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Effectiveness of Chemical Fertilizers with and without Bio-organic Materials in Transplanted Rice

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Abstract

A field experiment was conducted during wet *(kharif)* season of 2012 and 2013 at Rice Research Station, Chinsurah to evaluate different nutrient management options, each of which was inclusive of recommended fertilizer dose (RFD) applied at 80:40:40 kg N:P2O5:K2O/ha in transplanted rice. There were six treatment combinations of chemical fertilizers viz. urea, di-ammonium phosphate (DAP), single super phosphate (SSP) and muriate of potash (MOP), and bio-organic materials viz. biologically-active phosphate (BioAgPhos), BioAg Soil Amendment + Seed Inoculant (BioAgSS) and vermicompost. Maximum grain yield (5.87 t/ha) was achieved under RFD (urea + SSP + MOP) + BioAgSS (10 l/ha) + BioAgPhos (0.1 t/ha) + vermicompost (1.5 t/ha). Next in order of grain yield performance were RFD application (urea + DAP + MOP), when combined with BioAgSS at 10 l/ha + BioAgPhos at 0.2 t/ha (5.45 t/ha) and only BioAgPhos at 0.2 t/ha (5.36 t/ha). Significantly higher yields under these treatments were due to higher values of growth and yield attributes, compared with sole use of chemical fertilizers (urea + DAP + MOP) which registered the lowest grain yield of 4.83 t/ha. 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 7.66-21.53% higher grain yields.

Key words: Bio-organic materials, Chemical fertilizers, Integrated nutrient management, Productivity, Transplanted rice

Introduction

Rice is life for millions of people in the world, particularly in developing countries. It is the main staple food for most of the people in India. Intensive cropping along with extensive use of chemical fertilizers in rice farming not only results in nutrient imbalances including emerging deficiencies of secondary and micronutrients, decreasing organic carbon content, soil health deterioration etc., but also leads to plateauing productivity. Though chemical fertilizers are a major source of nutrients, their sole use for a long period of time leaves unfavorable effects on soil physical, chemical and biological properties, and environment. Use of organic manures and/or bio-organic materials plays an important role to enhance fertilizer use efficiency, improve soil health and ensure sustainable production. Conjunctive use of chemical fertilizers and bio-organic materials is very much imperative towards ensuring soil sustainability *vis-a-vis* higher rice production and productivity. Considering all these, an integrated nutrient management (INM) practice is of utmost importance (Bhowmick *et al*., 2011). With this perspective in view, the present study was undertaken to evaluate the effectiveness of chemical fertilizers with and without using bio-organic materials for improving growth and yield of transplanted rice.

Materials and Methods

A field experiment was conducted during wet (*kharif*) season of 2012 and 2013 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.

The experiment comprising of six treatments was laid out in a randomized complete block design with four replications, keeping individual plots of 5 m × 4 m in size. The recommended fertilizer dose (RFD) of 80:40:40 kg $N:P_2O_5:K_2O$/ha was applied through different chemical fertilizers *viz*. urea (46.0% N), di-ammonium phosphate (DAP: 18.0% N and 46.0% P_2O_5), single super phosphate (SSP: 16.0% P_2O_5 and 12.5% S) and muriate of potash (MOP: 60.0% K_2O) as per treatments. Besides, different bio-organic materials *viz.* biologically-active phosphate (Bio*Ag*Phos: P_2O_5 13%, S 1% and Ca 36%), Bio*Ag* Soil Amendment + Seed Inoculant (Bio*Ag*SS: P_2O_5 2.09%) and vermicompost (1.00% N, 1.86% P_2O_5 and 1.13% K_2O) were applied as per treatment schedule. The treatments taken for the study included RFD (urea + DAP + MOP); RFD (urea + DAP + MOP) + Bio*Ag*SS (10 l/ha); RFD (urea + DAP + MOP) + Bio*Ag*Phos (0.2 t/ha); RFD (urea + DAP + MOP) + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.2 t/ha); RFD (urea + SSP + MOP) + Bio*Ag*SS (10 l/ha) + vermicompost (3.0 t/ha); and RFD (urea + SSP + MOP) + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.1 t/ha) + vermicompost (1.5 t/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. Bio*Ag*Phos was applied 15 days ahead of transplanting whereas Bio*Ag*SS and vermicompost were applied on the surface of puddle soil and mixed into the soil at final land preparation. Besides, a common dose of $ZnSO_4.7H_2O$ was applied as basal at 25 kg/ha in all the treatment plots uniformly.

Rice variety Swarna (MTU 7029) was sown in 26th and 25th June, transplanted at a spacing of 20 cm × 20 cm on 3rd and 1st August, and harvested on 19th and 11th November in 2012 and 2013, respectively. The crop was raised with recommended package of practices.

Twelve hills were randomly sampled from each plot for recording biometric observations on growth and yield attributes. Plant height (cm) was measured from the base of stem up to the apex of the plant (tip of the longest leaf or the panicle if longer) at 45 days after transplanting (DAT) and harvest. Number of tillers/hill under each treatment was noted similarly on 12 random hills at 45 DAT and harvest by visual counting and their average values were multiplied by the number of hills/m^2. Likewise, number of effective tillers (panicles)/m^2, panicle length (cm) and panicle weight (g) were recorded for each plot at harvest. Each panicle was hand threshed separately, and the filled and partially-filled spikelets were separated by submerging threshed grains in tap water. All floating grains were considered as partially-filled spikelets. After drying them thoroughly under the sun, the empty and half-filled spikelets were separated from partially-filled spikelets by using a blower and then the number of filled, half-filled and empty spikelets was recorded for each panicle. These were then oven dried at 70 ^{0}C to constant weight for determining individual grain weight. Percentage filled grains and 1000-grain weight (g) were then computed from the collected observations. Grain and straw yields were recorded for each plot separately at harvest and converted in t/ha. Grains were harvested, dried and weighed, and grain weight was adjusted to a moisture content of 0.14 g H_2O/g fresh weight. Collected data were subjected to statistical analysis as per the procedures outlined by Gomez and Gomez (1984).

Results and Discussion

Effect of treatments on crop growth and yield attributes

The treatment including RFD (urea + SSP + MOP), Bio*Ag*SS, Bio*Ag*Phos and vermicompost recorded the highest values of plant height (89.00 cm at 45 DAT and 108.59 cm at harvest), number of tillers (306.50/m^2 at 45 DAT and 436.00/m^2 at harvest) and yield attributes (358.13 panicles/m^2, panicle weight 3.59 g, 87.74% filled grains/panicle and test weight 18.09 g) in both the years of study. SSP contained water-soluble phosphoric acid (monocalcium phosphate), being absorbed quickly by rice plants at the young stage when the root system was not fully developed (Yawalkar *et al*., 2011). Unlike conventional acidified fertilisers, Bio*Ag*Phos containing reactive phosphate rock treated with a proprietary fermented culture was not water soluble and therefore did not leach or become "locked up". As reported, about one-third of total P_2O_5 content in Bio*Ag*Phos was immediately available (i.e. citrate-soluble) for plant use and the remainder was slowly digested by microorganisms over a sustained period of time and added to the nutrient reservoir in the soil. Besides, Bio*Ag*SS (fermented liquid microbial culture) was reported to be a rich source of vitamins, minerals, proteins, enzymes, amino acids, carbohydrates, growth promoters and dormant beneficial organisms (Anonymous, 2015). Vermicompost was also known to contribute all the major nutrients along with certain other nutrients. All these nutrient sources combined together made the INM treatment (urea + SSP + MOP + Bio*Ag*SS + Bio*Ag*Phos + vermicompost) possible to maintain its superiority over the others. However, next in descending order of performance were RFD (urea + DAP + MOP) in combination with Bio*Ag*SS + Bio*Ag*Phos and Bio*Ag*Phos alone, indicating that the treatments inclusive of Bio*Ag*Phos were better than those devoid of it. Bio*Ag*Phos was reported to influence root architecture in producing high root biomass associated with the stimulation of mycorrhizae, improving the efficiency of phosphorus uptake (Anonymous, 2015). Application of RFD through chemical fertilizers without using any bio-organic materials remained inferior in terms of growth (Table 1) and yield attributes (Table 2), registering the lowest number of panicles (304.50/m^2) with their minimum length (21.84 cm) and weight (3.15 g) as per mean of two-year data. Conjunctive use of chemical fertilizers and bio-organic materials were found superior to sole use of chemical fertilizers, possibly due to the release of micronutrients, growth regulators and/or humic substances coupled with improved soil microbial activity with the addition of bio-organic materials. This might further be substantiated with the fact that the nutrients contained in chemical fertilizers were used rapidly but incompletely, and the nutrients supplied with organic matter were used slowly and stored for a long time in the soil (Kumazawa, 1984). Moreover, bio-organic materials would be more useful as because, fertilizer efficiency in rice was reported to be the lowest, hardly exceeding 40-50% even under well-managed conditions (Yawalkar *et al*., 2011). According to Surekha *et al*. (2015), any easily available organic sources might be efficiently utilized rather than using scarce organic manures at higher price.

Effect of treatments on crop productivity

In the first year, application of RFD (urea + SSP + MOP) along with Bio*Ag*SS, Bio*Ag*Phos and vermicompost recorded the highest grain yield (5.59 t/ha) and straw yield (6.54 t/ha), which was as good as that obtained with RFD (urea + DAP + MOP) + Bio*Ag*SS + Bio*Ag*Phos (5.54 t/ha). In the second year too, conjunctive use of RFD (urea + SSP + MOP), Bio*Ag*SS, Bio*Ag*Phos and vermicompost recorded the highest grain yield (6.15 t/ha), which was, however, followed by RFD (urea + SSP + MOP) + Bio*Ag*SS + vermicompost (5.50 t/ha). Based on two-year mean data (Table 3), it was found that maximum grain yield (5.87 t/ha) was achieved under RFD (urea + SSP + MOP) + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.1 t/ha) + vermicompost (1.5 t/ha), followed by RFD (urea + DAP + MOP) + Bio*Ag*SS + Bio*Ag*Phos (5.45 t/ha) and RFD (urea + DAP + MOP) + Bio*Ag*Phos (5.36 t/ha). Significantly higher yields (Table 3) under these treatments were due to higher values of growth (Table 1) and yield attributes (Table 2), compared with the sole use of chemical fertilizers (4.83 t/ha). Dhara and Bhowmick (2015) reported higher grain yields of summer rice with the use of 75% RFD + vermicompost (3.0 t/ha) + soil conditioner (50 kg/ha) and 100% RFD + vermicompost (3.0 t/ha) owing to higher values of panicle number and weight, which was attributed to effective absorption of nutrients and their supply in presence of useable moisture to crop plants. Improved microbial activity after application of Bio*Ag*Phos in soil might help in unlocking previously-applied phosphate, calcium and other nutrients, whereas Bio*Ag*SS as a soil inoculant might encourage early crop establishment with better root development. Moreover, Bio*Ag*SS was reported to be effective in delivering essential nutrients and metabolites directly to crop plants as well as stimulating microbial activities in soil, thereby improving natural soil fertility and moisture and nutrient utilization (Anon., 2015). It was found from the present study that inclusion of bio-organic materials in nutrient management practice resulted in grain yield enhancement to the extent of 7.66-21.53%. Adhikary and Majumdar (2002) suggested combined application of chemical fertilizers and organic manure for attaining higher grain yields. 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 (2001 and 2002) were of similar opinion. Comparatively lower levels of grain and straw yields in the plots of RFD applied through chemical fertilizers (urea + DAP + MOP) without applying any bio-organic materials might be ascribed to poor utilization of fertilizer nutrients in absence of organic nutrient sources

Conclusion

The study indicated that judicious use of chemical fertilizers along with application of bio-organic materials in balanced proportion would be an effective tool of integrated nutrient management for rejuvenating natural soil fertility and enhancing rice productivity.

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References

Anonymous. 2015. Bio*Ag*. Better Soils. Better Crops. Better Stock. Available at: http://www.bioag.com.au/ (Accessed on October 25, 2015).

Adhikary, J. and Majumdar, D. K. 2002. Effect of combinations of organic manures and chemical fertilizers on rice. *Proceedings.* National Seminar on "Development and use of biofertilizers, biopesticides and organic manures", Nov. 10-12, 2000, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India. pp. 288-293.

Bhowmick, M.K., Dhara, M.C., Bag, M. K., Adhikari, B. and Kundu, C. 2011. Integrated nutrient management for aromatic rice in West Bengal. *Oryza* 48(3): 276-277.

Bhowmick, M.K. and Ghosh, R.K. 2001. Effect of kri-kelp on growth and yield of transplanted paddy. *Advances in Plant Sciences* 14(2): 501-506.

Bhowmick, M.K. and Ghosh, R. K. 2002. Role of bio-organic materials in yield maximization of summer paddy. *Proceedings.* National Seminar on "Development and use of biofertilizers, biopesticides and organic manures", Nov. 10-12, 2000, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India. pp. 310-312.

Dhara, M.C. and Bhowmick, M.K. 2015. Methods of crop establishment and nutrient management with and without soil conditioner in summer rice. *SATSA Mukhapatra-Annual Technical Issue* **19**: 130-134.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research* (2nd ed.). An International Rice Research Institute Book. Wiley-Interscience Publication, John Wiley and Sons, New York. p. 20-30.

Kumazawa, K. 1984. Beneficial effects of organic matter on rice growth and yield in Japan. (in) *Organic Matter and Rice*. International Rice Research Institute, Philippines. p. 431-444.

Surekha, K., Mahender Kumar, R. and Viraktamath, B.C. 2015. Organic rice farming: Opportunities for quality seed production and soil health improvement. *SATSA Mukhapatra-Annual Technical Issue* **19**: 1-18.

Yawalkar, K.S., Agarwal, J.P. and Bokde, S. 2011. *Manures and Fertilizers*. Agri-Horticultural Publishing House, Nagpur, India. 366 p.

Table 1. Effect of treatments on crop growth of transplanted rice during wet season of 2012 and 2013

Treatment	Plant height (cm)				Tillers/m^2			
	45 DAT		Harvest		45 DAT		Harvest	
	2012	2013	2012	2013	2012	2013	2012	2013
Urea + DAP + MOP	78.25	81.33	96.31	98.36	254.75	272.00	330.00	320.50
Urea + DAP + MOP + Bio*Ag*SS (10 l/ha)	85.43	84.19	101.50	103.55	273.50	281.25	386.00	366.25
Urea + DAP + MOP + Bio*Ag*Phos (0.2 t/ha)	85.58	84.55	102.75	104.33	289.50	288.75	393.25	369.75
Urea + DAP + MOP + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.2 t/ha)	88.50	85.78	104.19	106.23	295.25	290.25	435.25	385.50
Urea + SSP + MOP + Bio*Ag*SS (10 l/ha) + Vermicompost (3.0 t/ha)	80.63	86.52	101.25	106.32	261.25	299.50	351.75	393.25
Urea + SSP + MOP + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.1 t/ha) + Vermicompost (1.5 t/ha)	88.55	89.45	109.13	108.05	304.75	308.25	455.75	416.25
SEm±	0.43	0.41	2.41	2.45	7.99	6.63	7.57	8.01
LSD (P=0.05)	1.29	1.24	7.27	7.38	24.07	19.98	22.80	24.14
C.V. (%)	1.02	8.20	4.71	5.22	5.71	6.54	3.86	7.85

Table 2. Effect of treatments on yield attributes of transplanted rice during wet season of 2012 and 2013

Treatment	Panicles/m^2		Panicle length (cm)		Panicle weight (g)		% filled grains		1000-grain weight (g)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Urea + DAP + MOP	300.75	308.25	21.58	22.09	3.16	3.14	82.93	83.45	16.45	16.39
Urea + DAP + MOP + Bio*Ag*SS (10 l/ha)	323.25	319.75	24.35	23.15	3.45	3.15	85.54	85.33	17.85	16.88
Urea + DAP + MOP + Bio*Ag*Phos (0.2 t/ha)	325.75	329.75	24.55	23.18	3.50	3.23	85.81	85.92	18.03	17.10
Urea + DAP + MOP + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.2 t/ha)	339.75	331.25	24.78	23.30	3.60	3.35	86.74	86.14	18.13	17.11
Urea + SSP + MOP + Bio*Ag*SS (10 l/ha) + Vermicompost (3.0 t/ha)	320.75	342.75	23.80	24.39	3.31	3.39	85.30	86.28	16.80	17.18
Urea + SSP + MOP + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.1 t/ha) + Vermicompost (1.5 t/ha)	352.75	363.50	25.55	24.51	3.66	3.51	87.25	88.22	18.93	17.25
SEm±	10.04	7.65	0.69	0.56	0.17	0.16	1.38	1.29	0.37	0.40
LSD (P=0.05)	30.26	23.05	2.09	1.69	NS	NS	NS	3.89	1.10	NS
C.V. (%)	6.14	7.22	5.75	6.35	9.59	10.05	3.23	4.59	4.14	5.53

NS: Not significant

Table 3. Effect of treatments on productivity of transplanted rice during wet season of 2012 and 2013

Treatment	Grain yield (t/ha)			Straw yield (t/ha)		
	2012	2013	Mean	2012	2013	Mean
Urea + DAP + MOP	4.81	4.85	4.83	6.25	6.46	6.36
Urea + DAP + MOP + Bio*Ag*SS (10 l/ha)	5.20	5.20	5.20	6.41	6.64	6.53
Urea + DAP + MOP + Bio*Ag*Phos (0.2 t/ha)	5.41	5.30	5.36	6.53	6.62	6.58
Urea + DAP + MOP + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.2 t/ha)	5.54	5.35	5.45	6.53	6.64	6.59
Urea + SSP + MOP + Bio*Ag*SS (10 l/ha) + Vermicompost (3.0 t/ha)	5.05	5.50	5.28	6.35	6.71	6.53
Urea + SSP + MOP + Bio*Ag*SS (10 l/ha) + Bio*Ag*Phos (0.1 t/ha) + Vermicompost (1.5 t/ha)	5.59	6.15	5.87	6.54	7.10	6.82
SEm±	0.17	0.19	-	0.21	0.48	-
LSD (P=0.05)	0.52	0.57	-	0.64	1.45	-
C.V. (%)	6.53	10.58	-	11.37	12.49	-