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Assessment of Household Waste, Poultry Manure and Cowdung in Rice Cultivation

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Abstract
The pot experiment was carried out to quantify the effect of different organic wastes in rice yield and to determine the effect on soil fertility. The experiment was laid down in a complete randomized design taking 11 treatments with three replicates. The applied treatments were; (1) Control, (2) Recommended doses of NPK, (3) HW 10%, (4) HW 20%, (5) HW 30%, (6) PM 10%, (7) PM 20%, (8) PM: 30%, (9) CD 10%, (10) CD 20% and (11) CD 30%. Application of 30% household waste produced the significantly higher grain yield (58.94 g pot^{-1}) even over the recommended doses of N, P and K ($p \leq 0.05$). The maximum sustainable yield index (SYI) was found 0.91 when 10% poultry manure and 30% cow dung were applied. But the SYI was 0.67 when 30% HW was applied. However, before approaching to a conclusion on SYI, it demands a long time field experiment using these organic wastes. Nutrient concentrations in rice crop/grains were not affected by the application of organic wastes, except P content in grain. The concentrations of N, P and K in rice grain varied 1.79 - 2.12, 0.14 - 0.21, and 1.44-1.99%, respectively. A significant nonlinear relationship was found between grain yield and N, P and K uptake individually. Post harvest chemical analysis of pot soil indicated that OM, N and P contents in soils significantly increased over the control which indicated the enhancement of soil fertility with the application of different organic wastes. The highest application rates of organic wastes attributed to maximum accumulation of organic matter and nitrogen in soil.

Keywords: Household waste, poultry manure, cowdung, rice, nutrient uptake

1. Introduction

In all agricultural systems there is inevitably a loss of plant nutrients. Nutrient mining, depletion of soil organic matter, reduction in soil aggregates etc. have been identified as reasons of yield stagnation or decline in the productivity of crops (Rahman and Yakupitiyage, 2006). Recycling of different organic wastes in agriculture could improve the organic matter status of soils, thus improve the soil physical and chemical properties and help to increase nutrients availability in soils (Chongrak, 1996). Waste is an unavoidable by-product of human activities and its production maintain positive relation with increasing population that are responsible for increasing the global pollution (Rathi, 2006). Waste management is considered to be one of the most serious environmental problems confronting urban areas in Bangladesh. Conversely, upon its proper management waste may treat an important resource because it contains essential plant nutrients for crop production. Waste recycling is becoming an essential component of sustainable environment.

The major sources of nutrients to be recycled to soils are household wastes, industrial wastes, crop residues and animal manures (Brady, 2001). Phosphorus is one of the main limiting plant nutrients and its deficiency is a major constraint for better crop production in most tropical soils (Tchienkoua and Zech, 2003). The deficiency of P primarily occurs as a result of shortage of inherent soil P, depletion of soil P by crop removal, sorption and fixation of P with Fe and Al oxides and hydroxides (Solomon and Lehmann, 2000). Different organic wastes are rich source of N, P, K and many other macro and micro nutrients (Chongrak, 1996). Therefore, the present study was proposed with overall objective of recycling of embedded nutrients of household waste, poultry manure and cow dung in agriculture using rice as a test crop. The specific objectives were to determine the effect of household waste, poultry manure and cow dung on the yield of rice, to assess their effect on N, P and K concentrations to rice and to quantify their effect for the improvement of soil chemical properties.

2. Materials and Methods

2.1. Collection of household waste, poultry manure and cow dung

Biodegradable and agriculturally usable portion of household waste was collected and sorted from Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) campus and allowed about 4 months for composting in pits. One month old poultry manure and cow dung were procured from local poultry and dairy farms, respectively. Background nutrient concentrations of household waste compost, poultry manure, cow dung and field soils were estimated (Table 1). Total N was determined by Kjeldhal systems (Bremner and Mulvaney, 1982), available P by Olsen's method (Olsen and Sommers, 1982) and K by Ammonium acetate extraction method (Barker and Surh, 1982).

2.2. Experimentation

The experiment was conducted during February to June 2008 at the premises of the Laboratory of Soil Science Department, BSMRAU, Gazipur, Bangladesh using household waste, poultry manure and cow dung in rice cultivation.

There were 11 treatments in the experiment with 3 replications. The experiment was laid down in a completely randomized design. The individual pot size was 15 x 30 PM. A total of 12 kg potting media composed of field soil, household waste, poultry manure and cow dung as per treatment combination used in each pot. The treatments were; (1) Control, (2) Recommended doses of NPK, (3) HW 10%, (4) HW 20%, (5) HW 30%, (6) PM 10%, (7) PM 20%, (8) PM: 30%, (9) CD 10%, (10) CD 20%, and (11) CD 30%.

Table 1. N, P and K content of household waste, poultry manure and cow dung (oven dried at 65^0C).

Waste materials	Total N (%)	Available N (%)	Available P ($\mu g\ g^{-1}$ soil)	Exchangeable K ($g\ kg^{-1}$ soil)
Household waste compost	1.41	0.068	148.13	4.29
Poultry manure	1.80	0.279	893.50	7.41
Cow dung	1.05	0.056	784.00	4.10
Plot soil	0.095	0.035	0.50	0.15 *

* unit of K in the plot soil only is meq/100 g soil to calculate the K requirements as per equation 1.

2.3. Fertilizer application and transplanting

Targeting the high yield goal the required amount of N, P and K were determined using the equation 1 (BARC, 2005).

$$Fr = Uf - (Ci / Cs) * (St - Ls) \quad \ldots\ldots\ldots (1)$$

Where, Fr = Fertilizer nutrient required for a given soil test value (kg ha^{-1}), Uf= Upper limit of the recommended fertilizer nutrient for the respective soil test value interpretation (STVI) class, Ci = Unit of class intervals used for fertilizer nutrient recommendation, Cs = Unit of class intervals used for STVI class, St = Soil test value, Ls = Lower limit of the soil test value within the STVI class.

Assuming $2x10^6$ kg soil per hectare furrow-slice, required amount of N, P and K for 12 kg pot soil was estimated. Recommended doses of NPK fertilizers were applied in addition to organic wastes to each and every pot except in the control treatment. The seedlings of 50 days old were transplanted in the pots on February 10, 2008. The full doses of P and K were applied using triple super phosphate (TSP) and muriate of potash (MP), respectively at the time of potting media preparation. Nitrogen as urea was applied in three equal split: 10 days after transplanting, at maximum tillering stage and at booting stage of the crop. Sulfur, zinc and boron were not applied as these elements were at high level in the potting media. Three seedlings were transplanted in each pot.

2.4. Harvesting and data collection

The crop was harvested after achieving full maturity on June 05, 2008. The harvested crop of each pot was bundled separately and yield data were recorded as g pot^{-1} on 14% moisture basis. The collected grain and straw samples from each pot were dried in an oven at 80^0C for about 24 hours until a constant weight obtained after which they were ground by a grinding machine (Jones *et al.*, 1991). Later the ground samples were sieved through a 20-mesh sieve. Rice straw and grain samples were analyzed for N, P and K. Nitrogen in plant samples was analyzed using Kjeldhal systems (Bremner and Mulvaney, 1982), whereas P and K were determined by the Acid Digestion method (Jones and Case, 1990; Watson and Issac, 1990). Soil samples were collected from each pot after harvesting of the crop and analyzed for residual nutrients. Soil pH was determined by Glass Electrode pH Meter method with soil water ratio 1:2.5 (McLean, 1982), OM by Walkley-Black method (Nelson and Sommers, 1982).

2.5. Calculation of Sustainable yield index (SYI)

Sustainable yield index (SYI) was calculated using the formula given by Singh *et al.* (1990).

SYI = (Y-SD)/Ymax

Where, Y is the average yield of replicates, SD is the standard deviation of yields of three replicates and Ymax is the maximum yield among replicates under each treatment. Singh *et al.* (1990) used the equation to calculate SYI within a time period.

2.6. Statistical analysis

SPSS version 10.0 statistical software was used to analyze the data. One-way-ANOVA and univariate analysis were performed. The test LSD was used to get the significant difference among the treatments' means.

3. Results and Discussion

Treatments significantly affected grain and rice straw production (Table 2). All the treatments gave significantly higher grain yield and straw over the control. Except control the amount of rice straw produced in other treatments were insignificantly different. Application of 30% household waste produced the significantly higher ($p \leq 0.05$) grain yield even over the treatment of recommended dose of N, P and K. However, the effect of this treatment (30% household waste) was insignificantly different with that of 20% household waste, 10% poultry manure and 30% cow dung. The highest grain yield 58.94 g pot^{-1} was observed when 30% household waste was mixed with field soil. The extrapolated grain yield of this treatment is 5.89 t ha^{-1}. The high yield goal of BRRI dhan 29 is 7.50±0.75 t ha^{-1} (BARC, 2005), whereas Alam *et al.* (2009) found maximum yield of 6.86 t ha^{-1} for this rice variety. As the present study was conducted in pots, therefore, yield data may not correlate with field levels performance of the crop.

The maximum sustainable yield index (SYI) 0.91 was found when 10% poultry manure and 30% cow dung was applied to soil (Table 2). The SYI nearness to 1 implies the closeness to an ideal condition that can sustain maximum crop yields over years, while deviation from 1 indicates the losses of sustainability (Singh *et al.*, 1990). The SYI in the present study was calculated using the replicated values of each treatment rather than considering time frame data. Therefore, final conclusion can not be made based on present SYI values, which demands a long time field experiment using these organic wastes.

The treatments did not show any significant effects on nutrient concentration in rice, except K concentration in grain, which was found significant (Table 3). It was observed that higher concentration of N in plants there is a corresponding increase of P and K concentrations. Nitrogen promotes P uptake by plants by improving the growth of the shoot and the root, altering the plant metabolism, and increasing the solubility and availability of P (Havlin *et al.*, 1999). The minimum content of N in rice grain was 1.79% and in straw was 1.49% in the control treatment, which increased to the maximum level of 2.12% in grain and 1.82% in straw where recommended NPK fertilizers were applied.

Table 2. Yield data of rice under different treatments in the pot experiment (mean ± s.d.).

Treatment No.	Treatment description	Grain yield (g pot^{-1})	Straw (g pot^{-1})	Sustainable yield index
1	Control	12.50^{c}	37.36^{b}	-
2	RD of N, P and K	42.50^{b}	58.87^{a}	0.79
3	HW 10%	46.15^{b}	63.60^{a}	0.75
4	HW 20%	49.91^{ab}	66.87^{a}	0.78
5	HW 30%	58.94^{a}	67.58^{a}	0.67
6	PM 10%	50.80^{ab}	67.60^{a}	0.91
7	PM 20%	44.23^{b}	67.32^{a}	0.71
8	PM 30%	49.04^{b}	62.38^{a}	0.72
9	CD 10%	46.58^{b}	69.33^{a}	0.75
10	CD 20%	44.11^{b}	65.94^{a}	0.90
11	CD 30%	49.57^{ab}	67.36^{a}	0.91
S.E. (±)		*3.34*	*5.36*	-
%CV		*12.87*	*14.70*	-

Different superscript letters under the same column indicate the significant difference among the means at 0.05 levels

The P content was found minimum in the control treatment both in grain (0.14%) and straw (0.09%), which reached to the maximum level of 0.21% in grain with the application of recommended doses of inorganic fertilizers and 0.15% in straw under different treatments of combined application of inorganic and organic fertilizers. The K content was found minimum also in the control treatment both in grain (1.44%) and straw (1.12%) and reached to the maximum level of 1.99% in grain and 1.38% in straw with the application of 30% cow dung to pot soils. However, the concentrations of N, P and K found in the present study are in agreement with the study of Sarwar *et al.* (2009). A significant nonlinear relationship was found between grain yield and N, P and K uptake individually (Fig. 1a, 1b & 2a). Nonlinear relationship between N & P , N & K and K & P uptake was also found significant (Fig. 2b, 3a & 3b).

The treatments significantly affected chemical properties of soils except soil pH and K (Table 4). The OM, N and P contents in soils significantly increased over the control. Application of 30% household waste and cow dung accumulated the significantly higher amount of OM content in soils. Significantly higher amount of N was observed in soils when all three types of organic wastes were applied at the rate of 30% to pot soil. However, residual nutrients indicated the fertility enhancement of soils with the application of different organic wastes.

Table 3. Concentrations of N, P and K in rice grain and straw.

Treatment No.	Treatment description	Nutrient concentration in grain (%)			Nutrient concentration in straw (%)		
		N	P	K	N	P	K
1	Control	1.76	0.14	1.44^{c}	1.49	0.09	1.12
2	RD of N, P and K	2.12	0.21	1.82^{ab}	1.82	0.12	1.20
3	HW 10%	2.08	0.19	1.82^{ab}	1.75	0.13	1.16
4	HW 20%	2.01	0.18	1.83^{ab}	1.74	0.14	1.13
5	HW 30%	2.06	0.18	1.80^{ab}	1.72	0.15	1.20
6	PM 10%	2.08	0.17	1.79^{b}	1.70	0.12	1.19
7	PM 20%	2.06	0.21	1.84^{ab}	1.70	0.14	1.19
8	PM 30%	1.88	0.20	1.83^{ab}	1.59	0.15	1.20
9	CD 10%	2.04	0.20	1.81^{ab}	1.68	0.13	1.18
10	CD 20%	1.94	0.20	1.94^{ab}	1.63	0.15	1.17
11	CD 30%	1.95	0.18	1.99^{a}	1.64	0.14	1.38
S.E. (±)		*0.11*	*0.03*	*0.07*	*0.10*	*0.03*	*0.07*
%CV		*9.76*	*29.33*	*6.54*	*10.48*	*24.95*	*9.91*

Different superscript letters under the same column indicate the significant difference among the means at 0.05 levels

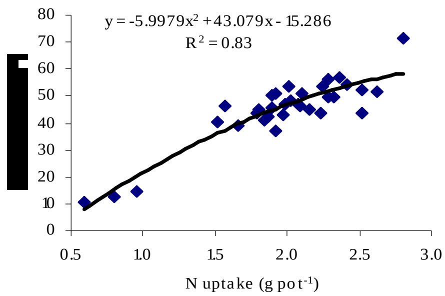

Fig. 1a. Relationship between grain yield and N uptake

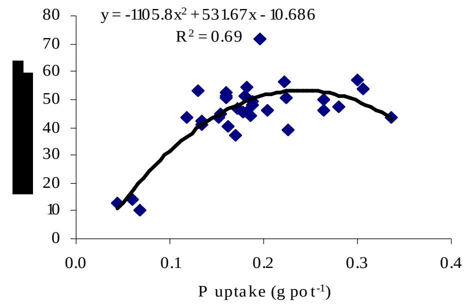

Fig. 1b. Relationship between grain yield and P uptake

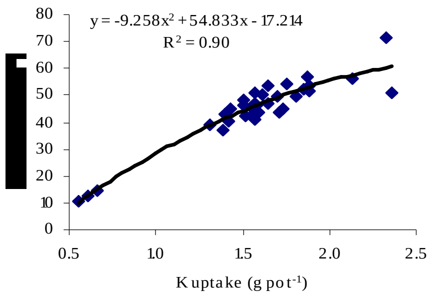

Fig. 2a. Relationship between grain yield and K uptake

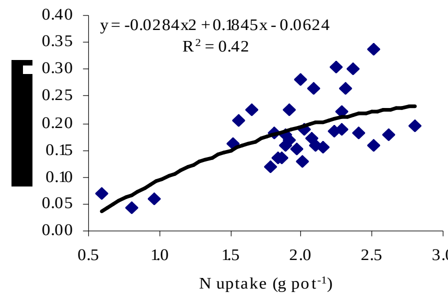

Fig. 2b. Relationship between N and P uptake

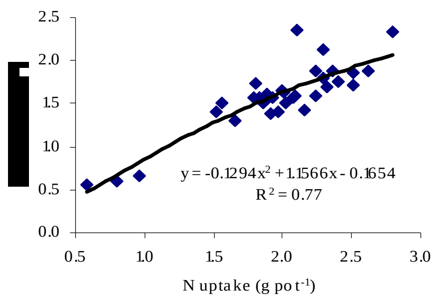

Fig. 3a. Relationship between N and K uptake

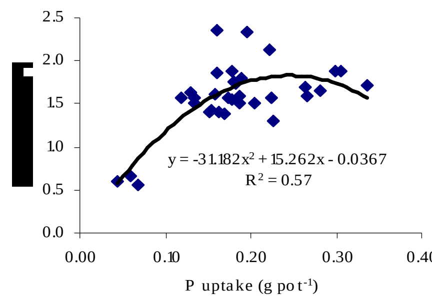

Fig. 3b. Relationship between P and K uptake

Table 4. Soil chemical properties under different treatments at crop harvest.

Treatment No.	Treatment description	pH	OM (%)	N (%)	P (μg g^{-1})	K (meq 100g^{-1})
1	Control	6.27	1.20^{f}	0.11^{d}	2.23d	0.15
2	RD of N, P and K	6.43	1.82^{de}	0.11^{d}	10.74^{c}	0.17
3	HW 10%	6.87	1.91^{de}	0.15^{e}	13.97^{abc}	0.20
4	HW 20%	7.10	2.34^{bc}	0.18^{ab}	12.67^{bc}	0.20
5	HW 30%	7.03	3.10^{a}	0.19^{a}	13.09^{bc}	0.19
6	PM 10%	6.77	1.67^{e}	0.15^{e}	13.10^{bc}	0.20
7	PM 20%	6.83	2.21^{bcd}	0.17^{abc}	15.11^{ab}	0.23
8	PM 30%	7.00	2.44^{bc}	0.19^{a}	17.74^{a}	0.16
9	CD 10%	6.47	1.76^{de}	0.16^{bc}	16.29^{ab}	0.24
10	CD 20%	6.60	2.13^{cde}	0.17^{abc}	17.32^{a}	0.18
11	CD 30%	6.57	2.85^{ab}	0.18^{ab}	17.23^{a}	0.18
S.E. (±)		*0.19*	*0.16*	*0.01*	*1.39*	*0.03*
%CV		*4.80*	*13.11*	*8.55*	*17.64*	*23.53*

Different superscript letters under the same column indicate the significant difference among the means at 0.05 levels

4. Conclusions

Different organic wastes are rich source of essential plant nutrients. They could be used to supplement nutrients to crops and improve soil physicochemical properties. The present study revealed that application of 30% household waste produced the significantly higher grain yield (58.94 g pot^{-1}) even over the recommended doses of N, P and K. The maximum sustainable yield index (SYI) 0.91 was found when 10% poultry manure and 30% cow dung were applied to soil, whereas the value was 0.67 when 30% HW was applied. However, before approaching to a conclusion on SYI, it demands long time field experiment using these organic wastes.

The treatments did not show any significant effects on nutrient concentration in rice, except P concentration in grain, which was found significant. It was observed that higher concentration of N in plants there was a corresponding increase of P and K concentrations. The concentrations of N, P and K in rice grain varied 1.79 - 2.12%, 0.14 - 0.21%, and 1.44-1.99%, respectively. A significant nonlinear relationship was found between grain yield and N, P and K uptake individually. Nonlinear relationship between, N & P, N & K and K & P uptake was also found significant. Post harvest chemical analysis of pot soil indicated that OM, N and P contents in soils significantly increased over the control, which indicated the fertility enhancement of soils with the application of different organic wastes. The maximum accumulation of OM and N were observed when 30% wastes were applied to pot soils.

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References

Alam, M. M., Ali, M. H., Amin, A. K. M. R. and Hasanuzzaman, M. 2009. Yield attributes, yield and harvest indez of three irrigated rice varieties under different levels of phosphorus. *Advances in Biological Research*, 3: 132-139.

BARC (Bangladesh Agricultural Research Council). 2005. *Fertilizer recommendation guide, Bangladesh Agricultural Research Council (BARC)*. Soil publication No. 45. Farm Gate, Dhaka 1215, Bangladesh, 260 p.

Barker, D. E. and Surh, N. H. 1982. Atomic absorption and flame emission spectroscopy. In: *Methods of soil analysis, Part 2, Chemical and microbiological properties, (*eds.*)* A.L. Page, R.H. Miller and D.R. Keeny, American Society of Agronomy and Soil Science Society of America, Inc., Madison, Wisconsin, USA, 13-26 pp.

Brady, N.C. 2001. The nature and properties of soils. Prentice-Hall of India Private Ltd. 621 p.

Bremner, J. M. and Mulvaney, C. S. 1982. Total nitrogen. In: *Methods of soil analysis, Part 2, Chemical and microbiological properties, (*eds.*)* A. L. Page, R. H. Miller and D. R. Keeny, American Society of Agronomy and Soil Science Society of America, Inc., Madison, Wisconsin, USA, 595-624 pp.

Chongrak, P. 1996. Organic waste recycling: technology and management. John Wiley & Sons Ltd., Baffins Lane, Chichester, West Sussex PO19 1UD, England, 412 p.

Havlin, J. L., Beaton, J. D., Tisdale, S. L. and Nelson, W. L. 1999. Soil fertility and fertilizers: An introduction to nutrient management, 6th edition, Prentice Hall, Upper Saddle River, NJ, 499 p.

Jones, Jr. J. B. and Case, V. W. 1990. Sampling, handling and analyzing plant tissue samples. In: *Soil testing and plant analysis*, 3rd edition, SSSA Book series 3, (ed.) W. S. Westermaan, Soil Science Society of America, Madison, WI, USA, 389-427 pp.

Jones, Jr. J. B., Wolf, B. and Mills, H. A. 1991. Plant analysis handbook. Micro-macro Publishing, Athens, GA, 23-26 pp.

McLean, E. O. 1982. Soil pH and lime requirement. . In: *Methods of soil analysis, Part 2, Chemical and microbiological properties, (*eds.*)* A. L. Page, R. H. Miller and D. R. Keeny, American Society of Agronomy and Soil Science Society of America, Inc., Madison, Wisconsin, USA, 199-224 pp.

Nelson, D. W. and Sommers, L. E. 1982. Total carbon, organic carbon, and organic matter. In: *Methods of soil analysis, Part 2, Chemical and microbiological properties*, (eds.) A.L. Page, R.H. Miller and D.R. Keeny, American Society of Agronomy and Soil Science Society of America, Inc., Madison, Wisconsin, USA, 539-579 pp.

Olsen, S. R. and Sommers, L. E. 1982. Phosphorus. In: *Methods of soil analysis, Part 2, Chemical and microbiological properties*, (eds.) A.L. Page, R.H. Miller and D.R. Keeny, American Society of Agronomy and Soil Science Society of America, Inc., Madison, Wisconsin, USA, 403-430 pp.

Rahman, M. M. and Yakupitiyage, A. 2006. Use of fishpond sediment for sustainable aquaculture-agriculture farming. *International Journal of Sustainable Development and Planning*, 1: 192-202.

Rathi, S. 2006. Alternative approaches for better municipal solid waste management in Mumbai, India. *Waste Management*, 26(10): 1192-1200.

Saleque, M. A., Uddin, M. K., Ferdous, A. K. M., Khatun, A. and Rashid, M. H. 2009. An evaluation of nutritional constraints on irrigated rice yield. International Plant Nutrition Colloquim, University of California, Davis. Paper No. 1083.

Sarwar, G., Schmeisky, H., Hussain, N., Muhammad, S., Tahir, M. A. and. Saleem, U. 2009. Variations in nutrient concentrations of wheat and paddy as ffected by different levels of compost and chemical fertilizer in normal soil. *Pakistan Journal of Botany*, 41(5): 2403-2410.

Solomon, D. and Lehmann, J. 2000. Loss of phosphorus from soil in semi-arid northern Tanzania as a result of cropping: evidence from sequential extraction and ^{31}P-NMR spectroscopy. *European Journal of Soil Science*, 51: 699-708.

Tchienkoua, M. and Zech, W. 2003. Chemical and spectral characterization of soil phosphorus under three land uses from an Andic Palehumult in West Cameroon. *Agriculture Ecosystems and Environment*, 100: 193-200.

Watson, M. E. and Isaac, R. A. 1990. Analytical instruments for soil and plant analysis. In: *Soil testing and plant analysis*, 3rd edition, SSSA Book series 3, (ed.) W.S. Westermaan, Soil Science Society of America, Madison, WI, USA, 691-740 pp.

Singh, R. P., Das, S. K., Rao, U. M. B. and Reddy, M. N. 1990. Towards sustainable dryland agricultural practices. CRIDA, Hyderabad, India.