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Plant Nutrient Status of Nerica 10 Under Integrated Fertilizer Management

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A B S T R A C T

An experiment was conducted to assess the effect of integrated nutrient management on plant nutrient content of NERICA 10 during Aus season (Mid March-July), 2012. Eleven treatments coded from T_1 to T_{11} were used in the experiment. N, P, K, S content in grain and straw and their uptake by grain and straw of NERICA 10 showed significant variation among the treatments. In post harvest soils, the contents of total nitrogen, available phosphorus, exchangeable potassium and available sulphur increased due to application of cowdung and vermicompost compared to initial soil. In the contrary, soil pH value decreased slightly as compared to that of initial soil. The overall results indicate that 100 kg N from urea along with 20 kg N from vermicompost was the best treatment in producing higher rice yield with sustenance of soil fertility.

Key words: *Oryza sativa, organic and inorganic fertilizers, NPKS content*

Introduction

Rice (*Oryza sativa* L.) constitutes a major crop for human diet in Bangladesh. Soil degradation and nutrient depletion have gradually increased and have become serious threats to agricultural productivity. A major factor in soil degradation is the soil chemical fertility and then in particular its decline as a result of the lack of nutrient inputs (Hartemink, 2010). Consistent utilization of inorganic fertilizer by rice farmers in Bangladesh constitutes soil nutrient imbalance and environmental pollution. In addition, lacking of inputs cause soil degradation, inherently low fertility status, inappropriate land use, poor management, erosion and salinization (Bationo et al., 2006). Livestock discharges huge amount of farm yard manure such as poultry manure, cattle dung, poultry manure etc., into the environment indiscriminately (Sharpe et al., 2004) and also huge amount of plant residue discharged in Bangladesh. These animal and plant remains constitute environment hazards. However, their utilization to improve nutrient deficient soil in the form of compost is yet to be explored maximally. Rice yields could be increased with adequate application of fertilizers and organic manure, but this will require that baseline fertility status of these soils. Studies on soil variability has relevance in sampling (Tabi and Ogunkunle, 2007), site specific soil fertility management (Tittonell et al., 2008) and definition of land management units (Salami et al., 2011, Tittonell et al., 2008) and in explaining variation in crop growth and yield (Tittonell et al., 2008). Response of rice to nutrient supply by organic and inorganic fertilizer is universal but may vary with locations, soil and fertilizer types (Arthanari et al., 2007). Similarly, crops have been reported to respond differently to different composts under similar soil fertility condition (Hassanein and Abul-Soud, 2010; Shu, 2005). It is well known that declines in crop yield are strongly related to soil quality degradation, particularly nutrient depletion (Roy et al., 2003). Nutrient depletion can be attributed to insufficient fertilizer use and unbalanced fertilization (Tan et al., 2005). The current study was conducted to find out the nutrient status of NERICA 10 through different fertilizer combinations.

Materials And Methods

Location of the study and period:

The experiment was conducted in the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh in Aus season (Mid March-July) of 2012. NERICA 10 cultivar was used in the experiment.

Treatments of the experiment

Eleven different fertilizer combinations viz., T_1: No chemical fertilizer and organic manure (Control); T_2: 100% recommended N (120 kg nitrogen ha^{-1}); T_3: 100 kg N from urea + 20 kg N substituted by vermicompost; T_4: 100 kg N from urea + 20 kg N substituted by cowdung; T_5: 80 kg N from urea + 40 kg N substituted by vermicompost; T_6: 80 kg N from urea + 40 kg N substituted by cowdung; T_7: 60 kg N from urea + 60 kg N substituted by vermicompost; T_8: 60 kg N from urea + 60 kg N substituted by cowdung; T_9: 40 kg N from urea + 80 kg N substituted by vermicompost; T_{10}: 40 kg N from urea + 80 kg N substituted by cowdung; T_{11}: 100% N substituted by equal portion of vermicompost were used in the experiment as treatment. Urea contained 46% N, Cowdung contain 1% N and Vermicompost contain 2.1% N.

Application of fertilizers

The amounts of nitrogen, phosphorus, potassium and sulfur fertilizers required per plot were calculated from fertilizers rate per hectare. TSP, MP and Gypsum were applied @ 80, 120, 55 kg/ha respectively during final land preparation. A blanket dose of 16 kg P, 60 kg K and 10 kg S $hectare^{-1}$ was applied to all plots in the forms of triple super phosphate (TSP), muriate of potash (MoP) and gypsum, respectively during final land preparation. Nitrogen was also applied as per treatment in the form of urea in three equal splits. The first split was applied after 15 days of sowing, the second split was applied after 35 days of sowing i.e. at active vegetative stage and the third split was applied after 60 days of sowing i.e. at panicle initiation stage.

Experimental design

Experiment was conducted using Randomized Complete Block with three replications. The unit plot size was 3.5 m × 2 m, block to block distance was 2 m and plot to plot distance was 1 m.

Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were drawn by means of an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were picked up and removed. Then the samples were air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

Chemical analysis of soil samples

Soil samples were analyzed for both physical and chemical properties in the laboratory of Soil Resource Development Institute (SRDI), Farmgate, Dhaka. The properties studied included soil texture, pH, organic matter, total N, available P, exchangeable K and available S. The physical and chemical properties of the initial soil have been presented in Table 1.

Table 1. Physical and chemical properties of the initial soil sample

Characteristics	Value
Particle size analysis	
% Sand	28.2
% Silt	41.2
% Clay	30.6
Textural class	Silty-clay
pH	5.6
Bulk Density (g/cc)	1.45
Particle Density (g/cc)	2.52
Organic carbon (%)	0.47
Organic matter (%)	0.81
Total N (%)	0.05
Available P (ppm)	18.1
Exchangeable K (meq/100g soil)	0.10
Available S (ppm)	40

Particle size analysis

Particle size analysis of soil was done by Hydrometer Method (Bouyoucos, 1926) and the textural class was determined by plotting the values for % sand, % silt and % clay to the “Marshall’s Textural Triangular Coordinate” according to the USDA system.

Soil pH

Soil pH was measured with the help of a Glass electrode pH meter using soil and water at the ratio of 1:2.5 (Jackson, 1962).

Organic carbon

Organic carbon in soil was determined by Wet Oxidation Method (Walkley and Black, 1934) where the principle was to oxidize organic carbon with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and to titrate the residual $K_2Cr_2O_7$ solution with 1N $FeSO_4$ solution. To obtain organic matter content, amount of organic carbon was multiplied by the Van Bemmelen factor (1.73) and expressed in percentage.

Total nitrogen

Total nitrogen of soil was determined by Micro Kjeldahl method where soil was digested with 30% H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se powder in the ratio of 100:10:1). Nitrogen in the digest was estimated by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01N H_2SO_4 (Bremner and Mulvaney, 1982).

Available phosphorus

Available phosphorus was extracted from soil by shaking with 0.5 M $NaHCO_3$ solution of pH 8.5 (Olsen et al., 1954). The phosphorus in the extract was then determined by developing blue color using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue color was measured at 660 nm wave length by Spectrophotometer and available P was calculated with the help of standard curve.

Exchangeable potassium

Exchangeable potassium was determined by 1N NH_4OAc (pH 7.0) extract of the soil by using Flame photometer (Black, 1965).

Available sulphur

Available sulphur in soil was determined by extracting the soil samples with 0.15% $CaCl_2$ solution (Page et al., 1982) The S content in the extract was determined turbidmetrically and the intensity of turbid was measured by Spectrophotometer at 420 nm wave length.

Chemical analysis of plant samples

Preparation of plant samples

Ten selected hills/plot were collected immediately after crop harvesting. Selected hills were threshed. Both grain and straw were cleaned and dried in an oven at 65^0 C for 48 hours. The dried samples were grinded and put into small paper bags and kept into a desiccators till being used.

Digestion of plant samples with sulphuric acid

For N determination, an amount of 0.1 g plant sample (grain/straw) was taken into a 100 ml Kjeldahl flask. An amount of 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se = 100:10:1), 2 ml 30% H_2O_2 and 3 ml conc. H_2SO_4 were added into the flask. The flask was swirled and allowed to stand for about 10 minutes, followed by heating at 200^0C. Heating was continued until the digest was clear, and colorless. After cooling, the contents were taken into a 100 ml volumetric flask and the volume was made with distilled water. A blank digestion was prepared in a similar way except plant sample. This digest was used for determining the nitrogen contents on plant samples.

Digestion of plant samples with nitric-perchloric acid mixture

An amount of 0.5 g of plant sample was taken into a dry clean 100 ml Kjeldahl flask, 10 ml of di-acid mixture (HNO_3, $HClO_4$ in the ratio of 2:1) was added and kept for few minutes. Then, the flask was heated at a temperature raising slowly to 200^0C. Heating was instantly stopped as soon as the dense white fumes of $HClO_4$ occurred and after cooling, 6 ml of 6N HCl were added to it. The content of the flask was boiled until they become clear and colorless. This digest was used for determining P, K, S and Zn.

Statistical Analysis

The statistical analysis for different character including the nutrient content and uptake were done following the ANOVA technique and the mean results in case of significant F-values were adjusted by the Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results and Discussion

N, P, K and S in grain and straw

Nitrogen, phosphorus, potassium and sulphur content in grain was varied significantly among the treatments. Maximum N content was found from T_3 (1.02%) while minimum was found from T_5 and T_{11} (0.90%) (Table 1). Maximum P content was found from T_5 (0.23%) while minimum was found from T_1 (0.18%) (Table 1). Maximum K content was found from T_3 (0.24%) while minimum was found from T_5 and T_6 (0.15%) (Table 1). Maximum S content was found from T_7 (0.35%) while minimum was found from T_3, T_6 and T_9 (0.09%) (Table 1). Nitrogen, phosphorus, potassium and sulphur content in straw showed significant variation among the treatments. Maximum N content was found from T_3 (0.57%) while minimum was found from T_1 (0.39%) (Table 1). Maximum P content was found from T_7 (0.12%) while minimum was found from T_4, T_5 and T_8 (0.09%) (Table 1). Maximum K content was found from T_9 (1.47%) while minimum was found from T_1 (1.27%) (Table 1). Maximum S content was found from T_{11} (0.12%) while minimum was found from T_1, T_3, T_5, T_6, T_7 and T_{10} (0.08%) (Table 1). N content in rice grain and straw increased significantly due to application of chemical fertilizers and residual effects of organic manures (Mann et al., 2006). Combined application of urea and FYM significantly enhanced N content in rice straw and grain (Gupta et al., 2000). Increase in P content both in rice grain and straw due to the application of chemical fertilizers and residual effects of organic manures (Indrani et al., 2008). P content was significantly increased where urea, cowdung, poultry manure and urban wastes are applied together (Solaiman et al., 2011). K content in grain and straw were increased due to application of chemical fertilizers and residual effects of organic manures (Krishnappa et al., 2006) also combined application of chemical fertilizers and organic manures (Shen et al., 2003). Application of chemical fertilizers and residual effects of organic manures increased the S content both in grain and straw of rice (Mann et al., 2006). Sulphur use efficiency was highest and sulphur content was higher in the presence of organic fertilizers (Bhuvaneswari et al., 2007).

Table 2. Effects of integrated nutrient management on N, P, K and S content (%) of NERICA 10 [X]

Treatment	Grain								Straw							
	N		P		K		S		N		P		K		S	
T_1	0.97	a-c	0.18	d	0.21	a-c	0.11	ab	0.39	c	0.10	bc	1.27	c	0.08	c
T_2	0.93	bc	0.21	bc	0.17	b-d	0.10	b	0.51	a-c	0.10	bc	1.34	bc	0.09	bc
T_3	1.02	a	0.22	ab	0.24	a	0.09	b	0.57	a	0.12	a	1.46	a	0.08	c
T_4	0.96	a-c	0.21	bc	0.22	ab	0.11	ab	0.52	a-c	0.09	c	1.35	bc	0.09	bc
T_5	0.90	c	0.23	a	0.15	d	0.10	b	0.48	a-c	0.09	c	1.37	a-c	0.08	c
T_6	1.00	ab	0.16	e	0.15	d	0.09	b	0.46	a-c	0.11	ab	1.42	ab	0.08	c
T_7	0.93	bc	0.17	de	0.21	a-c	0.35	a	0.56	a	0.12	a	1.34	bc	0.08	c
T_8	0.93	bc	0.17	de	0.20	a-d	0.12	ab	0.48	a-c	0.09	c	1.38	ab	0.10	b
T_9	0.93	bc	0.17	de	0.17	cd	0.09	b	0.41	bc	0.11	ab	1.47	a	0.09	bc
T_{10}	1.00	ab	0.20	c	0.19	a-d	0.10	b	0.53	ab	0.10	bc	1.43	ab	0.08	c
T_{11}	0.90	c	0.22	ab	0.16	cd	0.11	ab	0.56	a	0.11	ab	1.38	ab	0.12	a
LSD0.05	0.08		0.17		0.05		0.25		0.13		0.17		0.11		0.17	
CV (%)	4.59		10.09		12.82		9.86		15.39		14.31		4.84		22.11	

[X] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Total N, P, K and S uptake by grain and straw

Total nitrogen, phosphorus, potassium and sulphur uptake by grain showed significant variation among the treatments. However, maximum N uptake was found from T_{10} (43.5 kg/ha) while minimum was found from T_1 (14.6 kg/ha) (Table 2). Maximum P uptake was found from T_{10} and T_{11} (8.7 kg/ha) whereas minimum was found from T_1 (2.7 kg/ha) (Table 2). NIRCA 10 treated by T_3 and T_4 showed the maximum uptake of K (8.8 kg/ha) while minimum was found from T_1 (3.2 kg/ha) (Table 2). Maximum S uptake was found from T_8 (5.0 kg/ha) whereas minimum was found from T_1 (1.7 kg/ha) (Table 2). Total nitrogen, phosphorus, potassium and sulphur uptake by straw varied significantly among the treatments. However, maximum N uptake was found from T_{11} (30.0 kg/ha) while minimum was found from T_1 (8.5 kg/ha) (Table 2). Maximum P uptake was found from T_3 (6.1 kg/ha) whereas minimum was found from T_1 (2.2 kg/ha) (Table 2). NIRCA 10 treated by T_{10} showed the maximum uptake of K (74.4 kg/ha) while minimum was found from T_1 (27.7 kg/ha) (Table 2). Maximum S uptake was found from T_{11} (6.4 kg/ha) whereas minimum was found from T_1 (1.7 kg/ha) (Table 2). N uptake by rice grain and straw increased significantly with the combined application of organic manure and chemical fertilizers (Jacqueline et al., 2008). 75% recommended dose of N fertilizer + 25% N as poultry manure increased N uptake in rice (Vennila, 2007). NPK concentrations and their uptake in grain and straw significantly increased with the application of NPK + S fertilizers compared to the control (Sarfaraz et al., 2002). Nutrient content as well as nutrient uptake by rice was more in combined application of organic and inorganic fertilizers over other treatments (Moula, 2005). Organic manures increased labile, moderately stable and stable organic P contents in soil and uptake by plants (Zhang et al., 1998). Application of organic manure and chemical fertilizers significantly increased the K uptake by rice but K uptake by grain was much lesser than that by straw (Sreelatha et al., 2006). Application of organic manure and chemical fertilizers increased the sulphur uptake significantly by rice (Bhuvaneswari and Chandrasekharan, 2006) that significantly increased the crop yield (Azmi et al., 2004).

Table 3. Effect of integrated nutrient management on N, P, K and S uptake by NERICA 10 [X]

Treatment	Uptake by grain (kg/ha)								Uptake by straw (kg/ha)							
	N		P		K		S		N		P		K		S	
T_1	14.6	f	2.7	e	3.2	d	1.7	h	8.5	e	2.2	f	27.7	d	1.7	c
T_2	35.3	c-e	8.0	ab	6.5	bc	3.8	de	23.7	a-d	4.7	b-e	62.3	c	4.2	b
T_3	37.2	b-e	8.0	a	8.8	a	3.3	f	28.8	ab	6.1	a	74.1	a	4.0	b
T_4	38.4	b-d	8.4	a	8.8	a	4.4	b	25.5	a-c	4.4	c-e	66.2	bc	4.4	b
T_5	33.8	de	8.6	a	5.6	c	3.8	e	21.1	cd	4.0	e	60.3	c	3.5	b
T_6	41.0	ab	6.6	cd	6.2	bc	3.7	e	23.5	a-d	5.6	a-c	72.4	ab	4.1	b
T_7	32.6	e	6.0	d	7.4	ab	2.8	g	24.9	a-c	5.3	a-d	59.6	c	3.6	b
T_8	39.1	a-c	7.1	bc	8.4	a	5.0	a	23.3	cd	4.4	de	66.9	a-c	4.9	b
T_9	35.8	c-e	6.5	cd	6.5	bc	3.5	ef	17.6	d	4.7	b-e	63.2	c	3.9	b
T_{10}	43.5	a	8.7	a	8.3	a	4.4	c	27.6	a-c	5.2	a-d	74.4	a	4.2	b
T_{11}	35.6	c-e	8.7	a	6.3	bc	4.3	c	30.0	a	5.9	ab	73.8	ab	6.4	a
LSD0.05	5.1		0.9		1.7		0.3		6.5		1.2		7.8		1.4	
CV (%)	8.5		7.2		14.4		5.0		16.6		15.3		7.2		20.3	

[X] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

N, P, K and S content in post harvest soil

Total N, available P, exchangeable K and available S content in post harvest soil were also varies significantly among the treatments. Maximum total N was found in T_4, T_6, T_8 and T_9 (0.08%) while minimum was found from T_1 (0.06%) (Table 3). Maximum available P was T_6 (19.9 ppm) which was statistically with T_3 (19.0 ppm) whereas minimum was found from T_1 (15.2 ppm) (Table 3). Maximum exchangeable K was found from T_6 (0.16 meq/100 g soil) while minimum was found from T_1 (0.11 meq/100 g soil) (Table 3). Maximum available S was found from T_7 (30.9 ppm) whereas minimum was found from T_1 (19.1 ppm) (Table 3).

Table 4. Effect of integrated nutrient management on N, P, K and S content in post harvest soil of NERICA 10 [X]

Treatment	Total N (%)		Available P (ppm)		Exchangeable K (meq/100g soil)		Available S (ppm)	
T_1	0.06	c	15.2	e	0.11	d	19.1	i
T_2	0.07	b	16.5	d	0.13	c	21.6	h
T_3	0.07	b	19.0	ab	0.14	b	22.1	g
T_4	0.08	a	17.0	d	0.14	b	22.6	f
T_5	0.07	b	18.5	b	0.15	b	26.1	e
T_6	0.08	a	19.9	a	0.16	a	29.0	d
T_7	0.07	b	18.2	bc	0.14	b	30.9	a
T_8	0.08	a	18.4	b	0.15	b	29.5	c
T_9	0.08	a	17.3	cd	0.15	b	30.3	b
T_{10}	0.07	b	18.6	b	0.15	b	30.1	b
T_{11}	0.07	b	17.1	cd	0.14	c	29.9	bc
LSD0.05	0.17		1.1		0.17		0.5	
CV (%)	14.36		3.6		5.12		1.0	

[X] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Conclusion

Among the organic sources, vermicompost performed the best in recording yield and yield attributing characters as well as NPKS content and uptake by NERICA 10. Cowdung and vermicompost alone or with the combination of nitrogenous fertilizer insignificantly decreased (slight) soil pH than in initial soil. Nitrogen, Phosphorus and Sulphur content in rice grain was higher than the rice straw. Potassium content in rice straw was about 6-8 times higher than rice grain. Organic manuring slightly increased total N, available P and S and exchangeable K in post harvest soil compared to initial soil. Increasing trend in cowdung and vermicompost content was observed in soil where organic manures were applied.

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