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., T₁ - 100% NPK + 2 t Vermicompost ha⁻¹, T₂ - 100% NPK, T₃ - 100% NPK (– S) and T₄ – Farmer's practice. Results indicated that the highest

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average yield of rice was achieved in the treatment T₄-100% NPK + Vermicompost. Whereas, lowest yield was recorded in T₁-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 vermicompost 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°C and 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°C. Monsoon season extends from mid-June to mid-September. The temperature during this period ranges from 25 to 35°C and the relative humidity ranges between 70 to 80%. The total annual rainfall varies from 1400 to 1500 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, Chilod 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., T₁ - 100% NPK + 2 t Vermicompost ha⁻¹, T₂ - 100% NPK, T₃ - 100% NPK (- S) and T₄- 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 P₂O₅ and 40 kg K₂O 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 K were applied as a basal dose at the time of sowing. Whereas, remaining 75% 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| T₁ - 100% NPK + 2 t Vermicompost ha⁻¹                                   |
|                                   | T₂ - 100% NPK                                                           |
|                                   | T₃ - 100% NPK (– S) and                                                |
|                                   | T₄ - Farmer’s practice                                                 |
| Production system                 | Rice – Rice or Rice – Fallow                                          |
| Thematic area                     | Integrated Nutrient Management                                        |
| Constants identified and feedback | Facilities for soil testing are not available at block level           |
| for research work                 | 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 + vermicompost 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

| Treatments | Name of Villages | Average |
|------------|-----------------|---------|
|            | Koppe 2018-19   | 2019-20 |
|            | Chiloud 2018-19 | 2019-20 |
|            | Lendejhari 2018 | 2019-20 |
| 100% NPK + Vermicompost | 48.8 | 49.5 | 47.9 | 46.8 | 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 2. Grain Yield of Rice (q ha\(^{-1}\))

| Treatments | Name of Villages | Average |
|------------|-----------------|---------|
|            | Koppe 2018-19   | 2019-20 |
|            | Chiloud 2018-19 | 2019-20 |
|            | Lendejhari 2018 | 2019-20 |
| Extension Gap | 23.4 | 23.4 | 23.8 | 23.8 | 20.5 | 20.4 | 22.6 |
| 100% NPK + Vermicompost | 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 |

### Table 3. Extension and technology gap

| Treatments | Name of Villages | Average |
|------------|-----------------|---------|
|            | Koppe 2018-19   | 2019-20 |
|            | Chiloud 2018-19 | 2019-20 |
|            | Lendejhari 2018 | 2019-20 |
| Technology Gap | 1.2 | 0.5 | 2.1 | 1.4 | 3.7 | 3.1 | 2.0 |
| 100% NPK + Vermicompost | 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/leaflets/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.     | chandnalalpatle | 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.     | SunilaBhautekar | 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 | 5.88  | 267 |
| 3.     | KhemlataSonekar   | 6.21 | 0.29 | 0.73 | 267 | 6.28  | 238 |
| 4.     | ShivilalUike     | 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 / leaflet / 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.

REFERENCES

1. Agrawal SB, Sharma DP, Bisen Rajani and Singh DK. Attitude and adoption of farmers to use of biofertilizer. Abstract, National Seminar on Innovative Extension Approaches for Enhancing Rural Household Income, dated 27-29 Sept. held at JNKVV, Jabalpur (M.P.). 2011:86.
2. Dwivedi BS, Sharma Abhishek, Dwivedi AK, Thakur RK. Response of Phosphorus Application on Productivity of Wheat at Farmer Field. Universal Journal of Agricultural Research. 2019;7(1):20-24.
3. Kumar Y, Singh SP, Singh VP. Effect of FYM and potassium on yield, nutrient uptake and economics of wheat in alluvial soil. Annals of Plant and Soil Research. 2015;17(1):100-103.
4. Muhr GR, Datta NP, Subaramany HS, Leley VK, Dunahue RL. Soil testing. India Asian Press. New Delhi; 1965.
5. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soil by extraction with sodium bicarbonate (NaHCO₃). U.S.D.A. Cir. 1954;939:1-19.
6. Sarvade S, Shrivastava AK, Rai SK, Bisen S, Bisen U, Bisen NK, Agrawal SB, Mohammad Imran Khan. Socio-economic study of farming communities, their knowledge on climate change and agroforestry systems in the cluster of villages of Chhattisgarh plain region, Madhya Pradesh. Journal of Pharmacognosy and Phytochemistry. 2020;9(1):2158-2166.
7. Sarvade S, Gautam DS, Kathal D, Prabhat Tiwari. Waterlogged wasteland treatment through agro-forestry: A review. Journal of Applied and Natural Science. 2017;9(1):44-50.
8. Sarvade S, Singh R. Role of agroforestry in food security. Popular Kheti. 2014;2(2):25-29.
9. Sarvade S, Mishra HS, Rajesh Kaushal, Sumit Chaturvedi, SalitTewari. Wheat (Triticum aestivum L.) yield and soil properties as influenced by different agrisilviculture systems of Terai Region, Northern India. International Journal of Bioresource and Stress Management. 2014;5(3):350-355.
10. Sawarkar SD, Thakur R, Khamparia RS. Impact of long term continuous use of inorganic and organic nutrients on micronutrients uptake by soybean in Vertisol. Journal of Soils and Crops. 2010;20(2):207-210.
11. Sharma GD, Thakur Risikesh, Chouhan Narendra, Keram KS. Effect of Integrated Nutrient Management on Yield, Nutrient Uptake, Protein Content, Soil Fertility and Economic Performance of Rice (Oryza sativa L.) in a Vertisol. Journal of the Indian Society of Soil Science. 2015;63(3):320-326.
12. Shrivastava AK, Sarvade S, Bisen NK, Brajkishor Prajapati, Agrawal SB, Pooja Goswami. Growth and yield of rabi season forage crops under Chhattisgarh Plain of Madhya Pradesh, India. Int. J. Curr. Microbiol. App. Sci. 2020;9(2):878-885.
13. Sontakki BS, Venkatesan P, Rao VKJ. Participatory Rural Appraisal-tools and techniques. ICAR-NAARM, Hyderabad. 2019;189.
14. Subbiah BV, Asija EC. A rapid procedure for estimation of available nitrogen in soil. Curr. Sci. 1956;25:259-260.
15. Thakur Risikesh, Sawarkar SD. Influence of long term continuous application of nutrients and spatial distribution of Sulphur on soybean-wheat cropping sequence. Journal of Soils and Crops. 2009;19:225–228.

16. Thakur RK, Sawarkar SD, Vaishya UK, Singh. Impact of continuous use of inorganic fertilizers and organic manure on soil properties and productivity under soybean-wheat intensive cropping of a Vertisol. J. Indian Soc. Soil Sci. 2011;59(1):74-81.

17. Thakur RK, Kauraw DL, Singh Muneshwar. Effect of continuous applications of nutrient inputs on spatial changes of soil physicochemical properties of a medium black soil. Journal of Soils and Crops. 2009;19(1):14-20.

18. Walkley A and Black IA. Estimation of soil organic carbon by the chromic acid titration method. Soil Sci. 1934;47:29-38.