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Productivity Enhancement through Integrated Nutrient Management under System of Rice Intensification

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Abstract

A field experiment was conducted during dry (*boro*) season of 2011-12, 2012-13 and 2013-14 at Rice Research Station, Chinsurah, West Bengal to identify an integrated nutrient management (INM) practice for making judicious combinations of organic and inorganic (chemical) sources of nutrients in transplanted rice. The results revealed that maximum grain yield (6.60 t/ha) was achieved with 25% N applied through organic manure (vermicompost) + 25% N through green leaf manure (*Gliricidia sepium*) + 50% N through chemical fertilizer (CF) + 100% PK (CFs), being comparable with 50% N as organic manure (OM) + 50% N as CF + 100% PK as CFs (6.38 t/ha). Significantly higher grain yields under these treatments were due to higher values of growth and yield attributes, compared with 25% N (OM) + 75% N (CF) + 100% PK as CFs (6.15 t/ha), 100% NPK as CFs (6.07 t/ha) and farmers' practice (5.56 t/ha). Other than application of 100% PK as CFs, addition of N through OM and CF on 50:50 basis did not always differ significantly with the treatment considered for nutrient supply on 25:75 basis in influencing growth and yield attributes. All the INM treatments exhibited 10.61-18.71% yield advantages, compared with farmers' practice. However, INM involving 50% N through organics and rest other nutrients through CFs in SRI might be viewed as an effective strategy towards enhancing rice productivity, besides improving soil health.

Key words: Green leaf manure, Integrated nutrient management, Organic manure, System of Rice Intensification, Transplanted rice, Yield advantage

Introduction

Rice is the staple food of more than half of the world's population. Globally, more than 3.5 billion people depend on rice for more than 20% of their daily calories. Although India is the second largest producer of rice after China and produces one-fifth of the world's rice, rice farmers of the country are still unhappy due to many inter-related problems like rising input cost, growing water scarcity, diminishing economic return, etc. Extensive use of chemical fertilizers (CFs) in intensive rice farming system leads to plateauing productivity, besides nutrient imbalances including emerging deficiencies of secondary and micronutrients, decreasing organic carbon content, soil health deterioration, etc. With the objectives of increasing input use efficiency, improving soil health and achieving more output, the System of Rice Intensification (SRI) appears to be an ideal option as a resource-conserving, climate-resilient, economically viable and ecologically sustainable methodology. Use of organic manure (OM) and/or bio-organic materials plays an important role towards enhancing fertilizer use efficiency, reducing cost of nutrient supply and increasing production without much capital investment. Application of green leaf manure (GLM), in particular, is one of the important practices for increasing organic matter content in the soil (Srinivasa Rao *et al*., 2011). As soil aeration and organic matter creates beneficial conditions for plant root growth and consequent plant vigour and health, nutrients should preferably be fully sourced through OM. If full doses of organic sources of nutrients are not available or not possible to apply, it should be supplemented through CFs (Dhara *et al*., 2014). An integrated nutrient management (INM) practice is of utmost importance for enhancing crop productivity *vis-à-vis* sustaining soil fertility (Bhowmick *et al.*, 2011). Therefore, it becomes necessary to find out the extent of possibility for making judicious combinations of organic and inorganic (chemical) sources of nutrients. Keeping these perspectives in view, the present study was undertaken to identify an appropriate nutrient management practice in SRI.

Materials and Methods

Experimental site and season

A field experiment was conducted during dry (*boro*) season of 2011-12, 2012-13 and 2013-14 at the Rice Research Station, Chinsurah, Hooghly, West Bengal, located at $22^0 52'$ N latitude and $88^0 24'$ E longitude with an altitude of 8.62 m above mean sea level. The experimental soil was clay loam having pH 7.1, EC 0.5 dS/m, organic carbon 1.17%, available N 358 kg/ha, available P_2O_5 130 kg/ha and available K_2O 411 kg/ha.

Experimental design and treatment details

The experiment comprising of five treatments was laid out in a randomized complete block design with four replications. The treatments included farmers' common practice (only CFs without OM); 100% recommended dose of nutrients ($N:P_2O_5:K_2O$) applied through CFs as urea, single super phosphate (SSP) and muriate of potash (MOP); 25% N as OM (vermicompost) + 75% N as CF (urea) + 100% PK as CFs (SSP and MOP); 50% N as OM (vermicompost) + 50% N as CF (urea) + 100% PK as CFs (SSP and MOP); and 25% N as OM (vermicompost) + 25% N as GLM (*Gliricidiasepium*) + 50% N as CF (urea) + 100% PK as CFs (SSP and MOP). The recommended dose of nutrients ($N:P_2O_5:K_2O$) for summer (*boro*) rice was 130:65:65 kg/hafor all the treatments, excepting farmers' practice (120:60:60 kg/ha). Full doses of P_2O_5 and K_2O along with one-fourth of total N were applied as basal at the time of transplanting whereas the remaining half and one-fourth of total N were applied at active tillering and panicle initiation stages, respectively. Besides, a common dose of zinc sulphate hepta hydrate ($ZnSO_4.7H_2O$) was applied uniformly at 25 kg/ha to all the individual plots of 5 m × 3 m in size. As per treatments, vermicompost as OM (approx. 1.0% N) at 3.0 t/ha and leaf materials as GLM (approx. 2.0% N) at 1.5 t/ha were applied on the surface of puddle soil and mixed into the soil at final land preparation.

Crop establishment

Rice variety Satabdi (IET 4786) was sown in the second week of January and transplanted at the seedling age of 18-21 days (Table 1). Young seedlings at 2-3 leaf stage were carefully transplanted singly at shallow depth and wider spacing (25 cm × 25 cm). The crop was raised with other recommended package of practices (Dhara *et al*., 2014; Mahender Kumar *et al*., 2011 and 2013) and harvested in the second week of May (Table 1).

Data collection and analysis

Twelve hills were randomly sampled from each plot for determining dry matter accumulation (DMA) and yield attributes (panicle number and weight) at maturity. Samples collected at maturity were oven dried at 70ºC ± 1ºC till a constant weight was achieved. Number of panicles/hill under each treatment was recorded from twelve hills by visual counting and their average was multiplied by the number of hills/m^2. Panicle weight **(**g**)** was also determined from the same twelve hills used for other parameters. Grains were harvested, dried and weighed, and grain weight was adjusted to a moisture content of 0.14 g H_2O/g fresh weight. Grain and straw yields were recorded for each plot separately at harvest and converted in t/ha. Collected data were subjected to statistical analysis as per the procedures outlined by Gomez and Gomez (1984).

Table 1: Calendar of major field operations during dry season of 2011-12, 2012-13 and 2013-14

Date	2011-12	2012-13	2013-14
Sowing	January 08, 2012	January 11, 2013	January 12, 2014
Transplanting	January 25, 2012	January 30, 2013	February 01, 2014
Harvesting	May 09, 2012	May 10, 2013	May 11, 2014

Results and Discussion

Effect of treatments on crop growth and yield attributes

The treatment including OM, GLM and CFs produced significantly maximum amount of dry matter (1366 g/m^2) along with the highest values of panicle number (409/m^2) and panicle weight (2.84 g) in all the three years of study (Table 2). Srinivasa Rao *et al*. (2011) reported that application of GLM (*Gliricidia*) at 1.0 t/ha could provide 21 kg N, 2.5 kg P, 18 kg K, 85 g Zn, 164 g Mn, 365 g Cu and 728 g Fe besides considerable quantities of S, Ca, Mg, B, Mo etc. The GLM was also reported to improve mobilization of native soil nutrients in the soil, add valuable nutrients to the soil, reduce the emission of N_2O and CO_2 into atmosphere and contribute overall reduction of green house gases (Srinivasa Rao *et al*., 2011). Other than application of 100% PK as CFs, addition of N through OM and CF on 50:50 basis did not always differ significantly with the treatment considered for nutrient supply on 25:75 basis in influencing growth and yield attributes positively. All of these INM treatments were found superior to sole use of CFs and farmers' practice, possibly due to the release of micronutrients, growth regulators and/or humic substances. Application of recommended fertilizer dose (RFD) through CFs only remained inferior in terms of growth and yield attributes, registering comparatively lower panicle number (385/m^2) and weight (2.64 g), as also with the farmers' practice. This might further be substantiated with the fact that the nutrients contained in CFs were used rapidly but incompletely, and the nutrients supplied with OM matter were used slowly and stored for a long time in the soil (Kumazawa, 1984).

Effect of treatments on crop productivity

A critical perusal of data in Table 3 revealed that the highest mean grain yield of 6.60 t/ha and straw yield of 7.05 t/ha was achieved with 25% N (OM) + 25% N (GLM) + 50% N (CF) + 100% PK (CFs), which remained statistically at par with 50% N (OM) + 50% N (CF) + 100% PK as CFs in all the years. Next in order of grain yield performance was 25% N (OM) + 75% N (CF) + 100% PK as CFs (6.15 t/ha), followed by 100% NPK as CFs (6.07 t/ha) and farmers' practice (5.56 t/ha). Adhikary and Majumdar (2002) suggested combined application of CFs and OM for attaining higher grain yields. Bhowmick *et al.* (2011) reported application of 50% RFD + 50% farm yard manure (FYM) as good as 100% RFD in producing significantly higher grain yields, whereas 50% RFD + 50% FYM was effective for enhancing grain yield and sustaining soil fertility in the long run. Compared with farmers' practice, all the INM treatments recorded yield advantages to the tune of 10.61-18.71%, which might be attributed to improved soil biotic activities in and around the crop root zone through better soil aeration owing to application of OM and/or GLM. Supply of nutrients in required quantities through the combinations of organic and inorganic sources facilitated balanced nutrition of rice crop, which resulted in enhanced grain yields due to higher values of yield attributes. Bhowmick and Ghosh (2002) were of similar opinion. Comparatively lower levels of grain and straw yields in the plots of farmers' practice and 100% NPK (CFs) might be ascribed to poor utilization of fertilizer nutrients in absence of organic nutrient sources. Dhara (2010) earlier suggested applying 75% RFD along with full doses of organic sources of nutrients in SRI. Dhara and Bhowmick (2013 and 2015) subsequently advocated for the conjunctive use of vermicompost at 3.0 t/ha, 75% RFD and soil conditioner at 50 kg/ha for obtaining higher grain yields of rice. Inclusion of bio-organic materials in nutrient management practice might enhance soil microbial activity, widening the scope for efficient utilization of soil moisture and nutrients by rice crop plants, besides providing different secondary and micronutrients, leading to higher grain yields (Bhowmick *et al.*, 2015).

Conclusion

The present study clearly showed that an INM practice including 50% N through organic manure and/or green leaf manure and the rest others through chemical fertilizers proved to be an effective tool under SRI towards improving and sustaining rice productivity. Furthermore, at least 25% N might be supplemented through organic sources. Resource-poor farmers can easily and profitably produce more output, especially when chemical fertilizers are in short supply.

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Table 2: Effect of treatments on crop growth and yield attributes under SRI during dry season of 2011-12, 2012-13 and 2013-14

Treatment	DMA (g/m^2)			Panicle weight (g)			Panicle number/m^2		
	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14
FP	1113	1239	1207	2.43	2.58	2.59	339	373	352
100% NPK (CF)	1203	1320	1307	2.56	2.69	2.66	368	401	387
25% N (OM) + 75% N (CF) + 100% PK (CF)	1212	1315	1324	2.62	2.74	2.74	375	410	402
50% N (OM) + 50% N (CF) + 100% PK (CF)	1311	1328	1332	2.70	2.85	2.87	379	414	415
25% N (OM) + 25% N (GLM) + 50% N (CF) + 100% PK (CF)	1326	1372	1399	2.77	2.87	2.88	387	418	424
SEm±	18.18	17.86	28.89	0.06	0.04	0.05	5.30	5.80	5.85
LSD (P=0.05)	55.99	55.00	88.98	0.18	0.12	0.15	16.33	17.87	18.02
C.V. (%)	9.56	12.45	10.19	4.40	2.65	3.30	2.87	2.88	2.90

CF: Chemical fertilizer; DMA: Dry matter accumulation; FP: Farmers' practice; GLM: Green leaf manure; OM: Organic manure

Table 3: Effect of treatments on crop productivity under SRI during dry season of 2011-12, 2012-13 and 2013-14

Treatment	Grain yield (t/ha)				Straw yield (t/ha)			
	2011-12	2012-13	2013-14	Mean	2011-12	2012-13	2013-14	Mean
FP	5.22	5.81	5.66	5.56	5.91	6.58	6.41	6.30
100% NPK (CF)	5.72	6.27	6.21	6.07	6.31	6.93	6.86	6.70
25% N (OM) + 75% N (CF) + 100% PK (CF)	5.80	6.30	6.34	6.15	6.32	6.85	6.90	6.69
50% N (OM) + 50% N (CF) + 100% PK (CF)	6.32	6.40	6.42	6.38	6.79	6.88	6.90	6.86
25% N (OM) + 25% N (GLM) + 50% N (CF) + 100% PK (CF)	6.40	6.64	6.77	6.60	6.84	7.08	7.22	7.05
SEm±	0.13	0.15	0.14	-	0.08	0.08	0.11	-
LSD (P=0.05)	0.40	0.46	0.43	-	0.25	0.24	0.33	-
C.V. (%)	4.34	4.67	4.51	-	10.51	13.42	9.75	-

CF: Chemical fertilizer; FP: Farmers' practice; GLM: Green leaf manure; OM: Organic manure