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Growth and Yield of Rice (*Oryza sativa*) as Influenced by Humic Acid and Poultry Manure

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Abstract Humic acid (HA) and poultry manure (PM) were applied on T. aman rice cv. BRRI dhan39 to observe their effects on rice. Three levels of humic acid *viz.* 0, 3 and 6 L ha^{-1} and three levels of poultry manure *viz.* 0, 3 and 6 t ha^{-1} were applied along with recommended doses of N, P, K and S fertilizers from urea, TSP, MoP and gypsum, respectively following Randomized Complete Block Design (RCBD). Parameters used in the experiment were plant height, effective tillers $hill^{-1}$, panicle length, no. of grains $panicle^{-1}$, 1000-grain weight, grain and straw yields. The application of different treatments showed positive trend in all the parameters of BRRI dhan39. The highest grain yield (4.07 t ha^{-1}) was recorded by the application of 6 L ha^{-1} humic acid along with 3 t ha^{-1} poultry manure which was identical with the application of 6 L ha^{-1} humic acid along with 6 t ha^{-1} poultry manure but was different from other treatment combinations.

Keywords Humic Acid, Poultry Manure, Growth, Yield, BRRI Dhan39 Etc

1. Introduction

Rice is the main staple food of Bangladesh. About 80% of cropped area is used for rice cultivation, with annual production of 4,37,29,000 metric tons (IRRI, 2006). The average yield of rice in Bangladesh is 3.90 t ha^{-1} (BRRI, 2007) which is almost less than 50% of the world average yield. Continuous use of chemical fertilizers accelerated the depletion of soil organic matter and impairs physical and chemical properties of soil in addition to causing micronutrient deficiencies. In Bangladesh, most of the cultivated soils have less than 1.5% organic matter. This important component of soil is declining with time due to intensive cropping and use of higher doses of chemical fertilizers with little or no addition of manure. Humic acid is one of the major components of humic substances. Humic matter is formed through the chemical and biological humification of plant and animal matter and through the biological activities of microorganisms (Anonymous, 2010). The effects of humic substances on plant growth depend on the source and concentration, as well as on the molecular fraction weight of humus. Humic acid improves the physical, chemical and biological properties of the soil and influences plant growth by influencing the growth of roots. Initiation of root enhancement and increased root growth may be observed by the application of humic acids and fulvic acids to the soil (Pettit, 2004). The effects were directly correlated with enhanced uptake of macronutrients, such as nitrogen, phosphorus and sulfur, and micronutrients like Fe, Zn, Cu and Mn (Chen *et al.*, 2001). Poultry manure is an excellent source of nutrients and can be incorporated into most fertilizer programs. Application of manures must be practiced sound soil fertility management to prevent nutrient imbalances and associated animal health risks as well as surface-water and groundwater contamination. Global environment pollution can also be reduced considerably by reducing the use of chemical fertilizers and increasing the use of cowdung, poultry manure, rice straw and others. Bangladesh agriculture has experienced multiple nutrient deficiencies over the years. For sustainable agriculture, a soil management strategy must be based on maintaining soil quality, which is only possible by utilization of high quality manures along with inorganic fertilizers.

2. Materials and Methods

2.1. Experimental Site and Design

The experiment was carried out during the Aman season from August to November, 2010 at Central Farm of Bangladesh Agricultural University, Mymensingh. The experiment was set up in a typical rice growing soil. Rice cultivar BRRI dhan39 was used as test crop. There were 9 treatments consisting of three rates of humic acid (0, 3 and 6 L ha^{-1}) and three rates of poultry manure (0, 3 and 6 t ha^{-1}). The treatments are T_0 = HA_0+PM_0, T_1 = HA_0+PM_3, T_2 =

HA_0+PM_6, T_3 = HA_3+PM_0, T_4 = HA_3+PM_3, T_5 = HA_3+PM_6, T_6 = HA_6+PM_0, T_7 = HA_6+PM_3 and T_8 = HA_6+PM_6. The experiment was laid out in a randomized complete block design with three replications.

2.2. Data Collection and Statistical Analysis

Land was prepared with power tiller and leveled with ladder. The unit plot size was 10 m^2 (4.0 m x 2.5m). 25 days old seedlings were transplanted with the spacing of 15cm x 20cm.The doses of NPKS were as per the recommendations made by the Bangladesh Rice Research Institute (BRRI) and that was urea 150 kg ha^{-1} (69 kg N ha^{-1}), TSP 100 kg ha^{-1}, MoP 70 kg ha^{-1} and gypsum 10 kg ha^{-1}. Intercultural operations were practiced as and when necessary. The crop was harvested on 17th November 2010. The plant threshed and grain and straw was collected plot-wise. Humic acid was collected from Global Agrovat Company Limited and poultry manure was collected from the Poultry Farm of Bangladesh Agricultural University, Mymensingh. Humic acid was used in liquid form. Data were collected on crop characters such as plant height, number of total tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, panicle length, number of grains $panicle^{-1}$, number of filled grains $panicle^{-1}$, 1000-grain weight, grain yield, straw yield, biological yield and harvest index. Data were statistically analyzed using the MSTAT statistical Computer Package Programme (Gomez and Gomez, 1984).

3. Results and Discussion

3.1. Plant Height

Plant height was significantly influenced by different doses of humic acid (Table 1). Humic acid produced the longest plant (86.33 cm) by the application of 3 L ha^{-1} where the shortest plant height (86.11cm) was obtained at control. Application of poultry manure did not significantly influence the plant height (Table 1). There was no significant interaction in plant height due to combined application of humic acid and poultry manure (Table 2). Plant height might be increased due to greater availability of nutrients which is also stated by Sivakumar *et. al.* (2007) and Nguyen *et. al.* (2004).

Table 1. The effect of humic acid and poultry manure on the yield attributes of T. aman rice cv. BRRI dhan39

Treatments	Plant height (cm)	Total tillers $hill^{-1}$ (No.)	Effective tillers $hill^{-1}$ (No.)	Panicle length (cm)	Total grains $panicle^{-1}$ (No.)	Filled grains $panicle^{-1}$ (No.)	1000-grain weight (g)
HA_0	86.11c	10.33	8.56c	23.43b	105.22c	96.11c	18.28c
HA_3	86.33a	11.56	10.78a	24.50ab	125.11b	116.00b	19.53b
HA_6	86.22b	11.00	9.56b	24.78a	148.78a	137.56a	20.16a
CV (%)	2.20	7.88	2.95	2.71	10.71	10.76	1.83
Level of significance	*	NS	**	**	**	**	*
PM_0	85.44	10.22b	9.00b	23.78	113.78b	106.67b	19.04c
PM_3	86.44	11.00ab	9.78ab	24.43	114.00b	104.11b	19.39b
PM_6	86.78	11.67a	10.11a	24.50	151.33a	138.89a	19.53a
CV (%)	4.32	6.41	2.95	23.36	0.81	1.99	6.41
Level of significance	NS	*	*	NS	**	**	**

Legends: HA = Humic acid, PM= Poultry manure, * = Significant at 5 % level of probability, ** = Significant at 1 % level of probability, NS= Not significant.

Table 2. The interaction effects of humic acid and poultry manure on the yield attributes of T. aman rice cv. BRRI dhan39

Treatments	Plant height (cm)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Panicle length (cm)	Total grains panicle^{-1} (No.)	Filled grains panicle^{-1} (No.)	1000-grain weight (g)
HA_0PM_0	85.33	10.00c	8.33c	23.33	82.67e	79.00f	17.67d
HA_0PM_3	87.67	10.33c	8.67b	23.44	98.67d	90.67e	18.33c
HA_0PM_6	85.33	10.67bc	8.67b	23.50	134.33c	118.67c	18.83c
HA_3PM_0	84.00	10.33c	9.67b	23.33	120.67c	113.33c	19.53b
HA_3PM_3	86.67	12.00ab	11.33a	25.17	114.33cd	104.33d	19.57b
HA_3PM_6	88.33	12.33a	10.33a	25.00	140.33b	130.33b	19.50b
HA_6PM_0	85.00	10.67bc	9.33b	24.67	129.00c	117.33c	20.27a
HA_6 PM_3	86.67	12.00ab	11.33a	25.00	179.33a	167.67a	20.27a
HA_6 PM_6	87.00	10.33c	9.00b	24.67	138.00c	127.67c	19.93ab
CV(%)	4.32	6.41	2.95	2.71	10.71	10.76	1.83
Level of significance	NS	**	**	NS	**	**	*

Legends: HA = Humic acid, PM= Poultry manure, * = Significant at 5 % level of probability, ** = Significant at 1 % level of probability, NS = Not significant.

3.2. Total Tillers Hill^{-1}

Total number of tillers hill^{-1} was not significantly influenced by the application of humic acid (Table 1). The highest number of tillers hill^{-1} (11.67) was produced by the application of 6 t ha^{-1} PM and the lowest (10.22) was obtained at control. This result was partially supported by Miller (2007) and Bhattacharya *et al.* (2003). Total number of tillers hill^{-1} was significantly affected by the interaction effect of humic acid and poultry manure (Table 2). The highest number of tillers hill^{-1} (12.33) was obtained in T_5 which was statistically similar to T_4 and T_7. This increase in number of tillers hill^{-1} was perhaps due to the addition of humic acid and poultry manure which promote nitrogen supply which is essential for vegetative growth.

3.3. Effective Tillers Hill^{-1}

Humic acid and poultry manure both had significant effect on the number of effective tillers hill^{-1} (Table 1). The highest result (10.78) was obtained when humic acid was applied @ 3 L ha^{-1} and the lowest (8.56) was produced at HA_0. The highest number of effective tillers hill^{-1} (10.11) was produced when poultry manure was applied @ 6 t ha^{-1} and the lowest number of effective tillers hill^{-1} (9.00) was produced at control. Organic sources offer more balanced nutrition to plants, especially micro nutrients which has caused better affectivity of tiller in plants grown with poultry manure and vermicompost (Miller, 2007). This result was also partially supported by Rakshit *et al.* (2008). There was a significant difference in the total number of effective tillers hill^{-1} due to the interaction effect of humic acid and poultry manure (Table 2). The highest number of effective tillers hill^{-1} (11.33) was obtained in the interaction of humic acid and poultry manure in T_7 treatment where humic acid and poultry manure were applied @ 6 L ha^{-1} and 3 t ha^{-1}, respectively and the lowest (8.33) was obtained at T_0.

3.4. Panicle Length

A significant difference in panicle length was obtained with the application of humic acid (Table 1). The longest panicle length (24.78 cm) was obtained with humic acid applied @ 6 L ha^{-1} and the shortest (23.43 cm) was obtained at control. The loss of nitrogen is less in presence of humic acid which helps in vegetative growth such as panicle length of rice plant. This finding was similar with the

observation made by Mishra and Srivastava (1988). The application of poultry manure did not significantly influence the panicle length (Table 1). There was no significant difference in panicle length due to interaction effect of humic acid and poultry manure (Table 2).

3.5. Total Number of Grains Panicle^{-1}

Total number of grains panicle^{-1} was significantly increased by the application of humic acid (Table 1). The highest number of grains panicle^{-1} (148.78) was found with the application of humic acid @ 6 L ha^{-1} and lowest (105.22) at control. It was noticed that humic acid induced positive effect on total number of grains panicle^{-1}. The application of poultry manure also significantly increased the total number of grains panicle^{-1} (Table 1). The highest number of grains panicle^{-1} (151.33) was obtained with the application of poultry manure @ 6 t ha^{-1} and it was the lowest (113.78) at PM_0. The total number of grains panicle^{-1} was augmented significantly due to interaction effect of different levels of humic acid and poultry manure (Table 2). The highest (179.33) was obtained in the interaction effect of humic acid and poultry manure in T_7 treatment and the lowest (82.67) was obtained at T_0. Hasanuzzaman *et al.* (2010) also reported similar results.

3.6. Number of Filled Grains Panicle^{-1}

Application of humic acid extensively influenced the number of filled grains panicle^{-1} (Table 1). Humic acid produced significantly the highest number of filled grains panicle^{-1} (137.56) when applied @ 6 L ha^{-1} and the lowest (96.11) was obtained at control. Humic acid helps in uptake of phosphorus as phosphorus enhances fruiting of plant. Nottidge *et al*., (2005) stated the similar opinion. The number of filled grains panicle^{-1} was significantly increased by the application of poultry manure at higher dose but at lower dose it did not have any positive effect (Table). The highest number of filled grains panicle^{-1} (138.89) was obtained by the application of 6 t ha^{-1} PM and the lowest (106.67) was recorded at T_0. Interaction of different levels of humic acid and poultry manure had positive influence on rice (Table 2). The highest number of filled grains panicle^{-1} (167.67) was obtained in the interaction of humic acid and poultry manure in T_7 treatment and the lowest (79.00) was recorded at T_0.

3.7. Total Number of Grains Panicle^{-1}

Total number of grains panicle^{-1} was significantly increased by the application of humic acid (Table 1). The highest number of grains panicle^{-1} (148.78) was found with the application of humic acid @ 6 L ha^{-1} and lowest (105.22) at control. It was noticed that humic acid induced positive effect on total number of grains panicle^{-1}. The application of poultry manure also significantly increased the total number of grains panicle^{-1} (Table 1). The highest number of grains panicle^{-1} (151.33) was obtained with the application of poultry manure @ 6 t ha^{-1} and it was the lowest (113.78) at PM_0. The total number of grains panicle^{-1} was augmented significantly due to interaction effect of different levels of humic acid and poultry manure (Table 2). The highest (179.33) was obtained in the interaction effect of humic acid and poultry manure in T_7 treatment and the lowest (82.67) was obtained at T_0.

3.8. 1000-Grain Weight

The 1000-grain weight was significantly influenced by the application of humic acid (Table 1). The highest 1000-grain weight (20.16g) was obtained when humic acid was applied @ 6 L h ha^{-1} and it was lowest (18.28g) in control treatment. The application of poultry manure exaggerated 1000-grain weight significantly (Table 1). The highest 1000-grain weight was obtained (19.53g) when poultry manure was applied @ 6 t ha^{-1} and the lowest (19.04g) was found in control treatment. The interaction effect of humic acid and poultry manure had significant influence on 1000-grain weight (Table 2). The highest 1000-grain weight (20.27g) was obtained in T_7 which was similar with T_6 and it was lowest (17.67g) in T_0. Dhanasekaran and Govindasamy (2002) reported that availability of nutrients during reproductive stage helped for better grain filling and as a result grain weight was increased.

3.9. Grain Yield

The yield of grain of BRRI dhan39 was considerably influenced by the application of humic acid (Table 3). The highest grain yield (3.20 t ha^{-1}) was obtained when humic acid was applied @ 6 L ha^{-1} and the lowest (3.09 t ha^{-1}) was in control. Humic acid influenced the nutrition and growth of plants in an indirect manner. It might also influence the plant growth directly either through its effects on ion uptake or by more direct effects on the growth regulation of the plant (Vaughan and Linehan, 1976). The application of poultry manure increased the grain yield significantly (Table 3). The highest grain yield (3.42 t ha^{-1}) was obtained when poultry manure was applied @ 6 t ha^{-1} and the lowest (2.90 t ha^{-1}) was found in control. The results suggest that poultry manure offered better nutritional quality and favorable balance of nutrients when supplemented with NPK which provided the maximum yield. Rakshit *et al.* (2008) also observed similar findings. The combined application of humic acid and poultry manure induced higher the grain yield significantly (Table 4). The highest grain yield (4.07 t ha^{-1}) was obtained in T_7 treatment and the lowest grain yield (2.37 t ha^{-1}) was found in T_0 treatment.

Table 3. The effect of humic acid and poultry manure on the yield attributes of T. aman rice cv. BRRI dhan39

Treatments	Grain yield (t ha^{-1})	Grain yield increase over control (%)	Straw yield (t ha^{-1})	Straw yield increase over control (%)	Harvest Index (%)
HA_0	3.09b	0	8.22b	0	23.32b
HA_3	3.10ab	0.32b	8.33b	1.34b	27.09a
HA_6	3.20a	3.56a	8.45a	2.78a	27.46a
CV (%)	7.18	1.23	1.94	0.94	5.46
Level of significance	*	**	**	**	**
PM_0	2.90b	0	8.20b	0	25.34c
PM_3	3.06ab	5.52b	9.06ab	10.49b	26.07b
PM_6	3.42a	17.93a	9.25a	12.80a	27.06a
CV (%)	0.81	2.34	1.99	1.07	23.36
Level of significance	**	**	*	**	**

Legends: HA = Humic acid, PM= Poultry manure, * = Significant at 5 % level of probability, ** = Significant at 1 % level of probability, NS = Not significant.

Table 4. The interaction effects of humic acid and poultry manure on the yield attributes of T. aman rice cv. BRRI dhan39

Treatments	Grain yield (t ha^{-1})	Grain yield increase over control (%)	Straw yield (t ha^{-1})	Straw yield increase over control (%)	Harvest index (%)
HA_0PM_0	2.37d	0	7.98f	0	22.89bc
HA_0PM_3	2.97c	25.32d	10.00b	25.31b	22.89c
HA_0PM_6	2.98	25.74d	10.01a	25.44b	22.94c
HA_3PM_0	3.00bc	26.58cd	8.10e	1.50f	27.02a
HA_3 PM_3	3.05bc	28.69c	8.77c	9.90d	25.78b
HA_3 PM_6	3.23b	36.29b	8.23de	3.13ef	28.18a
HA_6PM_0	3.17b	33.76bc	8.29d	3.88e	27.66a
HA_6PM_3	4.07a	71.73a	10.28a	28.82a	28.36a
HA_6PM_6	3.34b	40.93b	9.46c	18.55c	26.09a
CV(%)	0.81	4.78	1.99	3.93	5.46
Level of significance	**	**	**	**	**

Legends: HA = Humic acid, PM= Poultry manure, * = Significant at 5 % level of probability, ** = Significant at 1 % level of probability, NS = Not significant.

3.10. Grain Yield Increase over Control

The percent grain yield increase over control was influenced by the application of humic acid (Table 3). The grain yield increased 0.32% when humic acid was applied @ 3 L ha^{-1} and 3.56% when applied @ 6 L ha^{-1}. The application of poultry manure also exerted increased percent grain yield over control (Table 3). The grain yield increased was 17.93% when poultry manure was applied @ 6 t ha^{-1} and it was 5.52% when it was applied @ 3 t ha^{-1}. The percent grain yield increase over control was due to combined application of humic acid and poultry manure (Table 4). The highest grain yield increased 71.73% in T_7 treatment where humic acid and poultry manure were applied @ 6 L ha^{-1} and 3 t ha^{-1}, respectively and it was lowest (25.32%) in T_2 treatment.

3.11. Straw Yield

The straw yield was significantly influenced by the application of humic acid (Table 3). The highest straw yield (8.45 t ha^{-1}) was obtained when humic acid was applied @ 6 L ha^{-1} and the lowest (8.22 t ha^{-1}) was in HA_0. The application of poultry manure increased the straw yield appreciably (Table 3). The highest straw yield (9.25 t ha^{-1}) was obtained when poultry manure was applied @ 6 t $ha^{-1}$and the lowest (8.20 t ha^{-1}) was obtained in control. An expressive effect was observed with the combined application of humic acid and poultry manure which augmented the straw yield significantly (Table 4). The highest straw yield (10.28 t ha^{-1}) was obtained when humic acid and poultry manure were applied @ 6 L ha^{-1} and 3 t ha^{-1}, respectively and the lowest (7.98 t ha^{-1}) was found in T_0 treatment.

3.12. Straw Yield Increase over Control

The percent straw yield increase over control was significantly influenced by the application of humic acid (Table 3). Straw yield increased 1.34% when humic acid was applied @ 3 L ha^{-1} and 2.78% when it was applied @ 6 L ha^{-1}. Application of poultry manure also increased the percent straw yield over control (Table 3). Straw yield increased 10.49% when poultry manure was applied @ 3 t ha^{-1} and it was 12.80% when it was applied @ 6 t ha^{-1}. The percent straw yield increase over control was also influenced due to combined application of humic acid and poultry manure (Table 4). The highest straw yield increased 28.82% in T_7 treatment where humic acid and poultry manure were applied @ 6 L ha^{-1} and 3 t ha^{-1}, respectively and it was lowest (1.50%) when humic acid and poultry manure were applied @ 3 L ha^{-1} and 0 t ha^{-1}, respectively.

3.13. Harvest Index

The application of humic acid significantly influenced harvest index (Table 3). The highest HI (27.46 %) was found when humic acid was applied @ 6 L ha^{-1} and the lowest HI (23.32%) was found at control. Harvest indices were appreciably varied with the application of different doses of poultry manure (Table 3). The highest HI (27.06%) was found when poultry manure was applied @ 6 t ha^{-1} and the lowest (25.34%) was found at control. It might be due to better grain yield with corresponding biological yield. Channabasavanna and Biradar (2001) stated the similar opinion. The highest HI with 6 t ha^{-1} poultry manure was due to more economic yield caused by more availability of nutrients. The combined application of humic acid and poultry manure significantly influenced HI (Table 4). The highest HI (28.36%) was recorded at treatment T_7 and the lowest HI (22.89%) was found at control.

4. Conclusion

Yield contributing characters were significantly influenced by different treatment combinations of HA and PM along with chemical fertilizers and became maximum when humic acid and poultry manure were applied @ 6 L ha^{-1} and 3 t ha^{-1}, respectively. The highest grain yield (4.07 t ha^{-1}) and straw yield (10.28 t ha^{-1}) was found in T_7 treatment and that was lowest (2.37 t ha^{-1} and 7.98 t ha^{-1}) at control, respectively. However, application of PM @ 3 t ha^{-1} along with HA @ 6 L ha^{-1} showed better performance than PM or HA alone. It is therefore concluded that the incorporation of HA @ 6 L ha^{-1} plus PM @ 3 t ha^{-1} with recommended doses of NPKS could be used for obtaining higher yield of T. aman rice particularly BRRI dhan39.

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