Influence of Rice Straw and Water Hyacinth Incorporation on the Performance of *Boro* Rice

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Abstract

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka from November, 2009 to May, 2010 to find out the effect of rice straw and water hyacinth incorporation into the soil on the performance of boro rice. The treatments of the experiment consisted of two rice varieties viz., BRRI dhan29 and BRRI hybrid dhan2, two biomass materials *viz*., rice straw and water hyacinth; and three levels of biomass concentration viz., control (no biomass), 0.5 kg biomass m^{-2} and 1.0 kg biomass m^{-2}. The experiment was laid out in a double split plot design with three replications having varieties in the main plot, biomass materials in the sub plot and concentrations in the sub sub-plot. Significantly higher grain yield of rice (6.90 t ha^{-1}) and harvest index (49.27) was obtained from BRRI hybrid dhan2 as compared to BRRI dhan29 (6.08 t ha^{-1} and 41.27) , however, significantly higher straw yield (8.64 t ha^{-1}) was registered with the latter variety.

1. Introduction

Rice (*Oryza sativa* L.) is the staple food of over half of the world's population. It is the grain with the second-highest worldwide production and predominant dietary energy source for 17 countries in Asia. The total acreage of rice was nearly 160 million hectares worldwide which produced more than 700 million tons grains every year (IRRI, 2013). The total production of rice in Bangladesh was 34.35 million metric tons from 11.35 million hectares of land in the fiscal year 2010-2011 (BBS, 2011). But there was a deficit of 1.27 million metric tons of rice in that year. In Bangladesh rice is grown under diverse ecosystems, irrigated, rainfed and deep water condition in three distinct seasons namely *aus, aman* and *boro* where *boro* covers the lion share of about 4.70 million hectare of land producing 18.65 million metric tons of rice (BBS, 2010). Bangladesh is an agriculture based country where about 84% of the total population lives in rural areas. Agriculture shares about 19.95% GDP (gross domestic product) of the country and 62% people directly involved with agriculture (BBS, 20011). The cultivation cost of different crops is gradually increasing due to the high prices of inputs. The soil health of Bangladesh is tremendously deteriorated due to intensive agriculture resulting in lower organic matter status of the soil thus lower yield (Bhuiyan, 1987). Hence, emphasis has to be given low cost, high profit and environmentally safety agriculture. Management plays an important role on crop production. Water hyacinth (*Eichhornia crassipes*) is free-floating perennial aquatic plant native to tropical and sub-tropical South America. With broad, thick, glossy, ovate leaves they grow in our country as an aquatic weed. They have long, spongy and bulbous stalks. Water hyacinth contains only 4.50% dry matter of which 75.80% organic matter, 1.5% nitrogen and 24.20% ash those enhances plant growth (Gohl, 1981). In Bangladesh most of the produced water hyacinth remains unused. Fresh water hyacinth can be used to increase the organic status in the soil. Another raw material is rice straw which can be used to improve the soil fertility which otherwise is burnt by the farmers. Considering that water hyacinth and rice straw is abundant residue in Bangladesh with little use, it was considered interesting to include it in the present study. Considering the above context the experiment was designed to compare the effectiveness, suitability and optimum concentration of rice straw and water hyacinth in improving soil health and performance of *boro* rice.

2. Materials and Methods

The field experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University (SAU), under the agro-ecological zone of Modhupur Tract, AEZ-28, during *boro* season (November to May) 2009-2010 with a view to finding out the effect of rice straw and water hyacinth biomass on the

performance of *boro* rice. Geographically the experimental area was located at 24˚75́ N and 90˚50́ E longitude at the elevation of above 8.6 m the sea level. The farm belongs to the Shallow Red Brown Terrace Soils under Tejgaon Series. The experiment was laid out on double split-plot design with three replications having variety in the main plot and biomass materials in the sub plot and concentration of biomass materials in sub sub-plot. There were two varieties viz., BRRI dhan29, BRRI hybrid dhan2, two biomass materials viz., Rice straw and water hyacinth and three concentration viz., control (no biomass application), application of 0.50 kg and 1.00 kg biomass m^{-2}. The experimental plots were fertilized with 5 t ha^{-1} cowdung 15 days before transplanting, 120, 40, 45, 5 and 5 kg ha^{-1} of N (urea), P_2O_5 (TSP), K_2O (MoP), S (gypsum) and Zn (Zinc sulphate), respectively applied during final land preparation except urea. Urea top dressed in 3 equal splits at 7, 33 and 55 DAT. Pre-germinated seeds of BRRI dhan29 and BRRI hybrid dhan2 were sown in the wet seedbed and proper care was taken to raise the seedlings in seedbed. Thirty days old seedling was transplanted maintaining the spacing of 25 cm×15 cm on the well puddled plots. Intercultural operations were done when necessary. Maturity of crop was determined when 90% of the grains become golden yellow in color. Three square meters at centre of each plot was harvested, dried, threshed and adjusted at 12% moisture content to estimate the grain yield. The yield contributing characters viz. number of effective tillers $hill^{-1}$, number of grains $panicle^{-1}$ and 1000-grain weight was recorded from plant samples. The data were analyzed statistically using the IRRISTAT (Version 4.0, IRRI, Philippines) computer package program developed by IRRI. The mean differences among the treatments were compared by Least Significant Difference Test (LSD) at 5% level of significance.

3. Results and Discussion

3.1. Effect of variety

The higher number of effective tillers $hill^{-1}$ (16.89), unfilled grains $panicle^{-1}$ (17.33) and straw yield (8.64 t ha^{-1}) was recorded by BRRI dhan29 whereas the higher non-effective tillers $hill^{-1}$ (4.17), 1000-grains weight (26.04 g), grain yield (6.92 t ha^{-1}) and harvest index (49.27%) by the hybrid variety BRRI hybrid dhan2 (Table 1 and Table 2). The grain yield of hybrid variety was 12.14% higher than the inbred variety. Similar higher yield of hybrid variety over inbred one was also reported by Julfiquar et al. (1998).

3.2. Effect of biomass materials

Only the straw yield was found significant for variation in biomass materials. The higher straw yield (8.31 t ha^{-1}) was obtained from water hyacinth incorporated plots whereas rice straw incorporated plots produced the lower amount (7.48 t ha^{-1}) of straw (Table 2).

3.3. Effect of biomass concentration

No significant variation was found for yield attributes and yields of rice due to the various concentrations of biomass materials (Table 1 & 2).

3.4. Interaction effect

Significant variations were observed for effective tillers $hill^{-1}$, non effective tillers $hill^{-1}$, filled grains $panicle^{-1}$, unfilled grains $panicle^{-1}$, weight of 1000-grains, grain yield, straw yield and harvest index from the interaction effect of variety and biomass (Table 1 and Table 2). The highest effective tillers $hill^{-1}$ (16.89) was recorded from BRRI dhan29 with rice straw that was identical (16.89) to the same variety with water hyacinth. The lowest number of effective tillers $hill^{-1}$ (12.67) was recorded from BRRI hybrid dhan2 with water hyacinth that was similar (12.78) to the same variety with rice straw. The highest number of non-effective tillers $hill^{-1}$ (4.78) was recorded from BRRI hybrid dhan2 with water hyacinth that was similar to the same variety with rice straw. The lowest number of non-effective tillers $hill^{-1}$ (2.22) was observed from BRRI dhan29 with rice straw that was similar to the same variety with water hyacinth and BRRI hybrid dhan2 with rice straw. The highest number of filled grains $panicle^{-1}$ (128.89) was recorded from BRRI hybrid dhan2 with rice straw that was similar to BRRI dhan29 with water hyacinth and BRRI hybrid dhan2 with the same biomass. The lowest number of filled grains $panicle^{-1}$ (114.89) was recorded from BRRI dhan29 with rice straw that was similar to the same variety with water hyacinth and BRRI hybrid dhan2 with the same biomass. The highest number of unfilled grains $panicle^{-1}$ (17.56) was observed from BRRI dhan29 with rice straw that was similar (17.11) to the same variety with water hyacinth (Table 1). The lowest number of unfilled grains $panicle^{-1}$ (14.44) was recorded from BRRI hybrid dhan2 with rice straw that was similar (14.89) to the same variety with water hyacinth. The highest weight of thousand grains (26.20 g) was recorded from BRRI hybrid dhan2 with water hyacinth incorporation which was similar (25.88) to the same variety with rice straw biomass. The lowest weight of thousand grains (19.48 g) was found from BRRI dhan29 with rice straw incorporation which was similar (19.68) to the same variety with water hyacinth biomass. The highest grain yield (7.33 t ha^{-1}) was recorded from BRRI hybrid dhan2 with water hyacinth incorporation which was similar to the same variety with rice straw. The lowest grain yield (6.00 t ha^{-1}) was found from BRRI dhan29 with rice straw incorporation which was similar to the same variety with water hyacinth (Table 2). The highest straw yield (9.23 t ha^{-1}) was recorded from BRRI hybrid dhan29 with water hyacinth incorporation. The lowest straw yield (6.91 t ha^{-1}) was found from BRRI hybrid dhan2 with rice straw which was similar to the same variety with water hyacinth incorporation. The highest harvest index (49.84%)

Table 1: Yield attributes of rice as affected by variety, type and concentration of biomass

Treatments	Effective tillers hill^{-1}	Ineffective tillers hill^{-1}	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Test wt. (g)
Variety					
V_1	16.89	2.28	117.78	17.33	19.58
V_2	12.72	4.17	123.67	14.67	26.04
CD (p=0.05)	2.31	0.43	NS	1.29	0.96
Biomass material					
M_1	14.83	2.89	121.89	16.50	22.68
M_2	14.78	3.56	119.56	16.00	22.94
CD (p=0.05)	NS	NS	NS	NS	NS
Biomass concentration					
C_0	13.58	3.25	120.67	15.92	22.99
C_1	15.75	3.42	122.17	15.75	22.76
C_2	15.08	3.00	119.33	16.33	22.67
CD (p=0.05)	NS	NS	NS	NS	NS
VxM					
V_1M_1	16.89	2.22	114.89	17.56	19.48
V_1M_2	16.89	2.33	120.67	17.11	19.68
V_2M_1	12.78	3.56	128.89	14.44	25.88
V_2M_2	12.67	4.78	118.44	14.89	26.20
CD (p=0.05)	2.05	1.03	8.18	0.78	0.96
VxC					
V_1C_0	14.50	2.00	121.67	18.17	19.61
$V1C_1$	17.83	2.82	118.17	16.83	19.29
V_1C_2	18.33	2.00	113.50	17.00	19.84
V_2C_0	12.67	4.50	119.67	13.67	26.38
V_2C_1	13.67	4.00	126.17	14.67	26.23
V_2C_2	11.83	4.00	125.17	15.67	26.00
CD (p=0.05)	2.37	0.82	10.08	1.68	0.36
VxMxC					
$V_1M_1C_0$	15.33	2.33	116.00	19.00	19.47
$V_1M_1C_1$	18.33	2.67	116.33	17.33	19.18
$V_1M_1C_2$	17.00	1.67	112.33	16.33	19.80
$V_1M_1C_0$	13.67	1.67	127.33	17.33	19.76
$V_1M_1C_1$	17.33	3.00	120.00	17.67	19.41
$V_1M_1C_2$	19.67	2.33	114.67	16.33	19.89
$V_2M_1C_0$	12.67	4.00	128.00	13.67	26.45
$V_2M_1C_1$	14.00	3.67	133.00	14.33	26.13
$V_2M_1C_2$	11.67	3.00	125.67	15.00	25.65
$V_2M_1C_0$	12.67	5.00	111.33	13.67	26.31
$V_2M_1C_1$	13.33	4.33	119.33	15.00	26.34
$V_2M_1C_2$	12.00	5.00	124.67	16.00	25.95
CD (p=0.05)	3.35	1.16	NS	2.18	0.56

V_1=BRRI dhan29; M_1=Rice straw; C_0=No biomass,; C_1=0.5 kg biomass m^{-2} ; V_2=BRRI hybrid dhan2; M_2=Water hyacinth; C_2=1.0 kg biomass m^{-2}

Table 2: Yield and harvest index of rice as affected by variety, type and concentration of biomass

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
Variety			
V_1	6.08	8.64	41.27
V_2	6.92	7.15	49.27
CD	0.79	0.43	5.16
Biomass material			
M_1	6.26	7.48	45.68
M_2	6.74	8.31	44.86
CD	NS	0.48	NS
Biomass concentration			
C_0	6.35	7.77	44.81
C_1	6.55	8.05	45.22
C_2	6.60	7.86	45.77
CD	NS	NS	NS
VxM			
V_1M_1	6.00	8.06	42.66
V_1M_2	6.15	9.23	39.87
V_2M_1	6.52	6.91	48.69
V_2M_2	7.33	7.39	49.84
CD	0.55	0.67	3.82
VxC			
V_1C_0	5.47	8.48	38.84
$V1C_1$	6.33	8.94	41.74
V_1C_2	6.44	8.51	43.21
V_2C_0	7.24	7.06	50.78
V_2C_1	6.78	7.17	48.70
V_2C_2	6.75	7.21	48.33
CD	0.56	0.92	4.54
VxMxC			
$V_1M_1C_0$	5.56	8.12	39.79
$V_1M_1C_1$	6.47	7.96	45.03
$V_1M_1C_2$	6.17	8.11	43.23
$V_1M_1C_0$	5.57	8.85	37.96
$V_1M_1C_1$	6.18	9.91	38.45
$V_1M_1C_2$	6.71	8.92	43.20
$V_2M_1C_0$	7.26	7.12	50.77
$V_2M_1C_1$	6.28	6.60	48.88
$V_2M_1C_2$	6.10	7.00	46.42
$V_2M_1C_0$	7.22	7.03	50.79
$V_2M_1C_1$	7.27	7.73	48.51
$V_2M_1C_2$	7.50	7.42	50.23
CD	0.82	1.32	6.41

V_1=BRRI dhan29; M_1=Rice straw; C_0=No biomass,; C_1=0.5 kg biomass m^{-2}; V_2=BRRI hybrid dhan2; M_2=Water hyacinth; C_2=1.0 kg biomass m^{-2}

was recorded in BRRI hybrid dhan2 with water hyacinth application that was statistically similar (48.69) to the same variety with rice straw. The lowest harvest index (39.87%) was found in BRRI dhan29 with water hyacinth application that was similar (42.66) to the same variety for the application of rice straw.

Statistically significant variations were observed for effective tillers hill^{-1}, non effective tiller hill^{-1}, unfilled grains panicle^{-1}, weight of 1000-grains, grain yield, straw yield and harvest index from the interaction effect of variety and biomass (Table 1 and Table 2). The highest number of effective tillers hill^{-1} (18.33) was recorded from BRRI dhan29 with 1.0 kg biomass m^{-2} that was similar to the same variety with 0.5 kg biomass m^{-2}. The lowest number of effective tillers hill^{-1} (11.83) was found from BRRI hybrid dhan2 with 1.0 kg biomass m^{-2} that was statistically similar to the same variety with other concentrations and BRRI dhan29 with no biomass. The highest number of non-effective tillers hill^{-1} (4.50) was recorded from BRRI hybrid dhan2 with no biomass that was statistically similar to the same variety with other concentrations. The lowest number of non-effective tillers hill^{-1} (2.00) was found from BRRI dhan29 with control and 1.0 kg biomass m^{-2} that was similar to the same variety with 0.5 kg biomass m^{-2}. The highest number of unfilled grains panicle^{-1} (18.17) was recorded from BRRI dhan29 with no biomass which was statistically similar to the same variety with other two concentrations and the lowest number of unfilled grains panicle^{-1} (13.67) was found from BRRI hybrid dhan2 with control that was similar to the same variety with other concentrations. The highest weight of thousand grains (26.38 g) was recorded from BRRI hybrid dhan2 with no biomass incorporation which was similar to the same variety with other interactions. The lowest weight of thousand grains (19.29 g) was found from BRRI dhan29 with 0.5 kg biomass m^{-2} which was similar to the same variety with other interactions (Table 1). The highest grain yield (7.24 t ha^{-1}) was recorded from BRRI hybrid dhan2 with control which was similar to the same variety with other concentrations and BRRI dhan29 with 1.0 kg biomass m^{-2}. The lowest grain yield (5.47 t ha^{-1}) was found from BRRI dhan29 with no biomass incorporation. The highest straw yield (8.94 t ha^{-1}) was recorded from BRRI dhan29 with 0.5 kg biomass m^{-2} which was similar to the same variety with other two interactions. The lowest straw yield (7.06 t ha^{-1}) was found from BRRI hybrid dhan2 with control which was similar to the same variety with other interactions. The highest harvest index (50.78%) was recorded in BRRI hybrid dhan2 with no biomass application that was similar to the same variety with other interactions. The lowest harvest index (38.84%) was found in BRRI dhan29 with control that was similar to the same variety due to other concentrations (Table 2).

Statistically significant variations were observed for effective tillers hill^{-1}, unfilled grains panicle^{-1}, weight of 1000-grains, grain yield, straw yield and harvest index from the interaction effect of varieties, biomass materials and their concentrations (Table 1 and Table 2). Significantly higher number of effective tillers hill^{-1} (19.67) was recorded from BRRI dhan29 with water hyacinth and the incorporation of 1.0 kg biomass m^{-2} that was similar to the same variety with rice straw and 0.5 kg biomass m^{-2} and the lowest number of effective tillers hill^{-1} (11.67) was found from BRRI hybrid dhan2 with rice straw and 1.0 kg biomass m^{-2} that was similar to the same variety with water hyacinth and all levels of concentration. The highest number of non-effective tillers hill^{-1} (5.00) was recorded from BRRI hybrid dhan2 with water hyacinth and the incorporation of 1.0 kg biomass m^{-2} that was similar to the same variety with the same material and other two concentrations and the lowest number of non-effective tillers hill^{-1} (1.67) was found from BRRI dhan29 with rice straw and 1.0 kg biomass m^{-2} that was similar to the same variety with water hyacinth and all levels of concentration. The highest number of unfilled grains panicle^{-1} (19.00) was recorded from BRRI dhan29 with rice straw and no biomass application which was similar to the same variety with all possible combinations and the lowest number of unfilled grains panicle^{-1} (13.67) was found from the same variety with all possible combinations (Table 1). The highest weight of thousand grains (26.45 g) was recorded from BRRI hybrid dhan2 with rice straw which was similar to the same variety with all possible combinations and the lowest weight of thousand grains (19.18 g) was found from BRRI dhan29 with rice straw and 0.5 kg biomass m^{-2} that was similar to the same variety with all possible combinations. The highest grain yield (7.50 t ha^{-1}) was recorded from BRRI hybrid dhan2 with water hyacinth and 1.0 kg biomass m^{-2} that was similar to the same variety with the same material and other two levels of concentration and the lowest grain yield (5.56 t ha^{-1}) was found from BRRI dhan29 with rice straw and no biomass which was similar to the same variety with water hyacinth and control. Application of rice straw @ 0.5 kg m^{-2} in inbred variety increased the yield but it was in increasing trend in case of hybrid variety. The water hyacinth application in inbred variety decreased the yield but the trend was reverse in hybrid variety. The highest straw yield (9.91 t ha^{-1}) was recorded from BRRI hybrid dhan2 with water hyacinth and 0.5 kg biomass m^{-2} that was similar to the same variety with the same material and other two levels of concentration and the lowest straw yield (6.60 t ha^{-1}) was found from BRRI hybrid dhan2 with rice straw and 0.5 kg biomass m^{-2} which was similar to the same variety with the same material and 1.0 kg biomass m^{-2}. The highest harvest index (50.79%) was recorded from BRRI hybrid dhan2 with water hyacinth and control which was similar to the same

variety with rice straw and the same concentration and the lowest harvest index (37.96%) was found from BRRI dhan29 with water hyacinth and no biomass that was similar to the same variety with the same material and 0.5 kg biomass m^{-2} (Table 2). Water hyacinth contained higher amount of nutrient and organic matter that helps to increase the growth and yield contributing characters and ultimately yield. This result agreed with the previous study by Gohl (1981) who stated that water hyacinth contains 4.50% organic matter, 1.5% nitrogen and 24.20% ash thus might have enhanced plant growth.

4. Conclusion

It may be concluded that hybrid variety gave 12.14% higher grain yield than inbred variety. Application of rice straw in inbred variety decreased the grain yield but in case of hybrid variety, water hyacinth showed positive impact in respect of yield and other yield attributes. However, incorporation of either water hyacinth or rice straw biomass at any of the three concentrations did not yield significant effect on yield.

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