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Influence of humic acid and poultry manure on nutrient content and their uptake by T. aman rice

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Abstract

A study was conducted to examine the nutrient content and their uptake of rice as influenced by the application of humic acid (HA) and poultry manure (PM). This experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Three levels each of humic acid (0, 3 and 6 L ha^{-1}) and poultry manure (0, 3 and 6 t ha^{-1}) were applied. BRRI dhan39 was used as test crop. Basal doses of N, P, K and S fertilizers were applied. Both humic acid and poultry manure either singly or in combination significantly affected the contents and uptake of N, P, K, S, Ca and Mg of BRRI dhan39. The maximum content of N, P, K, S and Ca except Mg and their uptake were recorded from the treatment combination of 6 L ha^{-1} humic acid along with 3 t ha^{-1} poultry manure.

Keywords: Humic acid, Poultry manure, Nutrient content and uptake, BRRI dhan39

Introduction

Rice is the main staple food of Bangladesh. The annual rice production in Bangladesh is about 4,37,29,000 metric tons (IRRI, 2006). The average yield of rice is 3.90 t ha^{-1} (BRRI, 2007). In Bangladesh, most of the cultivated soils have less than 1.5% organic matter. 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. This important component of soil is declining with time. 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). Humic acid improves the physical, chemical and biological properties of the soil and influences plant growth. Humic substances are recognised as a key component of soil fertility properties, since they control chemical and biological properties of the rhizosphere (Rengrudkij and Partida, 2003, Nardi *et al*., 2005, Trevisan *et al*., 2009). The effects of humic substances have been directly correlated with enhanced uptake of macronutrients, such as N, P and S, and micronutrients like Fe, Zn, Cu and Mn (Pettit, 2004, Chen *et al*., 2001). The mechanism of humic acid activity in promoting plant growth is not completely known, but several explanations have been proposed by some researchers such as increasing cell membrane permeability, oxygen uptake, respiration and photosynthesis, phosphate uptake, and root cell elongation (Cacco and Dell'Agnolla, 1984; Türkmen *et al*., 2004; Petronio *et al*., 1982). Poultry manure is an excellent source of nutrients and can be incorporated into most of the fertilizer programs. Those using manures must practice 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. Hence a study aiming at the effect of humic acid and poultry manure on nutrient content and their uptake by rice was undertaken.

Materials and Methods

The experiment was conducted at central farm of Bangladesh Agricultural University, Mymensingh from August to November, 2010. 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}). 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. The experimental treatments were $T_0 = HA_0+PM_0$ (control), $T_1 = HA_0+PM_3$, $T_2 = HA_0+PM_6$, $T_3 = HA_3+PM_0$, $T_4 = HA_3+PM_3$, $T_5 = HA_3+PM_6$, $T_6 = HA_6+PM_0$, $T_7 = HA_6+PM_3$ and $T_8 = HA_6+PM_6$. The doses of N, P, K and S fertilizers were as per the recommendations made by Bangladesh Rice Research Institute (BRRI) and that was 150 kg ha^{-1} urea (69 kg N ha^{-1}), 100 kg ha^{-1} TSP, 70 kg ha^{-1} MOP and 10 kg ha^{-1} gypsum. Land was prepared by ploughing and cross-ploughing with the help of power tiller and leveled with ladder. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 10 m^2 (4.0 m x 2.5m). 25 day old seedlings were transplanted with the spacing of 15 cm x 20 cm. Intercultural operations were practiced as and when necessary. The crop was harvested on 17th November, 2010. The plant was threshed and grain and straw was collected plot-wise. The soil sample was analyzed for particle size, pH and determination of organic matter, total N, available P, exchangeable K, cation exchange capacity and plant sample was analyzed for determination of N, P, K, S, Ca and Mg dontents. Grain and straw samples were dried in an oven at 65^0C for 48 hours and then ground after cooling. Grain and straw samples were digested by wet oxidation method using diacid mixture (HNO_3:$HClO_4$ = 2:1) for the analysis of nutrients under consideration as described by Jackson (1962). The content of N was determined by semi-micro kjeldahl method followed by Jackson (1962). The concentrations of P and S were analysed with the help of a spectrophotometer at 660 and 420 nm wavelength, respectively (Jackson, 1962; Tandon, 1995). Potassium concentration was determined directly with the help of a flame photometer (Jackson, 1962). The contents of Ca and Mg were determined by EDTA titrimetric method (Page *et al.,* 1982). Nutrient uptake was calculated by the following formula:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Minerals constituent (\%)} \times \text{Dry matter weight (kg ha}^{-1}\text{)}}{100}$$

Data were statistically analyzed using the MSTAT statistical Computer Package Programme (Gomez & Gomez, 1984).

Results and Discussion

Nutrient contents of rice grain and straw

Nitrogen: Nitrogen content was significantly influenced by the application of humic acid and poultry manure in grain and straw. The highest N content was obtained in both grain (1.38%) and straw (0.89%) by the application of 6 L ha^{-1} humic acid and the lowest (1.29% and 0.44%, respectively) was recorded in control (Table 1). These findings were partially supported by Govindasamy and Chandrasekaran (2002) who stated that the addition of humic acid was found to increase the content and enhance the uptake of N, P, K, Ca, Mg, Fe, Mn and Zn by rice. The highest N content (1.37 %) in grain was obtained by the application of 6 t ha^{-1} poultry manure which was similar to 3 t $ha^{-1}$and the lowest N content (1.28 %) was recorded at control (Table 2). The highest N content (0.74 %) in straw was recorded by the application of 6 t ha^{-1} poultry manure and the lowest (0.59 %) was at PM_0. The interaction effect of humic acid and poultry manure was statistically significant in grain (Table 3). The highest N content (1.43%) was obtained in grain by the combined application of 6 L ha^{-1} humic acid and 3 t ha^{-1} poultry manure while the lowest N content (1.21%) was found in T_0 (control) treatment. Interaction effect of humic acid and poultry manure was insignificant in straw for N content.

Phosphorus: Phosphorus content in grain and straw was significantly influenced by the application of humic acid and poultry manure. The highest phosphorus content in grain (0.26%) and straw (0.19%) was recorded by the application of 6 L ha^{-1} humic acid and the lowest (0.23% and 0.12%, respectively) was found in HA_0 (Table 1). At optimum level of HA, the roots were highly branched and this might have resulted an increase in surface area, which would have facilitated more efficient nutrient absorption (Mallikarjunarao *et al.*, 1987). The highest P content (0.25%) in grain was observed by the application of 6 t ha^{-1} poultry manure which was similar to 3 t ha^{-1} and the lowest content (0.23%) was recorded in PM_0 (Table 2). The highest P content (0.18%) in straw was obtained by the application of 6 t ha^{-1} poultry manure and the lowest (0.15%) was found in PM_0. This might be due to the application of poultry manure, which decreased the adsorption capacity and increased soluble P and phosphorus desorption (Amanullah *et al.*, 2007). The P content in grain and straw was significantly influenced by the interaction effect of humic acid and poultry manure (Table 3). The highest P content (0.27%) was obtained in grain at T_7 treatment by the combined application of 6 L ha^{-1} humic acid and 3 t ha^{-1} poultry manure followed by T_5, T_6 and T_8 treatments. The lowest content (0.21%) was found in T_0. The highest P content (0.21%) was obtained in straw at T_7 treatment by the combined application of 6 L ha^{-1} humic acid and 3 t ha^{-1} poultry manure and the lowest content (0.09%) was found in T_0 (control) treatment.

Table 1. Effect of humic acid on nutrient contents of T. aman rice

Treatments	N (%)		P (%)		K (%)		S (%)		Ca (%)		Mg (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Humic Acid$_0$	1.29c	0.44c	0.23c	0.12c	0.63c	1.00c	0.146c	0.047c	0.15b	0.43b	0.16b	0.59c
Humic Acid$_3$	1.34b	0.65b	0.24b	0.18b	0.76b	1.30b	0.156b	0.081b	0.27a	0.64ab	0.23a	0.72b
Humic Acid$_6$	1.38a	0.89a	0.26a	0.19a	0.81a	1.37a	0.162a	0.091a	0.26a	0.69a	0.22a	0.82a
CV (%)	1.50	3.76	7.77	8.77	2.54	11.76	6.46	18.42	7.00	6.76	13.28	5.60

Table 2. Effect of poultry manure nutrient contents of T. aman rice

Treatments	N (%)		P (%)		K (%)		S (%)		Ca (%)		Mg (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Poultry manure$_0$	1.28b	0.59c	0.23b	0.15b	0.54b	1.11b	0.15b	0.064c	0.18c	0.50b	0.19b	0.67c
Poultry manure$_3$	1.37a	0.66b	0.25a	0.17ab	0.85a	1.28a	0.16a	0.074b	0.24b	0.61ab	0.23a	0.70b
Poultry manure$_6$	1.37a	0.74a	0.25a	0.18a	0.82ab	1.27a	0.16a	0.080a	0.27a	0.65a	0.20b	0.77a
CV (%)	0.81	1.99	4.32	6.41	2.95	23.36	3.61	12.31	16.61	5.00	13.75	6.20

Table 3. Interaction effects of humic acid and poultry manure on nutrient contents of T. aman rice

Treatments	N (%)		P (%)		K (%)		S (%)		Ca (%)		Mg (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
HA_0PM_0	1.21f	0.36	0.21c	0.09d	0.06f	0.86	0.13c	0.030	0.02e	0.34	0.13d	0.53g
HA_0PM_3	1.39bc	0.45	0.24b	0.14c	0.80cd	1.06	0.15b	0.050	0.17d	0.46	0.14d	0.59f
HA_0PM_6	1.26f	0.51	0.22bc	0.14c	0.87b	1.07	0.18ab	0.060	0.26bc	0.48	0.22c	0.66e
HA_3PM_0	1.29e	0.58	0.23b	0.18ab	0.76de	1.16	0.15b	0.070	0.27ab	0.57	0.22c	0.68d
HA_3 PM_3	1.32d	0.63	0.23b	0.17b	0.75e	1.41	0.16b	0.083	0.27ab	0.65	0.22b	0.68d
HA_3 PM_6	1.36c	0.75	0.26a	0.18ab	0.78cde	1.31	0.16b	0.089	0.26bc	0.70	0.23b	0.81c
HA_6PM_0	1.40b	0.90	0.26a	0.19ab	0.82c	1.36	0.13c	0.089	0.27ab	0.73	0.23b	0.82b
HA_6 PM_3	1.43a	0.95	0.27a	0.21a	0.97a	1.41	0.19a	0.092	0.29a	0.77	0.22c	0.81c
HA_6 PM_6	1.38bc	0.83	0.26a	0.18ab	0.81c	1.32	0.15b	0.092	0.24c	0.59	0.24a	0.84a
CV	0.81	1.99	4.32	6.41	2.95	23.36	3.61	12.31	16.61	5.00	13.75	6.20

Legend: HA = Humic acid, PM= Poultry manure

Potassium: The content of K in grain and straw was significantly influenced by the application of humic acid and poultry manure. The highest K content in grain (0.81%) and straw (1.37%) was obtained by the application of 6 L ha^{-1} humic acid and the lowest content (0.63 and 1.00%, respectively) was obtained in HA_0 (Table 1). The highest K content in grain (0.85%) and straw (1.28%) was obtained by the application of 3 t ha^{-1} poultry manure and the lowest content (0.54% and 1.11%, respectively) was found in PM_0 (Table 2). The interaction effects of humic acid and poultry manure on K content in grain was significant though it was not significant in straw (Table 3). The highest K content (0.97%) in grain was observed by the combined application of 6 L ha^{-1} humic acid and 3 t ha^{-1} poultry manure and the lowest content (0.06%) was found in T_0 (control) treatment.

Sulphur: The content of S in grain and straw was significantly influenced by the incorporation of humic acid and poultry manure. The highest S content in grain (0.162%) and straw (0.091%) was obtained by the application of 6 L ha^{-1} humic acid and the lowest content (0.146 and 0.047%, respectively) was obtained in HA_0 (Table 1). The highest S content in grain (0.16%) and straw (0.080%) was recorded by the application of 6 t ha^{-1} poultry manure and the lowest (0.15% and 0.064%, respectively) was obtained in PM_0 (Table 2). The interaction effects of humic acid and poultry manure increased S content significantly in grain (Table 3). The highest S content (0.19%) in grain was observed by the combined application of 6 L ha^{-1} humic acid and 3 t ha^{-1} poultry manure and the lowest (0.13%) was found in T_0 (control) treatment. There was no significant interaction effect of humic acid and poultry manure on S content in straw.

Calcium: Calciam content in grain and straw was significantly influenced by the application of humic acid and poultry manure. The highest Ca content (0.27%) in grain was obtained by the application of 3 L ha^{-1} humic acid followed by 6 L ha^{-1} and the lowest concentration (0.15%) was in control. In straw, the highest Ca content (0.69%) was recorded by the application of 6 L ha^{-1} humic acid and the lowest (0.43%) was in HA_0 (Table 1). The highest Ca content was obtained in grain (0.27%) and straw (0.65%) by the application of 6 t ha^{-1} poultry manure and the lowest content (0.18% and 0.50%, respectively) was found in PM_0 (Table 2). The interaction effect of humic acid and poultry manure significantly increased the Ca content in grain (Table 3). The highest Ca content (0.29%) was obtained in grain by the combined application of 6 L ha^{-1} humic acid and 3 t ha^{-1} poultry manure and the lowest value (0.02%) was found in control (T_0) treatment. There was no significant interaction effect of humic acid and poultry manure on Ca content in straw.

Magnesium: The content of Mg in grain and straw was significantly influenced by the application of humic acid and poultry manure. The highest Mg content (0.23%) in grain was obtained by the application of 3 L ha^{-1} humic acid and the lowest value (0.16%) was obtained in HA_0 (Table 1). The highest Mg content (0.82%) in straw was found by the application of 6 L ha^{-1} humic acid and the lowest (0.59%) was recorded in HA_0. The highest Mg content (0.23%) was recorded in grain by the application of 3 t ha^{-1} poultry manure and the lowest value (0.19%) was observed in PM_0 (Table 2). The highest Mg content (0.77%) was obtained in straw by the application of 6 t ha^{-1} poultry manure and the lowest value (0.67%) was found in PM_0. Magnesium content was significantly influenced due to the combined application of humic acid and poultry manure in the grain and straw of rice (Table 3). The highest Mg content in grain (0.24%) and straw (0.84%) was obtained by the combined application of 6 L ha^{-1} humic acid and 6 t ha^{-1} poultry manure and the lowest content(0.13 and 0.53%, respectively) was found in control (T_0) treatment.

Nutrient uptake by rice grain and straw

Nitrogen: Nitrogen uptake by grain and straw of BRRI dhan39 was significantly influenced by the application of humic acid and poultry manure. The highest N uptake in grain (44.16 kg ha^{-1}) and straw (75.21 kg ha^{-1}) was obtained by the application of 6 L ha^{-1} humic acid and the lowest uptake (39.86 and 36.17 kg ha^{-1}, respectively) was found in HA_0 (Table 4). Saalbach (1956) stated that humic acid enhanced the uptake and content of nitrogen in rye. The highest N uptake was obtained in grain (46.88 kg ha^{-1}) and straw (69.09 kg ha^{-1}) by the use of 6 t ha^{-1} poultry manure and the lowest uptake (37.26 and 50.19 kg ha^{-1}, respectively) was recorded in PM_0 (Table 5). The uptake of N by grain and straw of BRRI dhan39 was significantly increased due to the interaction effects of humic acid and poultry manure (Table 6). The highest N uptake in grain (58.20 kg ha^{-1}) and straw (97.66 kg ha^{-1}) was obtained by the combined application of 6 L ha^{-1} humic acid and 3 t ha^{-1} poultry manure and the lowest uptake (28.68 and 28.73 kg ha^{-1}, respectively) was found in control (T_0) treatment.

Table 4. Effect of humic acid on the N, P, K, S, Ca and Mg uptake by T. aman rice

Treatments	N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})		S (kg ha^{-1})		Ca (kg ha^{-1})		Mg (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Humic $acid_0$	39.86c	36.17c	7.11c	9.86c	19.47c	82.20c	4.51b	3.86c	4.64b	35.35c	4.94b	48.50c
Humic $acid_3$	41.54b	54.15b	7.44b	14.99b	23.56b	108.29b	4.84a	6.75b	8.37a	53.31b	7.13a	59.98b
Humic $acid_6$	44.16a	75.21a	8.32a	16.06a	25.92a	115.77a	5.18a	7.69a	8.32a	58.31a	7.04a	69.29a
CV (%)	7.21	4.34	10.78	9.14	8.86	11.81	9.35	18.07	10.61	6.97	14.87	6.69

Table 5. Effect of poultry manure on the N, P, K, S, Ca and Mg uptake by T. aman rice

Treatments	N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})		S (kg ha^{-1})		Ca (kg ha^{-1})		Mg (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Poultry $manure_0$	37.26c	50.19c	6.84c	12.59b	17.04c	93.10b	4.40b	5.48c	5.54c	42.09c	5.69b	56.29c
Poultry $manure_3$	41.87b	61.33b	7.50b	15.29ab	25.98b	116.47a	4.82ab	6.81b	7.23b	56.25b	6.99a	63.79b
Poultry $manure_6$	46.88a	69.09a	8.48a	16.35a	28.12a	117.55a	5.38a	7.46a	9.07a	60.32a	6.57ab	71.44a
CV (%)	3.78	5.38	0.76	2.78	0.66	0.41	3.41	6.28	4.43	1.17	4.44	3.15

Phosphorus: The uptake of P by both grain and straw of BRRI dhan39 was significantly influenced by the application of humic acid and poultry manure. The highest P uptake in grain (8.32 kg ha^{-1}) and straw (16.06 kg ha^{-1}) was recorded at HA_3. The lowest uptake (7.11 and 9.86 kg ha^{-1}, respectively) was found at HA_0 (Table 4). Different levels of humic acid had significant effect on nitrogen and phosphorus uptake by oats. The efficiency indices of various humic acids ranged between 25 and 65 per cent (Mishra and Srivastava, 1988). The highest P uptake in grain (8.48 kg ha^{-1}) and straw (16.35 kg ha^{-1}) was obtained in PM_6 *i.e.* the application of 6 t ha^{-1} poultry manure and the lowest uptake (6.84 and 12.59 kg ha^{-1}, respectively) was found in PM_0 (Table 5). Anion exchange phenomenon could be another reason for increasing P availability and higher P uptake by rice (Deb and Datta, 1967). The difference in P uptake by grain and straw due to interaction effects of humic acid and poultry manure was also significant (Table 6). The highest P uptake in grain (10.99 kg ha^{-1}) and straw (21.29 kg ha^{-1}) was obtained by the combined application of 6 L ha^{-1} humic acid and 3 t ha^{-1} poultry manure and the lowest uptake (4.98 and 7.18 kg ha^{-1}, respectively) was found in control (T_0) treatment. Jelanic *et al.* (1966) reported that HA from lignite increased P content and uptake in maize plants.

Potassium: Potassium uptake by both grain and straw of BRRI dhan39 was significantly influenced by the application of humic acid and poultry manure. The highest K uptake in grain (25.92 kg ha^{-1}) and straw (115.77 kg ha^{-1}) was obtained by the application of 6 L ha^{-1} humic acid and the lowest uptake (19.47 and 82.20 kg ha^{-1}, respectively) was found in HA_0 (Table 4). The highest K uptake in grain (28.12 kg ha^{-1}) and straw (117.55 kg ha^{-1}) was obtained by the application of 6 t ha^{-1} poultry manure and the lowest value (17.04 and 93.10 kg ha^{-1}, respectively) was found in PM_0 (Table 5). The uptake of K was significantly influenced in grain due to the interaction effect of humic acid and poultry manure (Table 6). The highest K uptake in grain (39.48 kg ha^{-1}) was obtained by the combined use of 6 L ha^{-1} humic acid and 3 t ha^{-1} poultry manure and the lowest uptake (1.42 kg ha^{-1}) was found in T_0. The uptake of K was not significantly influenced in straw due to the interaction effect of humic acid and poultry manure.

Table 6. Interaction effect of different doses of humic acid and poultry manure on N, P, K, S, Ca and Mg uptake by T. aman rice

Treatments	N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})		S (kg ha^{-1})		Ca (kg ha^{-1})		Mg (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
HA_0PM_0	28.68d	28.73f	4.98e	7.18d	1.42d	68.63	3.08d	2.39	0.47f	27.13	3.08e	42.29e
HA_0PM_3	41.28a	45.00e	7.13c	14.00c	23.76c	106.00	4.46bc	5.00	5.05e	46.00	4.16d	59.00d
HA_0PM_6	37.55c	51.05de	6.56d	14.01c	25.93b	107.11	5.36b	6.01	7.75d	48.05	6.56c	66.07c
HA_3PM_0	38.70	46.98e	6.90d	14.58c	22.80c	93.96	4.50b	5.67	8.10c	46.17	6.60c	55.08de
HA_3 PM_3	40.26c	55.25d	7.02c	14.91b	22.88c	123.66	4.88b	7.28	8.24bc	57.01	6.71c	59.64d
HA_3 PM_6	43.93b	61.73c	8.40b	14.81b	25.19b	107.81	5.17b	7.32	8.40b	57.61	7.43b	66.66c
HA_6PM_0	44.38b	74.61b	8.24b	15.75b	25.99b	112.74	4.12c	7.38	8.56b	60.52	7.29b	67.98c
HA_6 PM_3	58.20a	97.66a	10.99a	21.59a	39.48a	144.95	7.73a	9.46	11.80a	79.16	7.35b	76.63b
HA_6 PM_6	46.09b	78.52b	8.68b	17.03b	27.05b	124.87	5.01b	8.70	8.02bc	55.81	9.77a	86.35a
CV (%)	3.78	5.38	0.76	2.78	0.66	0.41	3.41	6.28	4.43	1.17	4.44	3.15

Legend: HA = Humic acid, PM = Poultry manure

Sulphur: The uptake of S by both grain and straw was significantly influenced due to the application of humic acid and poultry manure. The highest S uptake in grain (5.18 kg ha^{-1}) and straw (7.69 kg ha^{-1}) was obtained by the application of 6 L ha^{-1} humic acid and the lowest uptake (4.51 and 3.86 kg ha^{-1}, respectively) was found in HA_0 (Table 4). Raina and Goswami (1988) reported a significant increase in the uptake of N, P, Cu, S and Fe upto 20 ppm carbon as humic acid over control. The highest S uptake in grain (5.38 kg ha^{-1}) and straw (7.46 kg ha^{-1}) was obtained by the use of 6 t ha^{-1} poultry manure and the lowest value (4.40 and 5.48 kg ha^{-1}, respectively) was found in PM_0 (Table 5). Sulphur uptake was significantly influenced in grain due to the interaction effects of humic acid and poultry manure (Table 6). The highest S uptake in grain (7.73 kg ha^{-1}) was obtained by the combined use of 6 L ha^{-1} humic acid and 3 t ha^{-1} poultry manure and the lowest uptake (3.08 kg ha^{-1}) was found in T_0 treatment. The uptake of S was not significantly influenced in straw due to the interaction effects of humic acid and poultry manure.

Calcium: Calcium uptake by both grain and straw of BRRI dhan39 was significantly influenced by the application of humic acid and poultry manure The highest Ca uptake in grain (8.37 kg ha^{-1}) and straw (58.31 kg ha^{-1}) was obtained by the application of 3 and @ 6 L ha^{-1} humic acid, respectively and the lowest uptake (4.64 and 35.35 kg ha^{-1}, respectively) was found in HA_0 (Table 4). The highest Ca uptake in grain (9.07 kg ha^{-1}) and straw (60.32 kg ha^{-1}) was obtained by the application of 6 t ha^{-1} poultry manure and the lowest value in grain (5.54 and 42.09 kg ha^{-1}, respectively) was found in PM_0 (Table 5). The uptake of Ca was significantly influenced in grain due to the interaction effect of humic acid and poultry manure (Table 6). The highest Ca uptake in grain (11.80 kg ha^{-1}) was obtained by the combined use of 6 L ha^{-1} humic acid and 3 t ha^{-1} poultry manure and the lowest uptake (0.47 kg ha^{-1}) was found in T_0. The uptake of Ca was not significantly influenced in straw due to the interaction effect of humic acid and poultry manure.

Magnesium: Magnesium uptake by both grain and straw of BRRI dhan39 was significantly influenced due to the application of humic acid and poultry manure. The highest Mg uptake in grain (7.13 kg ha^{-1}) and straw (69.29 kg ha^{-1}) was obtained by the application of 3 and @ 6 L ha^{-1} humic acid, respectively and the lowest uptake (4.94 and 48.50 kg ha^{-1}, respectively) was found when 0 L ha^{-1} humic acid was applied (Table 4). Application of 10 kg HA ha^{-1} as potassium humate along with 75% recommended doses of fertilizers found to increase the crude protein content and mineral nutrition (P, K, Ca, Mg, Zn, Cu, Fe and Mn) of Amaranthus (Bama and Selvakumari, 2001). The highest Mg uptake in grain (6.99 kg ha^{-1}) and straw (71.44 kg ha^{-1}) was obtained by the application of 3 and 6 t ha^{-1} poultry manure, respectively and the lowest uptake (5.69 and 56.29 kg ha^{-1}, respectively) was found in PM_0 (Table 5). The uptake of Mg by both grain and straw was significantly influenced due to the interaction effects of humic acid and poultry manure (Table 6). The highest Mg uptake in grain (9.77 kg ha^{-1}) and straw (86.35 kg ha^{-1}) was recorded at T_8 treatment by the combined use of 6 L ha^{-1} humic acid and 6 t ha^{-1} poultry manure. The lowest uptake in grain and straw (3.08 and 42.29 kg ha^{-1}, respectively) were found in treatment T_0 (control) treatment.

Conclusion

Nutrient content in both grain and straw were significantly influenced by the application of HA and PM along with recommended doses of chemical fertilizers. The highest N, P, K, S, and Ca contents in grain and straw were obtained from T_7 treatment. Only the highest content of Mg in grain and straw was found in T_8 treatment. Control treatment gave the lowest content in all the parameters studied. However, the application of 3 t ha^{-1} PM along with 6 L ha^{-1} HA showed the better performance than PM or HA alone. It is, therefore, concluded that the incorporation of 6 L ha^{-1} HA plus 3 t ha^{-1} PM with recommended doses of N, P, K,S, Ca and Mg fertilizers should be used for T. aman rice particularly BRRI dhan39.

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