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Response of Integrated Application of Inorganic Fertilizers and Vermicompost on Rice Productivity at Farmer Field

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Authors' contributions

This work was carried out in collaboration among all authors. Authors RT, AKS and SS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SKR and GKK managed the analyses of the study. Authors NKB and MIK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Rice (*Oriza sativa*) is one of most important *kharif* cereal crop. The availability of nutrients in the soil for plant utilization is known to be affected not only by the inherent soil characteristics but also by the use of fertilizers and management practices followed for crop production. Therefore, a study on the response of integrated application of inorganic fertilizers and organic manure (vermicompost) on rice productivity at farmer field was carried out at Balaghat district of Madhya Pradesh. In between the technology intervention, human recourse development components were also included to excel the farmers understanding and skills about the demonstrated technology on nutrient management aspects. The demonstrations were conducted at different farmers' field at villages viz. Koppe, Chillod and Lendejhari on rice (variety JRB-1) during *kharif* season 2018-19 and 2019-20 under Indian Council of Agricultural Research funded Project on Farmer FIRST, College of Agriculture, Balaghat (M.P.). Based on the basic soil properties of farmer's field, the present experiment included four treatments viz., T_1 - 100% NPK + 2 t Vermicompost ha^{-1}, T_2 - 100% NPK, T_3 - 100% NPK (– S) and T_4 – Farmer's practice. Results indicated that the highest

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average yield of rice was achieved in the treatment T_1-100% NPK + Vermicompost. Whereas, lowest yield was recorded in T_4-farmer's practice. Highest rice yield was observed with 100% NPK + vermicompost (47%),followed by 100% NPK (44%) over farmer's practice. Hence, the integrated use of inorganic fertilizers with vermicompost enhance rice productivity at farmer's field. Integrated nutrient applications are also more beneficial when the rate of nutrient application is below the normal rate.

Keywords: Rice; soil test values; extension and technology gap; vertisols.

1. INTRODUCTION

Rice is the premier food grain crops of the India and in particular of Balaghat district of Madhya Pradesh. There has been a phenomenal increase in their production after mid-sixties with the introduction of high yielding varieties to cope with famine [1]. Waterlogging situation in the rice fields may lower down the nutrient use efficiency and also responsible for increasing green house gases (GHGs) concentration in the atmosphere [2]. Due to inadequate and imbalanced fertilizer application, farmers are not able to harness the full yield potential of rice crop. There is an apprehension that the use of chemical fertilizers over the year's might may impair the soil fertility. In continuous cropping, use of imbalanced nutrients (N or NP alone) through inorganic fertilizers without organic manure cannot sustain the desired level of crop production [3-5]. Integration of inorganic fertilizers with organic manures will not only sustain the crop production but also will be effective in improving soil health and enhancing the nutrient use efficiency under rice-wheat cropping system in a Vertisol [6]. The balance fertilization through integrated use of manure, fertilizer and biofertilizer along with micronutrients has also been found useful in rice crop [7]. Hence, a field experiment was undertaken to study the effect of combined application of inorganic fertilizers and vermi-compost on yield of rice and nutrient balance at farmer's field. The availability of nutrients in the soil for plant utilization is known to be affected not only by the inherent soil characteristics but also by the fertilizer use and followed cropping practices [5]. It has been observed that a major part of the applied nutrient gets fixed and only a small part of it becomes available to the crop plants at farmer's field [6]. Keeping in view the above facts, the present investigation was undertaken.

2. MATERIALS AND METHODS

The present study is a part of the ongoing ICAR funded project on Farmer FIRST at College of Agriculture, Balaghat, Madhya Pradesh, India. The study area has a semi-arid and sub-tropical climate with a characteristic feature of dry summer and cold winter. In winter season i.e. from November to February months, the temperature ranges from 4 to 33^{o}Cand the relative humidity varies from 70 to 90%. Dry and warm weather usually prevails during the months of March to June. The temperature in the month of May rise as high as 46^{o}C. Monsoon season extends from mid-June to mid-September. The temperature during this period ranges from 25 to 35^{o}C and the relative humidity ranges between70 to 80%. The total annual rainfall varies from 1400 to1500 mm with the mean value of around 1400 mm [8-9].

Different tools of Participatory Rural Appraisal (PRA) were used to explore the detailed information of study area [10]. In between the technology intervention HRD components (Trainings/ Soil health camp/ Field day etc.) were also included to excel the farmers understanding and skill about the demonstrated technology on integrated nutrient management. The demonstration conducted at farmer's field of adopted villages viz. Koppe, Chillod and Lendejhari on rice (variety JRB-1) during *kharif* season 2018-19 and 2019-20. Information on soil condition of the farmer fields used in this experiment was ranged as, soil pH 6.6 to 7.4, EC 0.18 to 0.271 dSm^{-1}, organic carbon 3.8 to 5.3 g kg^{-1}, available nitrogen199 to 248 kg ha^{-1}, available phosphorus 7.6 to 14.8 ha^{-1} and available potassium 237 to 319 kg ha^{-1}. The experiment included four treatments viz., T_1 - 100% NPK + 2 t Vermicompost ha^{-1}, T_2 - 100%NPK, T_3 - 100% NPK (– S) and T_4– Farmer's practice Table 1.

The recommended dose of N, P and K, based on initial soil test value was 120 kg N, 80 kg P_2O_5 and 40 kg K_2O ha^{-1}, for rice. The sources of N, P and K used were urea, Single Super Phosphate (SSP) and Muriate of Potash. In Sulphur-free treatment, Diammonium Phosphate (DAP) was used instead of SSP as source of phosphorus.

During *kharif* season, all the nutrients, viz. 25% N + 100% P and Kwere applied as a basal dose at the time of sowing. Whereas, remaining75% of nitrogen in two split doses were applied as topdressing. However, in farmer's practice, 125 kg DAP per hectare was applied as basal dose and 250 kg Urea per hectare was applied (50% Urea at 15 – 20 days after sowing or transplanting and 50% Urea at 50 – 60 DAS). Organic manure i.e. Vermicompost @ 2 t ha^{-1} was applied prior to sowing in the concerning treatments.

Rice (JRB-1) was sown during first week of July and harvested after 110 – 120 days. Insects and diseases were kept under check following suitable control measures. The rice grain yield was recorded after harvest of the crop. For extension and technological gaps analysis all the package and practices except integrated nutrient management treatments, kept as same for all the treatments. These soil samples were analyzed for pH (1:2.5 soil: water suspension), electrical conductivity by conductivity meter, soil organic carbon by rapid titration method [11]. Available nitrogen contents in soil was estimated by alkaline permanganate method [12], available phosphorous was extracted by 0.5 m sodium bicarbonate and determined by Olsen's method [13] and available potassium content by ammonium acetate extraction method [14].

3. RESULTS AND DISCUSSION

3.1 Yield Analysis

Yield data of rice crop was presented in Table 2, indicated that the integrated use of inorganic fertilizers with organic manure (100% NPK + Vermicompost) produced the highest average rice grain yield 48.0 t ha^{-1} followed by 100% NPK which gave 45.8 t ha^{-1}. An integrated application of fertilizer with vermicompost was found to be beneficial for increasing the productivity potential of rice [6]. The lowest yield of rice 25.5 t ha^{-1} was recorded in farmer's practice. Maximum increase in yield (47%) was observed with 100% NPK + vermicompost over farmer's practice, followed by 44% increase in yield (100% NPK) of rice over farmer's practice. Increase in rice yield was due to combined application of inorganic fertilizer and organic manure (Vermicompost) might be attributed to controlled release of nutrients in the soil through mineralization of organic manure which might have facilitated better crop growth [6].

3.2 Extension and Technology Gap

Extension gap was calculated by subtracting farmer's practice yield from demonstrated yield. The difference of this gap is denoted that there is a sufficient chance to increase in rice yield by adopting recommended technologies. The data presented in Table 3, indicated that the 100% NPK + vermicompost treatment had the highest average extension gap (22.6 t ha^{-1}) followed by 100% NPK treatment (20.3 t ha^{-1}). The lowest average extension gap (17.3 t ha^{-1}) was recorded in 100% NPK (– S) treatments. The results are in close conformity with results of researchers [15] and they were reported that 39.8 per cent of the farmers had low and medium adopted use of recommended dose of fertilizers. These results are also in agreement with the findings of the trial on impact of FYM and potassium on yield, nutrient uptake and economics of wheat in alluvial soil [16].

Table 1. Information regarding experiment

Parameters	Details
Problem diagnose	Low yield of rice due to imbalance nutrition
Technology selected for assessment	T_1 - 100% NPK + 2 t Vermicompost ha^{-1} T_2 - 100%NPK T_3 - 100% NPK (– S) and T_4– Farmer's practice
Production system	Rice – Rice or Rice – Fallow
Thematic area	Integrated Nutrient Management
Constants identified and feedback for research work	Facilities for soil testing are not available at block level
Process for farmers participation and their reaction	Training, Soil Health Camp, Demonstration on INM, Field Day, Focused group discussion and Personal interview
Number of Respondents/ Farmers	Thirty (10 field from each villages)
Crop	Rice (Variety JRB-1)

Technological gap was calculated by subtracting demonstrated yield from yield potential of particularly variety. This gap is express that there is need to guide and educate for adopting recommended technology. The data presented in Table 3, indicated that the Farmer's Practices treatment had the highest average technology gap (24.6 t ha^{-1}) followed by 100% NPK (-S) treatments i.e. 7.3 t ha^{-1}. Lowest average technology gap 2.0 t ha^{-1} was recorded in 100% NPK + Vermicompost treatments. The similar findings were also reported by many researchers [15-16].

3.3 Soil Test Values

The result revealed that the soil pH recorded before sowing ranged between 6.0 -7.1, while pH value was found to be unchanged even at harvest of crop which ranged between 6.1 to 7.3 Table 4.

The EC values of the soil ranged between 0.20 to 0.37 dSm^{-1} in soil before sowing. Application of fertilizers could not exhibit any adverse effect on the soil physico-chemical properties due to its inherent high buffering capacity. Similar finding has also been reported from an experiment conducted on continuous applications of nutrient inputs on spatial changes of soil physicochemical properties of a medium black soil [5]. The data also indicated (Table 4) that organic carbon content in soil found to increase with increasing levels of fertilizer addition application thereby, lower content was found in farmer's practice as compared to 100% NPK + vermicompost application followed by treatment receiving imbalanced fertilizer doses. Organic carbon content in soil indicated that the contribution of organic carbon content appeared due to decomposition of plant and root residues [15,17]. Similarly, the available N, P and K contentin soil was found to be higher with 100% NPK + vermi-compost treatment, however, lowest content was noted in farmer's practice.

3.4 Human Resource Development (HRD)

During the study period, Human Resources Development Components i.e. training, soil health camp/day, field day, focused group discussion and Kisan Mela were also

Table 2. Grain Yield of Rice (q ha^{-1})

Treatments	Name of Villages						Average
	Koppe		Chillod		Lendejhari		
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	
100% NPK + Vermicompost	48.8	49.5	47.9	48.6	46.3	46.9	48.0
100% NPK	45.2	45.9	46.2	46.9	44.8	45.5	45.8
100% NPK (-S)	42.6	43.3	41.9	42.6	42.7	43.4	42.8
Farmer's Practice	25.4	26.1	24.1	24.8	25.8	26.5	25.5
Average	40.5	41.2	40.0	40.7	39.9	40.6	

Table 3. Extension and technology gap

Treatments	Name of Villages						Average
	Koppe		Chiloud		Lendejhari		
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	
Extension Gap							
100% NPK + Vermicompost	23.4	23.4	23.8	23.8	20.5	20.4	22.6
100% NPK	19.8	19.8	22.1	22.1	19.0	19.0	20.3
100% NPK (-S)	17.2	17.2	17.8	17.8	16.9	16.9	17.3
Technology Gap							
100% NPK + Vermicompost	1.2	0.5	2.1	1.4	3.7	3.1	2.0
100% NPK	4.8	4.1	3.8	3.1	5.2	4.5	4.3
100% NPK (-S)	7.4	6.7	8.1	7.4	7.3	6.6	7.3
Farmer's Practice	24.6	23.9	25.9	25.2	24.2	23.5	24.6

organized and disseminate information through popular articles/leaf lets/pamphlets, training handouts/manuals/booklets etc. to increase the farmers understanding and skill about the recommended practice on soil test crop response Table 5. Similar results were also supported by the scientists [18]. They concluded that farmers are required HRD components to make aware about the associated activities.

Table 4. Soil test values of selected farm sites

S. No.	Farmers Name	pH	EC	OC	Available Nutrients (kg ha^{-1})		
			(dSm^{-1})	(%)	N	P	K
Village – Koppe							
1.	NaganlalPatle	6.45	0.22	0.86	298	19.20	363
2.	chandanlalpatle	6.19	0.23	0.76	272	6.98	410
3.	TejramShirsagar	6.13	0.27	0.81	284	19.54	272
4.	Ram Prasad Thakre	6.33	0.28	0.73	267	8.73	324
5.	Ashok Patle	6.26	0.21	0.60	225	8.73	314
6.	ChaturbhujThakre	6.48	0.28	0.84	294	6.98	243
7.	NeeleshTembhre	6.42	0.29	0.85	298	5.93	288
8.	DhanulalKatre	6.30	0.28	0.83	287	3.49	269
9.	Beerendragautam	6.37	0.29	0.78	276	19.20	265
10.	BirramTembhre	6.06	0.25	0.85	298	4.19	249
Village – Chillod							
1.	TarachandMatre	6.06	0.18	0.40	180	7.68	273
2.	KishorGautam	5.98	0.23	0.67	251	7.68	327
3.	RajkumarRawde	6.46	0.26	0.84	294	5.93	311
4.	JaglalMatre	6.19	0.21	0.67	251	10.47	322
5.	SahajlalKawre	6.05	0.25	0.44	186	10.47	432
6.	GhosaramPatle	6.30	0.28	0.65	240	12.22	333
7.	SunitaBhautekar	6.14	0.21	0.62	229	3.84	336
8.	Sardar Singh Maskole	7.01	0.24	0.76	272	13.61	243
9.	MaltanPatle	6.17	0.27	0.82	285	15.01	245
10.	MaheshwariPancheshwar	6.50	0.23	0.83	287	6.98	449
Village – Landejhari							
1.	GulabSirsathe	6.08	0.37	0.84	294	11.52	244
2.	KhelchandBisen	6.27	0.24	0.65	240	5.58	267
3.	KhemlataSonekar	6.21	0.29	0.73	267	6.28	238
4.	ShivlalUike	6.18	0.19	0.84	294	7.33	237
5.	DasharamUike	6.02	0.28	0.72	266	5.58	245
6.	RooplalShende	6.50	0.27	0.85	298	14.31	235
7.	RavindNikuse	7.10	0.22	0.65	240	18.85	318
8.	RupendBisen	6.31	0.26	0.66	245	19.84	250
9.	Manish Katre	6.50	0.28	0.83	287	6.98	274
10.	DhanwantaChaudhari	6.66	0.25	0.59	218	3.49	260

Table 5. Human resource development components

HRD Components	Frequency	Beneficiaries
Training		
Soil Health Camp / Day	02	150
Field Day	06	130
Popular article / leaf let /Pamphlets	06	Mass
Training Handout /manuals/booklets	06	210
Kisan Mela	02	Mass

4. CONCLUSIONS

Trainings on soil health/quality and the events like field day are the effective medium to disseminate information on different agriculture technologies among farming communities with extension publications. Balanced and integrated nutrient management concept should improve the soil properties as well as increases production of rice crop during kharif season. Soil test values helps farmers to analyze the amount of fertilizers required for the particular crop during whole growth period. We experienced the gap between farmers-scientist before the Farmer FIRST Project for technology dissemination other extension activities. After implementation of the project this gap is merged and farmers benefited with the new technologies. Integrated nutrient management technology helps farmers to increase 47% rice yield over traditional system.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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