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Effect of long-term organic practices on yield and nutrients uptake by rice (*Oryza sativa* L) in an acid Inceptisol

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ABSTRACT

An investigation was carried out to the study the impact of long-term organic farming practices on yield and uptake of nutrients by rice in an acid soil of Assam. The seven treatments were evaluated in randomized block design with three replications. The treatments consisted of T_1; Absolute control, T_2; Biofertilizer consortia @ 3.5 kg ha^{-1}, T_3; Compost @ 5.0 t ha^{-1}, T_4; Compost @ 5.0 t ha^{-1}+ Biofertilizer consortia @ 3.5 kg ha^{-1}), T_5; Enriched compost @ 2.5 t ha^{-1}, T_6: Enriched compost @ 5 t ha^{-1}, T_7: Azolla @ 0.5 t ha^{-1} + Biofertilizer consortia @ 3.5 kg ha^{-1}. Result revealed that significantly higher grain and straw yields were recorded as 34.5 and 57.1 q ha^{-1} with use of enriched compost @ 5.0 t ha^{-1} treatments. The grain yield of rice was increased by 14.6 and 43.1% over compost @ 5.0 t ha^{-1} and control, respectively and statistical similar grain yield was obtained with compost @ 5.0 t ha^{-1}+biofertilizer consortia @ 3.5 kg ha^{-1} treatment. Application of enriched compost @ 5 t ha^{-1} significantly improve total nitrogen phosphorus and potassium uptake by rice and found similar to compost @ 5.0 tha^{-1} + biofertilizer consortia @ 3.5 kg ha^{-1} (except total K uptake) as compared to other treatments. Total uptake of micronutrient (Zn, Fe, Mn and Cu) by rice significantly enhanced with the use of organic farming practices over control. Thus, the dose of compost could be reduced by using enriched compost to obtain higher crop production with its quality.

Keywords- Long term organic practices, consortia, acid soil, nutrient uptake, yield, rice

INTRODUCTION

In tropical and subtropical regions of the world a large proportion of rice is cultivated in acid soils. Food and nutritional security in Asian nations rely to a great extent on rice which is the source of 15% of protein and 21% of energy intake for the population of this continent (Depa *et al.*, 2011). In India, the total area under acidic soil is approximately 90 Mha, out of which total 49 Mha is arable covering about 30 per cent of the country's total cultivable area. Rice is the major crop cultivated in those areas. The growth of crops in acidic soils is primarily unstable due to aluminum (Al) and iron (Fe) toxicity, nitrogen (N) and phosphorus (P) deficiency, diminished microbial activity, poor base saturation and some other nutritional and fertility-related problems (Biswas *et al.*, 2009). The soil acidity has a negative impact on the assembly of major food crops expanding in these regions, it is important to control these acid soils in order to achieve global and regional agricultural production goals. Organic farming is a method of development that prohibits, or virtually avoids, the use of synthetic fertilizers, pesticides and growth regulators. Addition of organic matter plays an important role in soil fertility as well as several physical and chemical properties like soil water holding capacity, improved germination, aeration, cation exchange capacity and plant root growth. The essential micronutrients present in organic manures also improve plant metabolic activities during the initial growth stages.

Other measures adapted in organic farming, apart from addition of compost and manure, are crop rotation, biofertilizers application and cover cropping. Application of organic amendment considerably influences the soil quality and ecosystem sustainability because it functions as a buffering agent, sources of plant nutrients and a means for increasing soil microbial biomass, activity and variety (Wang *et al.,* 2011). Biofertilizer induced soil biological enhancements vary from soil to soil and play a major role in soil nutrient cycling and soil organic carbon stabilization which, in turn, affects soil quality and agricultural

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productivity (Kumar *et al.,* 2017). The enriched compost application is directly related to the increase in the soil nutrients and enhancement of other beneficial properties of soil, for example, microbial activity, humus fraction, soil structure and cation exchange capacity. Enriched compost has also been advantageous with regards to its residual effect on successive crops. Demerits of dense organic materials such as FYM and ordinary compost can also be effectively resolved by enriched composting (Biswas *et al.*, 2009). India has tremendous potential to become an important international exporter of organic rice. Around 5630 MT of organic basmati rice was exported from India through the Agricultural and Processed Food Products Export Development Authority (APEDA) during 2008-09. A study performed on rice in a deep black clayey Vertisol at Rice Research Farm Directorate (Hyderabad, Andhra Pradesh) showed that although it took three years for organically cultivated rice to attain the *kharif* yield as obtained under inorganic cultivation, but after four years, there was a substantial rise in the SOC, available N, P and K under organic cultivation (Saha *et al.,* 2010). Therefore, the present study was carried out to evaluate the organic farming practices using rice crop.

MATERIALS AND METHODS

The experiment was carried out in the rainy season using rice crops from the long-term organic farming practices at Assam Agricultural University, Assam, ($26^0$43' N latitude and 94^o11' E longitude). The experimental soil was clay loam in texture with 4.6 pH, 0.17 dS m^{-1} electrical conductivity, 6.6 g kg^{-1} organic carbon, 302 kg ha^{-1} available N, 26.3 kg ha^{-1} available P (Bray No.1) and 149 kg ha^{-1} available K content. Thus, the soil was rated to be medium with respect to available N and K and low with respect to available P status. The experiment was laid down in randomized block design (RBD) and repeated with seven treatments and replicated three times. The treatments consisted of T_1; Absolute control, T_2; Biofertilizer consortia @ 3.5 kg ha^{-1}, T_3; Compost @ 5.0 t ha^{-1}, T_4; Compost @ 5.0 t ha^{-1}+ Biofertilizer consortia @ 3.5 kg ha^{-1}), T_5; Enriched compost @ 2.5 t ha^{-1}, T_6: Enriched compost @ 5 t ha^{-1}, T_7: Azolla @ 0.5 t ha^{-1} + Biofertilizer consortia @ 3.5 kg ha^{-1}. Biofertilizers viz., *Azospirillum* and Phosphate solubilizing bacteria (PSB) were applied as overnight seedling root dip treatments. Treatments have been continuously applied in the same plot for seven years. Enriched compost (EC) [primed with *Azospirillum* and PSB @ 1% broth each containing 10^8 -10^9 cfuml^{-1} and adjusted with 1% rock phosphate (RP contained 19.46 % P_2O_5) was used in the experiment prepared from rice biomass. The properties of prepared enriched compost was neutral in reaction with 7–7.5 pH, 3.57–3.80 dS m^{-1} EC, 192–196 g kg^{-1} O C, 1.67–1.72% total N, 1.15 % total P, and 0.91% total K. The rice variety *Joha* was transplanted with isolation distance 20 x 20 cm^2 during the first fortnight of June, 2019. After harvest, plant samples (grain and straw) were collected and thoroughly mixed to make one composite sample. The plant samples were dried in oven at 65± 2°C for 72 h. The oven dried plant samples were then ground in a Wiley mill. The procedures outlined by Jackson (1973) were followed for the analysis of nitrogen in grain and straw samples. Plant samples were digested with di-acid mixture. In the diluted acid digest, P, K and micronutrients (Fe, Cu, Mn and Zn) were determined using spectrophotometer (after employing vanadomolybdate yellow colour method), flame photometer and AAS, respectively. As suggested by Gomez and Gomez (1984), data obtained from the field experiments were subjected to the statistical analysis of variance relevant to the experimental design. Data were assessed by Duncan's multiple range tests with a probability P= 0.05. The lowest significant difference (LSD) between means was determined using the SAS-9.3, SAS.

RESULTS AND DISCUSSION

Yield

The use of different organic sources under organic farming practices *viz*., compost, enriched compost and biofertilizer clearly showed significant changes in grain yield over control, it ranged from 24.1 (Control) to 34.5 q ha^{-1} with enriched compost @ 5 t ha^{-1}. The significant highest with percent change in grain yield (43.2%) was observed with application of enriched compost @ 5 t ha^{-1} over control. The use of biofertilizer consortia @ 3.5kg ha^{-1} alone increased the grain yield by 18.3% as compared to absolute control (Table 1). Straw yield of rice increased from 38.3 qt ha^{-1} (Control) to 57.1 qt ha^{-1} with enriched compost @ 5.0 t ha^{-1} due to different doses of organic sources *viz*., compost, enriched compost and biofertilizer. The straw yield was significantly increased by 49.1% over control under enriched compost @ 5.0 t ha^{-1}. Moreover, statistically similar changes (47.5, 39.1, 49.7 and 40.7 %) in straw yield were recorded with compost @ 5.0 t ha^{-1}+biofertilizer consortia @ 3.5kg ha^{-1}, enriched compost @ 2.5 t ha^{-1}, enriched compost @ 5 t ha^{-1} and azolla @ 0.5 t ha^{-1} + biofertilizer consortia @ 3.5 kg ha^{-1}, respectively.

Tables 1: Effect of organic farming practices on yields of rice

Treatment	Grain yield	Straw yield	Per cent change in grain yield over control	Per cent change in straw yield over control
	(q ha^{-1})		(%)	(%)
T_1: Absolute control	24.1	38.3	0	0
T_2: Biofertilizer consortia @ 3.5 kg ha^{-1}	28.5	46.2	18.3	20.6
T_3: Compost @ 5.0 t ha^{-1}	30.1	49.8	24.9	30.0
T_4: Compost @ 5.0 t ha^{-1}+Biofertilizer consortia @ 3.5 kg ha^{-1}	34.1	56.5	41.9	47.5
T_5: Enriched compost @ 2.5 t ha^{-1}	30.5	53.4	26.6	39.4
T_6: Enriched compost @ 5.0 t ha^{-1}	34.5	57.1	43.2	49.1
T_7: Azolla @ 0.5 t ha^{-1}+Biofertilizer consortia @ 3.5 kg ha^{-1}	30.7	53.9	27.4	40.7
LSD @ 5%	1.69	2.83	7.87	8.05

Macronutrients uptake

Different organic farming practices significantly improved the N uptake over control. Total N uptake by plants ranged from 72.3 to 126 kg ha^{-1}. Total N uptake (126 kg ha^{-1}) by rice was highest in enriched compost @ 5 t ha^{-1} as compared to other treatments of organic farming practices whereas, N uptake under enriched compost @ 5 t ha^{-1}, Compost @ 5.0 t ha^{-1} + Biofertilizer consortia @ 3.5 kg ha^{-1} and Azolla @ 0.5 t ha^{-1}+Biofertilizer consortia @ 3.5 kg ha^{-1} was statistically at par with each other in terms of total N uptake (126, 122.0 and 116.5 kg ha^{-1}). Total P uptake of rice was also improved significantly due to different organic farming practices. Phosphorus uptake ranged from 8.6 to 24.4 kg ha^{-1} which was highest under enriched compost @ 5 t ha^{-1} and compost @ 5.0 t ha^{-1} + biofertilizer consortia @ 3.5 kg ha^{-1}. Results also indicated that the use of compost alone @ 5.0 t ha^{-1} and lower dose of enriched compost @ 2.5 t ha^{-1} were statistically at par for total uptake (17.9 and 18.7 kg ha^{-1}) of P.

Table 2: Effect of organic farming practices on total nitrogen, phosphorus and potassium uptake (kg ha^{-1})

Treatment	Total nutrients uptake by rice (kg ha^{-1})		
	Nitrogen uptake	Phosphorus uptake	Potassium uptake
T_1: Absolute control	72.3^{d}	8.6^{d}	65.0^{e}
T_2: Biofertilizer consortia @ 3.5 kg ha^{-1}	89.9^{c}	14.5^{c}	85.4^{d}
T_3: Compost @ 5.0 t ha^{-1}	102^{b}	17.9^{b}	107^{c}
T_4: Compost @ 5.0 t ha^{-1}+Biofertilizer consortia @ 3.5 kg ha^{-1}	122^{a}	23.0^{a}	123^{b}
T_5: Enriched compost @ 2.5 t ha^{-1}	104^{b}	18.7^{b}	107^{c}
T_6: Enriched compost @ 5.0 t ha^{-1}	126^{a}	24.4^{a}	133^{a}
T_7: Azolla @ 0.5 t ha^{-1}+Biofertilizer consortia @ 3.5 kg ha^{-1}	116^{a}	16.3^{bc}	104^{c}
LSD @ 5%	11.6	2.4	8.7

There was a significant increase in K uptake (65.0 to 133 kg ha^{-1}) due to use of different organic farming practices over control. Highest total K uptake (133 kg ha^{-1}) was recorded under enriched compost @ 5 t ha^{-1}, which was statistically similar to compost @ 5.0 t ha^{-1} + biofertilizer consortia @ 3.5 kg ha^{-1}. Treatments compost @ 5.0 t ha^{-1}, enriched compost @ 2.5 t ha^{-1} and azolla @ 0.5 t ha^{-1} + biofertilizer consortia @ 3.5 kg ha^{-1} were also statistically similar to each other with respect of K uptake by grain, straw and total K uptake by plant. The lowest N (72.3 kg ha^{-1}), P (8.6 kg ha^{-1}) and K (65.0 kg ha^{-1}) uptake were recorded under absolute control (Table 2)

Micronutrients uptake

The Zn uptake by rice under organic farming practices was increased significantly over control and it ranged between 170 and 453 g ha^{-1}. Highest Zn uptake was recorded under enriched compost @ 5 t ha^{-1} (453 g ha^{-1}) and compost @ 5.0 t ha^{-1}+biofertilizer consortia @ 3.5 kg ha^{-1} (425 g ha^{-1}) which were statistically similar to each other. Whereas, under azolla @ 0.5 t ha^{-1} + biofertilizer consortia @ 3.5 kg ha^{-1}, enriched compost @ 2.5 t ha^{-1} and compost @ 5.0 t ha^{-1}, Zn uptake by rice was recorded to be 296, 322 and 321 g ha^{-1}, respectively, which were also statistically at par with each other. The Fe uptake by rice enhanced significantly under all organic farming practices over control and ranged from 681 g ha^{-1}(control) to 1160 gha^{-1} with enriched compost @ 5 t ha^{-1}. The highest amount of Fe uptake was obtained as 1160 g ha^{-1} with enriched compost @ 5 t ha^{-1} as compared to other organic farming practices treatments except compost @ 5.0 t ha^{-1}+biofertilizer consortia @ 3.5 kg ha^{-1}. The Mn uptake by rice ranged from 456 to 883 g ha^{-1}. Highest Mn uptake by rice was recorded with enriched compost @ 5 t ha^{-1} (893 g ha^{-1}). Highest Cu uptake by rice (52.7g ha^{-1}) was recorded with enriched compost @ 5 t ha^{-1} which was also similar with compost @ 5.0 t ha^{-1}+biofertilizer consortia @ 3.5 kg ha^{-1} (Table 3).

Table 3: Effect of organic farming practices on total uptake of micronutrients (g ha^{-1}) by rice

Treatment	Zinc	Iron	Manganese	Copper
T_1: Absolute control	170^d	681^e	456^d	24.5^f
T_2: Biofertilizer consortia @ 3.5 kg ha^{-1}	241^c	845^d	614^c	33.0^e
T_3: Compost @ 5.0 t ha^{-1}	321^b	969^{cd}	740^b	38.3^d
T_4: Compost @ 5.0 t ha^{-1}+Biofertilizer consortia @ 3.5 kg ha^{-1}	425^a	1116^{ab}	861^a	48.3^b
T_5: Enriched compost @ 2.5 t ha^{-1}	322^b	1005^{bc}	767^b	40.0^{cd}
T_6: Enriched compost @ 5.0 t ha^{-1}	453^a	1160^a	893^a	52.7^a
T_7: Azolla @ 0.5 t ha^{-1}+Biofertilizer consortia @ 3.5 kg ha^{-1}	296^b	1001^{bc}	728^b	43.3^c
LSD @ 5%	36.1	124	80.6	4.03

Higher doses of enriched compost were observed to improve crop growth and soil nutrient uptake (Zhang *et al.,* 2020; Prabhu *et al.*, 2021). Kumar *et al.* (2017) also pointed out that exogenous application of manures increases microbial function because organic inputs give food and shelter to soil a microorganism, which improves the microbial population and activity. Besides increased enzyme activity, the degradation of organic amendments also results in essential nutrients (Benbi *et al.*, 2018; Medhi *et al.*, 2022). The addition of compost and enriched compost to acidic soil changed the chemical processes in the soil and enhanced the solubility and availability of metals (Kumar *et al.,* 2017). Chen *et al.* (2019) revealed that organic inputs enhance metal solubility by forming organometallic complexes, which reduces cation sorption and increases plant availability. Antecedent researchers also highlighted the considerable uptake of micronutrients in rice, notably in long-term systems (Saha *et al.,* 2019). Overall, using organic sources increases the availability of nutrients to plants in an acidic inceptisol.

Therefore, uptake of total macro (N, P, K) and micronutrients (Zn, Fe, Mn and Cu) by rice was significantly enhanced with the use of organic farming practices over control. Application of Enriched compost @ 5 t ha^{-1} consistently showed the best result with respect to total uptake of all nutrients.

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