treatment	Dead leaf dry weight (g m^{-2})				Panicle dry weight (g m^{-2})			
	21 DAT	96 DAT	111 DAT	126 DAT	81 DAT	96 DAT	111 DAT	126 DAT
T_1	28.71	44.28	58.34	0.00	216.6	436.6	705.1	0.00
T_2	30.23	31.99	42.72	69.58	29.08	217.4	498.0	743.9
T_3	26.51	35.50	51.46	59.77	32.42	190.4	703.44	811.2
T_4	31.10	45.36	60.21	67.27	53.12	347.8	828.6	1001.0
T_5	44.66	42.71	61.78	118.9	84.41	318.9	858.1	1081.0
T_6	47.95	53.22	71.11	123.0	87.22	313.6	825.3	940.6
T_7	74.59	86.14	125.0	307.1	162.9	314.3	830.6	918.0
LSD (0.05)	13.74	6.62	5.65	12.89	9.82	60.59	145.6	66.49
CV(%)	19.05	7.68	4.73	6.80	5.84	11.15	10.92	4.76

Table 5. Stem dry weight (g m^{-2}) of three rice varieties at different days after transplanting

Treatment	Stem dry weight (g m^{-2})					
	51 DAT	66 DAT	81 DAT	96 DAT	111 DAT	126 DAT
T_1	12.94	45.12	159.9	147.3	147.5	0.00
T_2	12.86	22.1	106.4	159.6	178.0	190.8
T_3	6.812	22.88	89.80	173.9	203.0	202.3
T_4	12.55	23.73	94.24	219.3	237.7	259.9
T_5	18.59	31.93	113.2	239.6	241.2	289.0
T_6	16.36	26.43	119.6	221.6	254.8	265.3
T_7	27.27	56.61	202.4	251.2	266.9	268.96
LSD (0.05)	3.06	2.94	21.95	49.91	42.92	20.08
CV(%)	11.23	4.72	9.75	13.90	11.01	5.35

Table 6. Change in different dry matter as affected by variety and population density

Treatment	Period (DAT)	Percent change of different dry matter					
		Green leaf dry matter	Leaf sheath dry matter	Dead leaf dry matter	Panicle dry matter	Stem dry matter	Total dry matter
T_1	81-111	-23.41*	-8.05*	103.2**	231.66***	-7.88***	61.89***
T_2	81-126			130.17**	2458.12***	79.32***	75.25***
T_2	96-126	-32.16*	-38.16*				
T_3	81-126	-29.64*		125.46**	2402.16***	125.28***	123.79***
T_3	96-126		-23.89*				
T_4	81-126			116.30**	1784.41***	175.79***	100.98***
T_4	96-126	-14.85*	-20.72*				
T_5	81-126			166.23**	1180.65***	155.30***	86.34***
T_5	96-126	-17.59*	-2.48*				
T_6	81-126	-19.86*	-21.94*	156.52**	978.42***	121.82***	62.85***
T_7	81-126	-71.66*	-36.66*	311.72**	463.54***	27.96***	30.09***

* Period indicates from the point of maximum accumulation up to maturity. ** Period indicates from the point of first sampling up to maturity.*** Period indicates from the point of first sampling for panicle dry matter up to maturity. T_1 = IR68877H at 27 hills m^{-2}; T_2 = IR69690H at 27 hills m^{-2}; T_3, T_4, T_5, T_6 and T_7 = BRRI dhan 29 at 27, 40, 50, 67 and 111 hills m^{-2} respectively.

Dead leaf dry matter: Dead leaf mass followed similar trends in BRRIdhan 29, IR69690H and IR68877H at standard plant density. From 81 DAT up to maturity the growth rate of dead leaf mass was the highest in IR69690H (130.17 %) and the least (103.20 %) was observed in IR68877H. Among the density treatments of BRRIdhan 29 dead leaf mass also increased with increasing population density except T_4 (40 hills m^{-2}) where the rate was the least among the density treatments. In the T_7 (111 hills m^{-2}) treatment the rate of increase in dead leaf mass was up to maturity the highest (311.72%) (Table 6). It might be due to severe competition for light and other growth resources. The result is similar with the findings of Gupta (1995) that in closer spacing the lower leaves do not get sufficient light and their contribution to assimilation might be very poor or even negative.

Panicle dry matter: Among the varieties at standard density, BRRIdhan 29 produced the heaviest panicles (811.20 g m^{-2}) and the lightest were observed in IR68877H (705.10 g m^{-2}) (Table 4). However, the growth rate of panicles was the highest in IR69690H (2458.12%) and it was the least IR68877H (231.66%). It might be due to that this variety matured 15 days earlier than the other two varieties. Among the density treatments of BRRIdhan 29, the heaviest panicles was observed in the T_5 (50 hills m^{-2}) treatment (1081 g m^{-2}) and it was followed by T_4 (40 hills m^{-2}) treatment (1001 g m^{-2}) (Table 4). The lightest panicles were observed in the standard spacing treatment (811.2 g m^{-2}). But the highest growth rate (2402.16%) over time was observed in standard density (27 hills m^{-2}) treatment while the least (463.54%) was in the highest density treatment (111 hills m^{-2}) (Table 6).

Stem dry matter: At maturity, BRRIdhan 29 accumulated the highest dry matter in stem (202.3 g m^{-2}), while the least was observed in IR68877H. From 81 DAT till maturity BRRIdhan 29 and IR69690H gained dry matter in their stem by 125.28% and 79.32%, while IR78877H incurred slight loss (-7.88%) indicating probable stem reserve translocation towards panicle (Table 6). In case of BRRIdhan 29 at different spacing, T_5 (50 hills m^{-2}) produced the highest stem mass (289 g m^{-2}), while the least (202.30 g m^{-2}), was by the T_3 treatment (27 hills m^{-2}) at maturity. However, the rate of increase in stem mass was the highest in T_4 (40 hills m^{-2}) treatment with 175.79% increase and the least was observed in T_7 (111 hills m^{-2}) treatment with only 27.96% increase (Table 6). Results revealed that among the varieties and population densities stem reserve translocation was apparent in IR68877H compared to other two varieties.

References

Barari, T.D., Pirdasti, H., Nasiri, M., Gazanchian, A. and Hoseini, S. 2007. Determination of morphological characteristics affected by different agronomical treatments in rice (IR-687-3-2 promising line).Asian Journal of Plant Science, 6(1):61-65.

Bonnet, G.D., and Incoll, L.D. 1992. The Potential pre-anthesis and post-anthesis contributions of stem internodes to grain yield in crop of winter barley. Ann. Bot., 69: 219-225.

Gupta, U.S. 1995. Physical Principles of Dryland Crop Production, Pp. 1-165. In: Production and Improvement of Crops for Drylands. U.S. Gupta (ed.). Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi.

Hasanuzzaman, M., Rahman, M.L., Roy, T.S., Ahmed, J.U. and Zobaer, A.S.M. 2009. Plant characters, yield components and yield of late transplanted *Aman* rice as affected by plant spacing and number of seedling per hill. Advances in Biological Res, 3(5-6):201-207.

Murty, P.S.S. and Murty, M.S. 1981. Effect of spacing on the physiological attributes of two high yielding long duration rice cultivars. Oryzae, 17(2): 148-150.

Omidi, H.1998. Effects of plant density and source limitation on yield, yield components and dry matter and nitrogen remobilization in corn. Thesis of M.Sc. Agricultural faculty of Tarbiat Modarres University, pp: 200.

Tahmasebi Sarvestani,Z. and Pirdasti, H. 2001. Dry matter and nitrogen remobilization of rice genotypes under different transplanting dates. Proceedings of the 10th Australian Agronomy Conference.

Talukder, M.A.M. 1998. Planting density effects on productivity of old and modern varieties of rice in relation to canopy structure and light interception. Ph D. Dissertation, BSMRAU, Gazipur, Bangladesh.

Tanaka, A.1983. Physiological aspects of productivity. *In:* Potential productivity of field crops under different environments. Intl. Rice Res. Inst. Los Banos, Philippines. Pp. 61-99.

Yoshida, S. 1972. Growth rate and plant characters of rice varieties in relation to nitrogen application. Indian J. Agric. Sci. 60 (100:246.