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Effect of integrated nutrient management on system productivity, nutrient uptake, nitrogen balance, soil structural properties and nitrogen use efficiency under wheat-rice cropping system

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Abstract
A field experiment was conducted at BCKV, Kalyani (West Bengal) on medium loam soil during *rabi* seasons 2013-14 to *kharif* seasons of 2014-15 under upland situation to study the effect of integrated nutrient management on system productivity system, nutrient uptake, nitrogen balance, soil structural properties and nitrogen use efficiency and apparent nutrient recovery % in wheat-rice cropping system. The experiment was laid out in Split-Split Plot design with twenty four treatments having three replications. The treatments comprised of organic source in Main plot viz. No FYM and FYM (10 t ha^{-1} Farm yard manure), Sub plot treatments consist of No Fertilizers (NPK), 75% NPK and 100% NPK whereas Sub-sub plot treatments comprised of No biofertilizers, *Azotobacter,* PSB and *Azotobacter*+PSB. Whereas, in kharif season, direct seeded rice crop got only 100% RDF in all treatments.

Experimental findings revealed that FYM at 10 t, 100% RDF and combined application of bio-fertilizers recorded 16.22, 75.97 and 12.04 % higher wheat equivalent yield (WEY) over treatments of without FYM, 0% RDF and no inoculation. The maximum build-up of soil aggregation and uptake of NPK were observed in the plots receiving FYM @ 10 t ha^{-1},100% RDF and combined application of *Azotobacter* and PSB but the effect was statistically at par when compared with 100 and 75% RDF. N-use efficiency and apparent recovery % were much better under FYM, 75% RDF and combined inoculation of *Azotobacter* and PSB. Negative N-balance was noted in control plots after two years of the experiment but it was positive in the plots treated with FYM, chemical fertilizers and bio-fertilizers.

Based on these findings, it is concluded that application of 10 t FYM ha^{-1} and dual inoculation of *Azotobacter* and PSB along with 75 % RDF maximized system productivity, nutrient uptake, nitrogen balance, soil structural properties and nitrogen use efficiency and apparent nutrient recovery %, economized fertilizer use to the extent of 25% and ultimate improved soil health in wheat-rice cropping system.

Keywords: Aggregates, Cropping system, Rice, System Productivity, Wheat

Introduction
India is a second largest producer of rice and wheat, in order to make farmers and farming sustainable, there is urgent need to double the income of farmers. The Govt. of India is emphasizing to double the farmers income by 2021-22.The pathway for doubling the farmers income requires consideration of different nutrient management practices. The mining of nutrients from soil due to growing population with increasing food demand for ages severely limits crop production. However, integrated nutrient management is the most important nutrient sources for enhancing double income and sustainability in agricultural systems. The principle behind a good fertilizers management practices rests on right sources, doses, timing and methods of application in existing system. Rice-Wheat is the dominant cropping system across the Indo-Gangetic Plains (IGP) and in the Himalayan foot-hills of India. The system is fundamental to employment, income and livelihood for 700 million populations in India. This system now occupies 12.3 million ha in north India, of which 10 million ha is in the Indo-Gangetic Plains (IGP), covering 75% of the total wheat area in India [1]. Out of the total rice and wheat production in India 42% comes from IGP comprising Punjab, Haryana, UP, Bihar & West Bengal.

In India as well as in West Bengal these are the major food grain crops. In India, total area, production and productivity under rice is 43.65 million hectares, 104.40 million tonnes and 2462 kg ha^{-1} and wheat is 29.64 million hectares, 92.46 million tones and 3118 kg ha^{-1} of respective crops. However, agricultural scenario with respect to the cultivation of these crops in West Bengal is quite different. Rice occupies first position in production, covering about

5.43 million hectares, whereas wheat crop is cultivated on 0.32 million hectares with the production of 14.96 million tonnes and 0.91 million tonnes, respectively [2]. Therefore, the average yield of wheat is far below than the national average. The most important factor for low productivity is the inadequate and imbalanced use of chemical fertilizers coupled with aberrant weather conditions.

Increase in the cost of fertilizers, deterioration of soil health and productivity due to continuous use of large quantities of chemical fertilizers, resulting in environmental pollution and concern for sustainable agriculture with emphasis on ecologically friendly inputs have resulted in the renewed interest on integrated plant nutrient supply systems. The basic concept underlying the integrated plant nutrient supply system is the maintenance of soil fertility, sustaining agricultural productivity and improving farmer's profitability through judicious and efficient use of fertilizers, organic manures and biofertilizers to the extent possible. Plant nutrition through organics is a practice adopted by the farmers from antiquity. Organic sources of plant nutrients are effective in enhancing wheat productivity, soil properties and biological activity [3]. Organics also increase the efficiency of applied nutrients in rice-wheat cropping system [4].

Considering the above facts, it is considered worthwhile to undertake the present investigation to find out the effectiveness of organic manure and biofertilizers, i.e. farmyard manure, *Azotobacter* and Phosphate solubilizing bacteria and their combination with chemical fertilizers on system productivity, nutrient uptake, nitrogen balance, soil structural properties and nitrogen use efficiency in wheat-rice cropping system under prevailing agro-climatic condition of New Alluvial Zone of West Bengal.

Materials and Methods

A Field experiment was conducted during *Rabi* and *Kharif* seasons of 2013-14 and 2014-15 at Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal (22^{O} 57'N Latitude, 88^{O} 20'E Longitude and 9.75 meter above mean sea levels). The experiment was laid out in Split-split Plot design with twenty four treatments having three replications. The treatments comprised of organic source in Main plot viz. No FYM and FYM (10 t ha^{-1} Farm yard manure), Sub plot treatments consist of No Fertilizers (NPK), 75% NPK and 100% NPK whereas Sub-sub plot treatments comprised of no biofertilizers, *Azotobacter*, PSB and *Azotobacter*+PSB. Whereas, in kharif season,direct seeded rice crop grown on residual soil fertility in the undisturbed plots and got only 100% RDF in all treatments.

The experimental plot soil was medium loam in texture with pH 7.58. The organic carbon, electrical conductivity, bulk density, available nitrogen, phosphorus and potash were 0.54 %, 0.175 mmhos cm^{-1}, 1.27 g cm^{-3}, 198.55, 19.25 and 182.50 kg ha^{-1}, respectively. The recommended dose of fertilizers for wheat in this region is 150:60:40 NPK kg ha^{-1} and for rice is 60:30:30 NPK kg ha^{-1}. In wheat, one third quantity of nitrogen along with entire phosphorus and potassium as per the treatments were applied before sowing. Another one third dose of nitrogen was top dressed at CRI stage and remaining one third dose of nitrogen was applied at maximum tillering stages. Urea, single super phosphate (SSP) and muriate of potash (MOP) were used as sources of nitrogen, phosphorus and potassium, respectively. In rice crop, one fourth of the nitrogen, whole of phosphorus and potassium as per treatments were applied at the time of sowing through urea, SSP and MOP, respectively. Half dose of nitrogen was top dressed at tillering stage and remaining one fourth was applied at panicle initiation stages. The desired doses of FYM 10 t ha^{-1} mixed before sowing of the wheat crop. Then wheat variety (DBW39) was sown @ 100 kg seed ha^{-1} in *Rabi* season and rice variety Shatabdi (IET 4786) was sown as direct seeded @ 50 kg seed ha^{-1} in *Kharif* season. The wheat seeds were inoculated with *Azotobactor* and PSB inoculants @ 5 g kg^{-1} of seed by standard method and applied to the open furrows for sowing of wheat seed. The unit plot was 5.0 m x 3.0 m, sowing of wheat seed at 20xContinious row spacing on 07.12.2013 and 24.11.2014 in 2013-14 and 2014-15 respectively. After harvesting of wheat, direct seeded rice was sown at 20 cm apart in rows in the first fortnight of June, it depends upon the onset of monsoon during the cropping seasons. The climate is characterized by the alternate hot rainy season from mid June to last September with mean temperature of 35°C. The rainfall received during the crop season of respective years was 1178 mm and 1410 mm respectively.

Wheat crop was irrigated five times in both the seasons (immediately after sowing, at CRI, maximum tillering, flowering and milk stage). The depth of irrigation was maintained at 6 cm. Rice was grown as a direct seeded crop and need based two irrigations were applied. All intercultural operation was done as when necessary. For working out the wheat grain equivalent yield, the market price of grain of wheat and rice and straw of both crops were considered. Soil samples up to the depth of 15 cm were collected at harvest of the second crop cycle and analyzed for soil structure (Aggregates) of soil. The both crop were harvested at full maturity. The plant sample were analysed for nutrients uptake. Nutrient balance and nutrient use efficiency and apparent nutrient recovery were worked after maturity. Grain yield was converted to t ha^{-1} at 14% moisture content.

Results and Discussion

Direct and residual effect on wheat-rice system

System productivity

The total productivity of wheat-rice cropping system has been expressed as wheat equivalent yield (WEY) of the system. The data on this aspect as influenced by direct and residual effect of FYM, chemical fertilizers and bio-fertilizers have been presented in (Table 1). It is apparent from the pooled data the highest wheat equivalent yield of the system (6.16 t ha^{-1}) was registered from FYM @ 10 t ha^{-1} which produced 0.86 t more yield from the system after two years over no FYM (5.30 t ha^{-1}). The effect was also statistically significant. Higher yields of wheat and rice crops during both the years computed higher wheat equivalent yield of the system.

The effect of application of chemical fertilizers on wheat equivalent yield of the system was also found to be significant. The highest wheat equivalent yield (6.74 t ha^{-1}) was recorded from 100% RDF, however, it remained at par with 75% RDF (6.63 t ha^{-1}). Both these treatments were significantly superior to no chemical fertilizers which virtually produced lowest total productivity from the system (3.83 t ha^{-1}) recorded from the plots without having any fertilizers application.

Bio-fertilizers produced same trend of wheat equivalent yield. Direct and residual effect of combined application of *Azotobacter* + PSB (6.05 t ha^{-1}) produced 12.03% and 5.37% higher WEY than control and PSB, respectively while remained statistically at par with sole treatment of *Azotobacter* (5.77 t ha^{-1}). Enrichment of soil nutrient status over time in FYM, chemical fertilizers and biofertilizers

treated plots increased the crop yields of rice and wheat and influenced the system wheat equivalent yields accordingly. [5] revealed that reverse trend of soil status was noticed in treatments with no FYM, chemical fertilizers and biofertilizers which was reflected in the crop yields and also in system wheat equivalent yields.

Nutrient (NPK) uptake

NPK uptake by cropping system increased with the increase of levels of FYM and chemical fertilizers (Table 1). Combined application of *Azotobacter* and PSB produced more influence on nutrient uptake than their sole application. It has been noted from the pooled data that FYM at 10 t ha^{-1} resulted in removal of (131.65 kg N, 36.61 kg P and 144.48 kg K ha^{-1}) and 100% RDF accounted for (153.31 kg N, 41.47 kg P and 164.04 kg K ha^{-1}). Wheat seed inoculation with *Azotobacter* and PSB resulted in NPK removal of (132.74 kg N, 36.56 kg P and 145.23 kg K ha^{-1}). Higher uptake of NPK with the organics and chemical fertilizers indicated that mineralized nutrient form these sources could sufficiently meet the nutritional requirement of the crops. Thus higher doses of organics and fertilizers influenced the plant growth and developmental characters which ultimately resulted in higher uptake of nutrients reported by [6].

Soil structural properties

The data presented in (Table 2) indicate that the soil structural parameters increased from its initial values. It was noted that FYM and fertilizers at higher rates and combined inoculation of *Azotobacter* + PSB had more pronounced effect on soil structure. Higher values of aggregate ratio (AR), percent aggregate stability (AS), mean weight diameter (MWD) and Geometric mean diameter (GMD) were noted from the aforesaid treatments as compared to the lower rates of FYM, fertilizers and sole application bio-fertilizers. Similar finding accordance with [7] revealed that the effect of integrated use of organic materials, chemical fertilizers and biofertilizers improved the soil aggregation and thereby decreased the bulk density, which in turn increased the saturated hydraulic conductivity and infiltration rate of the soil in rice-wheat cropping system.

Nitrogen balance in wheat-rice system

The data related to nitrogen balance after two cycles of wheat-rice cropping system as influenced by direct and residual effect by FYM, chemical fertilizers and biofertilizers have been presented in (Table 1).

Positive nitrogen balance in soil after two cycles of wheat-rice sequence was found under application of FYM. The higher value of nitrogen balance (17.46 kg ha^{-1}) was obtained from the plots, where FYM was applied @ 10 t ha^{-1} and negative balance (-9.38 kg ha^{-1}) was recorded from the plots where no FYM was applied in wheat-rice sequence.The effect of application of chemical fertilizers on nitrogen balance of wheat-rice sequence was also found to be positive (9.08 and 7.57 kg ha^{-1}) from the plots where 100% RDF and 75% RDF, respectively was applied and negative (-6.88 kg ha^{-1}) nitrogen balance was recorded from no fertilized plots. Maximum positive value of N balance (11.7 kg ha^{-1}) was recorded from the combined application of *Azotobacter* + PSB and lower values but positive influence was obtained from sole application of *Azotobacter* and PSB and the negative influence (-12.98 kg ha^{-1}) was recorded from the control. This positive balance could be ascribed to the addition on N from different sources of nutrients and variations in the addition and uptake of the nutrients by the crops. The findings support those of [8].

Nitrogen-use efficiency and Apparent N recovery %

The data on nitrogen-use efficiency and apparent N recovery % as influenced by residual effect of FYM, chemical fertilizers and biofertilizers have been presented in (Table 2).Nitrogen-use efficiency (NUE) and apparent N recovery % was influenced by the different nutrient sources. It was observed that NUE was higher in the second year (2014-15) in the treatment of FYM and recorded higher value (6.17 kg grain /kg N) than the first year. Similarly, apparent N recovery percentage was also higher in the year 2014-15 (7.95%) as compared to the first year. So far the residual effect of application of inorganic fertilizers is concerned, it was observed that application of 100% RDF recorded higher value of NUE (7.67 kg grain /kg N) and apparent N recovery (13.33%) in the first year and the same trend was noted in case of 75% RDF also. 100% RDF also recorded higher values than 75% RDF. However, the overall trend of residual effect of chemical fertilizers was reverse as that of FYM.

Regarding the application of different bio-fertilizers, it was observed that values of NUE and apparent N recovery were same or higher in the second year. Combined application of *Azotobacter* + PSB registered higher values of NUE and apparent N recovery in the second year (6.50 kg grain /kg N and 11.55 %, respectively) compared with other treatments. [9] reported that residual effect of organics was found to more persistent than chemical fertilizers. The results are indicative of the fact that the treatments increased the production capacity per unit of nutrient applied which might be due to prolonged N availability. The recovery percentage could be attributed to higher N uptake under the treatments.

Table 1: Effect of integrated nutrient management on system productivity, nutrient uptake, and nitrogen balance in wheat-rice cropping system (after completion of 2 years).

Treatments	Wheat equivalent yield of the system (t ha^{-1})	N-uptake (Kg ha^{-1})	P-uptake (Kg ha^{-1})	K-uptake (Kg ha^{-1})	Initial available Nitrogen (Kg. ha^{-1}) in soil	Nitrogen balance (Kg. ha^{-1}) in soil	Actual gain/loss (Kg. ha^{-1}) in soil
Manure							
No FYM	5.30	120.36	32.79	131.18	198.55	189.17	-9.38
FYM (10 t/ha)	6.16	131.65	36.61	144.48	198.55	216.01	17.46
SEm ±	0.07	1.66	0.55	1.77			
CD (P=0.05)	0.25	4.84	1.69	5.36			
Fertility level							
0%RDF	3.83	83.27	23.75	94.23	198.55	191.67	-6.88
75%RDF	6.63	141.43	38.88	155.23	198.55	206.12	7.57
100%RDF	6.74	153.31	41.47	164.04	198.55	207.63	9.08
SEm ±	0.12	3.76	0.83	2.59			

CD(P=0.05)	0.41	12.73	2.63	9.23			
Biofertilizers							
No biofertilizer	5.40	118.59	32.64	129.67	198.55	185.57	-12.98
Azotobacter	5.77	127.44	35.11	139.62	198.55	205.13	6.58
PSB	5.69	125.24	34.48	136.81	198.55	203.58	5.03
Azotobacter+PSB	6.05	132.74	36.56	145.23	198.55	210.25	11.7
SEm ±	0.09	1.65	0.64	2.40			
CD(P=0.05)	0.28	6.70	1.48	7.53			

Table 2: Effect of integrated nutrient management on soil structure, nitrogen use efficiency and apparent N recovery % in wheat-rice cropping system (after completion of 2 years).

Treatments	Aggregate ratio (AR)	Percent aggregate stability (AS%)	Mean weight diameter (MWD)	Geometric mean diameter (GMD)	Nitrogen use efficiency (kg grain/kg N applied)	Apparent N recovery (%)
Manure						
No FYM	0.347	0.253	0.577	0.677	-	-
FYM (10t/ha)	0.538	0.335	0.788	0.719	6.17	7.95
Fertility level						
0%RDF	0.484	0.206	0.483	0.629	-	-
75%RDF	0.516	0.328	0.632	0.678	5.50	4.97
100%RDF	0.538	0.335	0.915	0.918	6.33	10.42
Biofertilizers						
No biofertilizer	0.139	0.115	0.603	0.619	-	-
Azotobacter	0.343	0.249	0.633	0.716	4.17	7.55
PSB	0.331	0.230	0.555	0.641	3.67	6.35
Azotobacter+PSB	0.484	0.281	0.640	0.719	6.50	11.55
Initial	0.219	0.168	0.525	0.625		

Conclusion

Based on these findings, it is concluded that application of 10 t FYM ha^{-1} and dual inoculation of *Azotobacter* and PSB along with 75 % RDF maximized system productivity, nutrient uptake, nitrogen balance, soil structural properties and nitrogen use efficiency and apparent nutrient recovery %, economized fertilizer use to the extent of 25% and ultimate improved soil health in wheat-rice cropping system.

References

1. Mishra B. Advance in rice and wheat research for food and nutritional security. Paper presented at 9th Agricultural Science Congress on Technological and Institutional Innovations Enhancing Agricultural Income, Srinagar, 2009.
2. Directorates of Economics and Statistics, Cost of cultivation of principal crops of India. Ministry of Agriculture, New Delhi, 2014.
3. Singh F, Kumar R, Pal S. Integrated nutrient management in rice (*Oryza sativa*)-wheat (*Triticum aestivum)* cropping system for sustainable productivity. *Progress. agric.* 2003; 3(1, 2):115-116.
4. Singh JP, Kaur J, Mehta DS, Narwal RP. Long term effect of nutrient management on soil health and crop productivity under rice (*Oryza sativa*)-wheat (*Triticum aestivum)* cropping system. Indian J. Fert. 2012; 8(8):28-48.
5. Chauhan DS, Shrama RK, Tripathi SC, Kharub AS, Chhokar RS. News paradigm in tillage technology for wheat production. *Research Bulletin NO.* DWR, Karnal, 2011; 8:16.
6. Upadhyay VB, Vishwakarma SK. Long-term effect of integrated nutrient management in rice (*Oryza sativa*)-wheat (*Triticumaestivum*) cropping system. Indian Journal of Agronomy. 2014; 59(2):209-214.
7. Yadav DS, Kumar Alok. Long-term effect of nutrient management on soil health and productivity of rice-wheat system. Indian Journal of Agronomy**.** 2009; 54(1):15-20.
8. Sharma A, Singh H. Dry matter accumulation pattern of wheat (*Triticum aestivum*) as influenced by integrated nutrient management and irrigation. *Advances in Plant Science* 2008; 21**(**2**)**:429-432.
9. Upadhyay VB, Jain V, Vishwakarma SK, Kumhar AK. Production potential, soil health, water productivity and economics of rice (*Oryza sativa*)–based cropping systems under different nutrient sources. Indian Journal of Agronomy. 2011; 56(4): 311-16.