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Effect of integrating organic amendments and inorganic fertilizers on growth and yield of rice (*cv.IR-36*) in a lateritic soil of West Bengal

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ABSTRACT

A field experiment was conductedin a farmer's field at Jhargram, PaschimMedinipur, West Bengal for consecutive two seasons (rabi and kharif, 2009) to access the effect of the integrated use of organic amendments viz., rice straw, glyricidialeaves, FYM and vermicompost,intended to supply 1000 kg carbon ha^{-1},integrated with chemical fertilizers in comparison with chemical fertilizers alone on growth and yield of rice variety IR-36. The amount of N, P, K in the organic amendments were subtracted from the total amount to arrive at a rate of 80 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1}.Substitution of chemical fertilisers with organic amendments for supplying a part of N, P, and K requirement of rice crop resulted in lower values of different plant parameters. The tallest plants (73.59 cm), highest numbers of tillers and panicles (536.33 and 513.17 m^{-2}, respectively),number of grains $panicle^{-1}$ (120.83), test weight (24.9 g), straw yield (5.03 t ha^{-1}) and grain yield (5.42 t ha^{-1}) were recorded in fertilizer treated plots. The uptake of N, P and K by rice was highest in the chemical fertilizer treatment (75.39, 15.41 and 106.64 kg ha^{-1}). The results obtained suggested important role of chemical fertilizers in the experimental soil. Among the organic amendments, performance of vermicompost was the best.

***Keywords*:** Amendments, growth, grain yield, INM, rice

Introduction of high yielding varieties, intensive tillage system with high dose of chemical fertilizers and pesticides, undoubtedly enhanced food production elevating India into a food self-sufficient nation for its one billion plus population when it was needed most with only 2 per cent of the world's total land resources (Sarkar, 2005).Rice, the staple food for more than 3 billion global population, has also played a very important role in this feat and provided 85.59 MT in the food production kitty of the country from an area of 39.16 M ha during 2012-23 (Anon., 2014). While the estimated demand for food grain will reach at 325 MT by the year 2025 for 1.4 billion projected population, continuous use of chemicals without adequate organic manures, has resulted in deficiencies of several nutrients and deterioration of soil health (Mahajan *et al*., 2008) raising the issues of crop production sustainability (Khan *et al*., 2010). While sustainable crop production cannot be maintained by using chemical fertilizers alone (Khan *et al*., 2008) nutrient management integrating organic manure and inorganic chemical fertilisershas been reported to improve rice crop growth by maintaining proper ecology of the rhizosphere and lead to higher production on a sustainable basis (Hussain *et al*., l99l; Hedge,1998; Islam *et al*., 2011).

The red and laterite zone of West Bengal lying between 21º452 N to 24º352 N and 85º452 E to 88º252 E spreading over 85 development blocks accounting for 28 per cent of the geographical area of the state. The zone is dominated by the soils acidic in reaction, light in texture and low in organic matter, N, P, K, Ca, S and micronutrients like Zn, B and Mo producing poor rice yield (Lungmuana*et al*, 2012). Rice is the main crop of the zone and is cultivated in 3 out of 4 agro-ecological situations during *kharif* (rainy) season. The zone has a tropical sub-humid climate and receives between 1300-1500 mm rainfalls annually. Soil organic carbon, described as an indicator of soil quality and sustainability (Doran and Parkin, 1994), has declined during the post green revolution era (Ramasamy, 2005).Soil organic carbon plays an important role in regeneration of the soil by acting as a nutrient source for soil microbes and crops, soil chemical and physical functioning. Use of organic residues enhance nutrient cycling, improve nutrient efficiency and increase crop productivity in rainfed lowland rice systems (Seng *et al*., 2004) and this may have more relevance in augmenting soil health in the severely impoverished soils of the Red and Laterite Zone of West Bengal. The objective of this study was to evaluate the effect of application of locally organic amendments in the region (rice straw, glyricidia leaves, farm yard manure and vermicompost) in combination with chemical fertilizers ingrowth and yield of ricein the Red and Laterite Zone of West Bengal.

MATERIALS AND METHODS

Field experiments were conducted during *rabi*and *kharif* season of 2009 in a typical lateritic soil (*Typichaplustalf*) with rice variety *cv.*IR-36 in the farmers' field at Jhargram, PaschimMedinipur, West Bengal. The treatments comprised, four organic sources *viz*., rice straw, Glyricidia leaves, Farm Yard Manure (FYM) and Vermicompost integrated with chemical fertilizers and compared with a control receiving neither

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chemical fertilizers nor organic manure and recommended doses of chemical fertilizers through urea, single super phosphate and muriate of potash. Calculated amount of each of the organic sources intended to supply 1000 kg carbon ha^{-1} were incorporated in the soil of each specified plots at the time of first ploughing for land preparation. The nutrient content of all the amendments are presented in table 1. The N, Pand K contents of the applied organic sources were computed and required balance amount of N, Pand K were compensated through inorganic fertilizers to arrive at a dose of 80:40:40 kg ha^{-1}. Half of the N and total of P and K were applied as basal dose two days before transplanting. The remaining half of nitrogen was applied as top dressing uniformly after 21 days of transplanting. Usual agronomic practices were followed during the entire period of crop growth. Nitrogen content in the plant samples (grain and straw) were determined by the micro kjeldahl digestion method. Phosphorus and potassium content in the plant samples were digested by tri acid mixture and determined colorimetrically by spectrophotometer and flame photometer. N, P and K content in the grain and straw samples were added to constitute plant N, P and K content and similarly, uptake was estimated with grain yield and straw yield and added to constitute the total N, P and K uptake. All analyses and agronomic parameters were followed as per standard procedures.

Table 1 : Nutrient content of organic amendments (on air dry basis)

Amendments	C (%)	N (%)	P (%)	K (%)
i) Rice straw	50.46	0.42	0.07	1.48
ii) Glyricidia leaves	54.52	2.76	0.28	0.46
iii) FYM	15.37	0.57	0.19	0.48
iv) Vermicompost	16.59	1.14	1.33	1.4

All replicated data of plant, growth and yield parameters for *rabi* and *kharif* seasons were pooled statistically. Analysis of variance (ANOVA) for RCBD followed by Duncan's Multiple Range Test (DMRT) at the 5% level of significance was used for comparing day-wise and treatment mean. All statistical analysis was carried out by SAS 9.3 software (SAS Institute).

RESULTS AND DISCUSSION

Appraisal of the data pooled over two seasons (*rabi* and *kharif*) (Table2, 3, 4) revealed significant influence of treatments onplant height, number of tillers, number of panicles, panicle length, test weight, straw yield, grain yield and total N,P and K content of rice plant and their uptake compared to the control.

Plant growth parameters

Appraisal of the mean values pooled over the two consecutive seasons (*rabi* and *kharif*) and their comparison through DMRT (P=0.05) revealed significant influence of amendments in comparison to control on plant height, number of tillers, number of panicles, panicle length, test weight, at harvest (Table 2). The highest plant height (73.59 cm) and number of tillers(536.33) were recorded in sole fertilizer treatment with a percent increment of 23.9 per cent, 43.6 per cent over control. The improved soil chemical properties of the organic and chemical fertilizer treated plots provided adequate environment for the superior growth than on the plots without residue treatments. The crops could also have benefited from the changes in soil physical properties including reduced soil density, increased soil aggregation, increased porosity, lower soil temperature, reduced resistance to root penetration, increased soil aeration and reduced loss of water through run-off resulting from application of organic residues in soil. The superiority of chemical fertilizer and organic manures with chemical fertilizer over the control were also observed by many researchers (Sheela and Thomas, 1995; Ogbodo, 2009).

Table 2 : Effect of organic amendments and fertilizer on plant height and number of tillers of rice. (Pooled mean of *rabi* and *kharif* seasons)

Treatments	Plant height (cm)	Tiller (m^{-2})
Control (T_1)	59.38^e	373.5^e
Straw + NPK (T_2)	66.58^c	451.91^d
Glyricidia + NPK (T_3)	64.56^d	485.83^c
FYM + NPK (T_4)	67.11^c	518.66^b
Vermicompost + NPK (T_5)	71.45^b	532.0^a
Chemical fertilizer (T_6)	73.59^a	536.33^a
LSD (0.05)	**0.604**	**5.45**

Notes:*Within a column, means followed by the same letter are not significantly different at the 0.05 level of probability by DMRT*

Yield parameters

Number of panicle per meter square (513.17) and number of grains per panicle (120.83) were recorded in sole fertilizer treatment with a percent increment of 57.9 and 29.7 per cent over control (Table 3). The length of panicle (21.9 cm) was the highest under treatment comprising integrated use of vermicompost and chemical fertilizer with an increment of 16.4 per cent over control. Similarly, the test weight (weight of 1000 grains), straw yield and grain yield pooled over two seasons (*rabi* and *kharif*) were also significantly influenced by the treatments over control. The highest

test weight (24.9), straw yield (5.03) and grain yield (5.42) were recorded in treatment comprising chemical fertilizer and the percent increment over control treatment were 14.3, 109.6 and 104.1 per cent, respectively.

This may be explained by the availability of nutrients due to the treatments of which sole fertilizer treatment supplied the highest amount thereby improving crop growth. Improved yield of rice due to integration of organic amendments and inorganic fertilizers has also been reported (Ray and Mukhopadhyay, 2013). Among the treatments receiving the integration of organic amendments and chemical fertilizer, vermicompost performed the best for the rice yield which is in conformity with the findings of Kumar *et al*., 2014 suggesting that vermicompost can improve rice yield earliest.

Nutrient Content and total Nutrient Uptake by Rice

While application of chemical fertilizer ($N:P_2O_5:K_2O$::80: 40: 40 $kgha^{-1}$), resulted in the highest N and K content (1.27 and 1.76 per cent),the highest P content was observed under integrated application of FYM and chemical fertilizer (0.336 per cent) (Table 4). The higher P content by FYM may be due to direct addition of P on decomposition of FYM and release of the fixed P through anion exchange. Aziz *et al.,* (2010) also reported increase in P content due to FYM than fertilizer alone. The percent increase in N and P contents were to the tune of 22.5 and 69.7 per cent, respectively, over control.

The uptake of N, P and K were significantly higher in the chemical fertilizer treated plot (:75.39; P: 15.41 and K: 106.64 kg ha^{-1}) with a percent increase of 153.1, 110.0 and 212.8 per cent, respectively, over control.The highest nutrient content and yield by application of 100 per cent of NPK may be attributed to the increase in nutrient concentration thereby improving the metabolic process which directly impacted vegetative and reproductive growth of plants (Saitoh *et al.,* 2001). Similarly, the higher uptake of P by recommended dose of fertilizer than integrating with organic manures was observed by Banerjee *et al*., 2006.

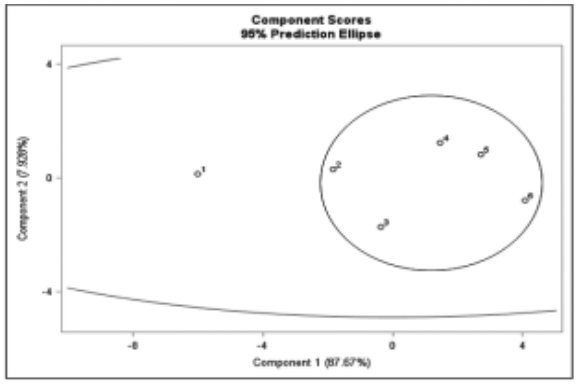

Fig. 1 : Diagram of regression factor scores due to all parameters correstponding to principle components.

Notes.1,2,3,4,5,6 represent treatments from 1 to 6 [Control (T_1); Straw + NPK (T_2); Glyricidia + NPK (T_3); FYM + NPK (T_4); Vermicompost + NPK (T_5) and Chemical fertilizer (T_6)].

Table 3: Effect of organic amendments and fertilizer on test weight straw and grain yield of rice. (Pooled mean of *rabi* and *kharif* seasons)

Treatments	No. of Panicles (m^{-2})	Panicle length (cm)	No. of Grains ($panicle^{-1}$)	Test weight (g)	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
Control (T_1)	325.00^{e}	18.74^{c}	93.17^{f}	21.79^{c}	2.40^{f}	2.66^{f}
Straw + NPK (T_2)	412.33^{d}	19.69^{b}	101.17^{e}	23.33^{abc}	3.71^{e}	3.92^{e}
Glyricidia + NPK (T_3)	462.00^{c}	20.00^{b}	105.33^{d}	23.83^{ab}	4.37^{d}	4.73^{d}
FYM + NPK (T_4)	494.50^{b}	21.03^{a}	111.00^{c}	22.91^{bc}	4.79^{c}	5.03^{c}
Vermicompost + NPK (T_5)	508.17^{a}	21.90^{a}	115.83^{b}	22.87^{bc}	4.94^{b}	5.26^{b}
Chemical fertilizer (T_6)	513.17^{a}	21.81^{a}	120.83^{a}	24.90^{a}	5.03^{a}	5.42^{a}
LSD (0.05)	**7.053**	**0.948**	**1.898**	**1.753**	**0.045**	**0.039**

Notes: Within a column, means followed by the same letter are not significantly different at the 0.05 level of probability by DMRT

Table 4: Effect of organic amendments and fertilizers on nutrient content and nutrient uptake by rice. (Pooled mean of *rabi* and *kharif* seasons)

Treatments	Nutrient content (%)			Nutrient uptake (kg ha^{-1})		
	N	P	K	N	P	K
Control (T_1)	1.04^{d}	0.32^{c}	1.04^{f}	29.78^{f}	7.34^{e}	34.09^{f}
Straw + NPK (T_2)	1.10^{c}	0.329^{b}	1.36^{e}	47.59^{e}	11.54^{d}	60.92^{e}
Glyricidia + NPK (T_3)	1.14^{c}	0.310^{d}	1.43^{d}	57.87^{d}	12.80^{c}	74.76^{d}
FYM + NPK (T_4)	1.19^{b}	0.336^{a}	1.54^{c}	65.62^{c}	14.53^{b}	82.05^{c}
Vermicompost + NPK (T_5)	1.21^{b}	0.330^{ab}	1.62^{b}	69.39^{b}	15.26^{a}	96.41^{b}
Chemical fertilizer (T_6)	1.27^{a}	0.324^{c}	1.76^{a}	75.39^{a}	15.41^{a}	106.64^{a}
LSD (0.05)	**0.039**	**0.005**	**0.030**	**1.424**	**0.331**	**1.902**

Notes: Within a column, means followed by the same letter are not significantly different at the 0.05 level of probability by DMRT

Principle component analysis (PCA)

Scatter diagram of regression factor scores due to all parameters corresponding to principle components (Figure 1) revealed significant influence of all the treatments on rice growth and yield characteristics compared to the control. Other researchers (Xu, 2010; Ray and Mukhopadhyay, 2013;Kumar *et al*., 2014) observed significant improvement in yield characters of rice under integration of organic amendments with chemical fertilizers in comparison to sole fertilizer application.

However, our results pointed out that in a span of two seasons recommended dose of fertilizer proved better than the integration.Translation of the beneficial effects of integrated use of organic and inorganic sources of plant nutrients in to improved growth and yield of rice crop in the soils of this region may require continuous use for some more time in these impoverished and degraded soils.

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