Current Journal of Applied Science and Technology

21(6): 1-8, 2017; Article no.CJAST.33914
Previously known as British Journal of Applied Science & Technology
ISSN: 2231-0843, NLM ID: 101664541

Comparative Efficacy of Organic and Inorganic Sources of Nutrients in Paddy (*Oryza sativa* L.)

Saurav Sharma[1*], J. P. Saini[1], Ranu Pathania[1], Ashish Kumar[1] and Raghuveer Singh[2]

[1]Department of Organic Agriculture, CSKHPKV, Palampur-176062, Himachal Pradesh, India.
[2]ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut 250110, Uttar Pradesh, India.

Authors' contributions

This work was carried out in collaboration between all authors. Author SS designed the study, wrote the protocol and wrote the first draft of the manuscript. Author JPS guided and monitored the work. Authors RP and AK performed the statistical analysis, collected the review of literature. Author RS brought the manuscript in final mode by corrected and updated it. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2017/33914
Editor(s):
(1) Hamid El Bilali, Mediterranean Agronomic Institute of Bari (CIHEAM/IAMB), Sustainable Agriculture, Food & Rural Development department, Via Ceglie 9, 70010 Valenzano (Bari), Italy.
Reviewers:
(1) Ali Musa Bozdogan, Cukurova University, Turkey.
(2) Swapan Kumar Paul, Bangladesh Agricultural University, Bangladesh.
Complete Peer review History: http://www.sciencedomain.org/review-history/19698

Original Research Article

Received 3rd May 2017
Accepted 2nd June 2017
Published 25th June 2017

ABSTRACT

The experiment was conducted at the research farm of Department of Organic Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during *kharif* 2014 to study the comparative efficacy of organic and inorganic sources of nutrients in paddy. The experiment consisted of eight treatments comprising of combinations of four nutrient management treatments *viz.,* Organic nutrient management (soil treatment with jeevamrit & seed treatment with biofertilizer, vermicompost (VC) 10 t ha^{-1} & 3 sprays of vermiwash at 15, 30, 45 days after sowing), Inorganic nutrient management (recommended NPK), Integrated nutrient management (5 tonnes VC + 50% of recommended NPK), Control (Farmer's practices) (2.5 tonnes VC + 25% of recommended NPK) with two ecosystems *i.e* transplanted and direct seeded rice (rainfed) were tested in split plot design, replicated thrice. Growth, yield attributes, grain and straw yield of rice was increased in transplanted

**Corresponding author: E-mail: sauravsharma416@gmail.com;*

ecosystem and integrated nutrient management practice. The transplanted ecosystem recorded 18.64 per cent higher yield and 50.60 per cent higher net return per rupee invested over direct seeded rainfed ecosystem. Integrated nutrient management being statistically at par with organic nutrient management recorded the higher paddy yield over inorganic nutrient management and farmer's practice. Integrated nutrient management recorded higher net returns per rupee invested (1.18) but remain statistically at par with organic nutrient management and inorganic nutrient management.

Keywords: Organic; transplanted rice; direct seeded rice; integrated nutrient management.

1. INTRODUCTION

Rice forms staple food for more than half of the world population. Globally, it occupied an area of 164.3 m ha with a production of 744.9 m t of paddy [1]. In India, rice is the most important and extensively grown food crop, occupied 42.81 m ha of land and produced 143.96 m t paddy (95.97 million tonnes rice)[2].

During the Green Revolution period (mid-1960s), a phenomenal yield increase was observed with a corresponding increase in net cultivable area, realization of high yield with short-duration, nutrient and irrigation responsive, high yielding varieties. The post-green revolution period, however, showed a decline in yield trend, mostly because of imbalanced use of fertilizers and pesticides. These led to yield stagnation, causing concern about the future potential for productivity growth and long-term sustainability [3]. However, it is now realized that in fields under intensive monoculture which receive heavy applications of chemical fertilizers alone, there is a decline in productivity. This decline occurs even in irrigated paddy fields [4]. Excessive fertilizer application may lead to wastage of nutrients and reduction in yield and quality of crop [5].

The concerns such as declining productivity of land, depletion of soil organic carbon and mineral nutrients, water logging, salinization and increasing nitrate concentration in well water are the main consequents of the modern rice-wheat production system with its unbalanced and injudicious use of chemical fertilizers and pesticides [6]. In view of these facts organic nutrient management has significant role in improving productivity of crop and soil fertility. The organic farming today is not traditional agriculture. The principles governing organic farming are more scientific than even the principles followed in modern agriculture. Organic manures provide regulated supply of N by releasing it slowly resulting in increased yields of rice and nutrient use efficiency [7]. Crop residues have potential for improving soil and water conservation, sustaining soil productivity and enhancing crop yields [8]. Alternate sources of soil fertility build up through renewable sources like bio-fertilizer also play an important role in improving the nutrient supply capacity for achieving higher yield of rice under organic nutrient management and maintain soil health besides providing non-polluting environment.

India has a tremendous potential to become a major exporter of organic rice in the international market. Since, the quantitative information about the advantages of organic manures in rice is lacking. The present study carried out to compare the impact of organic and inorganic nutrients sources on the paddy productivity and soil health.

2. MATERIALS AND METHODS

A field experiment was conducted at Holta organic farm, Department of Organic Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during *Kharif* 2014. The soil was moderately acidic (pH 5.45), high in organic C (1.09 %), low in available nitrogen (152.50 kg ha^{-1}) and medium in phosphorus (18.74 kg ha^{-1}) and available potassium (196.00 kg ha^{-1}). During the rice crop seasons (June to September, *kharif* 2014), the crop experienced well distributed rainfall of 1334 mm in 154 days. Prior to the commencement of the present study, the field was under rice (*kharif* 2013) – wheat (*rabi* 2013-14) cropping.

Treatments consisted of combinations of two ecosystems in main plots viz. Transplanted paddy and Direct seeded rice (rainfed) and four nutrients management in sub plots viz. Organic nutrient management (soil treatment with jeevamrit & seed treatment with biofertilizer, vermicompost (VC) 10 tha^{-1} & 3 sprays of vermiwash (liquid organic manure) at 15, 30, 45 days after sowing, Inorganic nutrient management (recommended NPK), Integrated nutrient management (VC 5 tones + 50% of recommended NPK) and Control (Farmer's practices) (VC 2.5 tones + 25% of recommended NPK) was laid out in split plot design with three replications to examine the effect of organic and inorganic sources of nutrients on rice. In organically managed plots, soil was drenched with jeevamrit after dilution with water in the ratio 1:10 before sowing of crop. Organically produced seeds of 'RP 2421' variety of rice was used, sowing was done keeping spacing of 20 cm between two rows in direct seeded rainfed ecosystem and 12 days old seedlings were transplanted with 20 × 20 cm spacing in row to row and plant to plant in transplanted ecosystem. Seed rate of 80 kg ha^{-1} in direct seeded ecosystem and 8 kg ha^{-1} for nursery raising in transplanted ecosystem was used. Prior to sowing seeds of rice as per treatment were inoculated with *Azospirillum* + Phosphate Solubilising Bacteria culture. The vermicompost was incorporated in soil at the time of sowing of crop as per the treatment with nutrient composition of 1.5 per cent nitrogen, 1 per cent phosphorus and 0.60 per cent potassium. Foliar application of vermiwash was done as per the treatment. Vermiwash was sprayed after dilution (1:10) with water at 15, 30, 45 Days after sowing/ transplanting. In inorganically managed plots recommended dose of NPK used was 90 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1} in transplanted ecosystem and 50 kg N, 25 kg P_2O_5 and 25 kg K_2O ha^{-1} in direct seeded ecosystem, respectively. Half dose of nitrogen and whole P_2O_5 and K_2O were incorporated in soil as per the treatment as basal dose and remaining half of the nitrogen was top dressed through urea in two equal splits each at tillering and panicle initiation stages of rice.

Plot-wise composite soil samples from 0 to 15 cm depth were collected with the help of tube auger before the start and after the completion of the crop cycle. The soil samples were air dried, processed and analyzed for different chemical properties *viz.* pH, organic carbon (OC), available N, P, and K following standard methods [9,10,11,12,13]. The nutrient uptake was calculated by multiplying per cent concentration of a particular nutrient with crop yields. The uptake of the nutrients obtained in respect of each component crop was summed up to compute the amount of total nutrient removed by each crop sequence. Plant samples were analyzed for nutrient uptake viz. Total N, P and K following standard methods [9,13]. Economics of the crop sequences was computed based upon the prevailing prices of inputs used and the output realised. The cost of cultivation of different crops individually and for crop sequences were calculated. The yields of different crops in various crop sequences were converted into gross returns in rupees. Further, net returns and B: C (Benefit cost) ratio was also calculated as per the formulae given below:

Net Returns per rupee invested = Net returns (Rs ha^{-1})/ Cost of cultivation (Rs ha^{-1})

Net returns (Rs ha^{-1}) = Gross returns (Rs ha^{-1}) – Cost of cultivation of crop (Rs ha^{-1})

The data recorded on various parameters were subjected to statistical analysis, following analysis of variance technique as described by [14,15] and were tested at 5 per cent level of significance to interpret the significant differences.

3. RESULTS AND DISCUSSION

3.1 Grain Yield

With regard to ecosystems, rice crop in transplanted ecosystem produced significantly higher grain yield as compared to direct seeded (rainfed). Among nutrient management treatments, integrated nutrient management being at par with organic produced significantly higher grain yield as compared to other treatments. Farmer's practice produced significantly lowest grain yield over all other treatments. Integrated and organic nutrient management treatments produced 41.84 and 35.07 per cent more grain yield over farmer's practice, respectively (Table 1). All the nutrient treatment in direct seeded rainfed condition recorded significantly higher yield over farmer choice but with in treatment no difference recorded. Over all integrated nutrient management in irrigated recorded highest yield (5.41 t ha-1) followed by organic treatment (4.87 t ha-1) which was significantly higher yield over inorganic and farmer choice in irrigated ecosystem (Table 2). Higher growth due to integrated and organic nutrient management owing to improvement in physical, chemical and biological properties resulted in higher assimilation area and more leaf area duration, better nutrient supply and better translocation of photosynthates to storage organs might have improved the yield attributes and ultimately grain yield. Moreover, organics besides supplying macro and micronutrient also have solubilizing effect on native soil nutrients due to the action of organic acids produced during decomposition. These results are in conformity with earlier findings of [16,17].

3.2 Straw Yield

The rice crop in transplanted ecosystem produce significantly higher straw yield as compared to direct seeded (rainfed). Among nutrient management, statistically identical straw yield was obtained from integrated and organic treatments which were significantly higher than the remaining treatments. On the other hand, the lowest straw yield was obtained from farmer's practice. Similar results also reported by [18].

Interaction effect treatments *viz.,* main ecosystem and nutrient management were found to be significant with respect to grain yield of paddy. The interaction between different treatments in direct seeded paddy was found to be significant over farmer's practice. In case of transplanted paddy all the treatments were found to be significantly different from each other, yet, the yield was found to be significantly higher in integrated treatment. Yield from organic treatment was observed to be significantly higher than inorganic and farmer's practice.

3.3 Soil pH

Soil pH and organic carbon was not significantly influenced by ecosystems and different nutrient management treatments. However, the results indicated that numerical values for soil pH increased from the initial value in organic and farmer's practice. In inorganic fertilized plots there was negligible change in soil pH in comparison to initial value.

Increase in value of soil pH, in general, with the application of organic might be because of quick release of K^+ from organic fertilizer and also the buffering property of organics when added to acidic soils [17,19] reported decline in soil pH in NPK treated plots as compared to organically treated over a long period of time. Also, decline in pH due to the application of chemical fertilizers alone could be attributed to the acid producing nature of nitrogenous fertilizers [20] which upon nitrification release H^+ ions which are potential source of soil acidity. However, marginal increase in soil pH was observed in some treatments involving conjoint use of organic manures and chemical fertilizers might be due to moderating effect of organic manures as it decreases the activity of exchangeable Al^{3+} ions in soil solution due to chelation effect of organic molecules. Similar results have also been reported by [21,22,23].

3.4 Organic Carbon

Organic carbon in soil was increased slightly but not significantly from initial level of 0.83 per cent to about 0.96 per cent after harvest (Table 1) Integrated use of organic manures and chemical fertilizers significantly improved the soil organic matter [24]. Whereas, experiment conducted by [25,26] found that organic carbon status of soil was not influenced significantly by organic fertilizer application. But a slight increase in organic carbon content of soil was observed over its initial value with the addition of organic manures.

3.5 Available Nitrogen, Phosphorous and Potassium

Different ecosystems were not able to significantly influence the nitrogen, phosphorus and potassium in soil but these were significantly influenced by different nutrient management practices. All the plots which received organics along with chemical fertilizers had a positive response on chemical properties of soil [27].

Available N, P and K were significantly higher in inorganic treatment as compared to other treatments. Although organic treatment is also having significantly higher value of nitrogen and potassium as compared to farmer's practice. Different researchers also found significant improvement in available N, P and K status of soil in chemical fertilized treatments over control [28,29]. Further, Kumar and Singh [30] have reported increased available nitrogen status of soil over control on application of organic manures in rice. Such increase in the content of available nutrients with the use of organics with chemical fertilizers has also been reported by [22,26,31].

Table 1. Effect of treatments on yield, soil properties and economics of paddy

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	pH	Organic Carbon (%)	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net returns (Rs ha^{-1})	Net returns per rupee invested
Ecosystem										
Transplanted	4.40	6.47	5.32	0.95	283.6	18.5	257.6	30182	38475	1.25
Direct seeded	3.71	5.54	5.26	0.93	297.1	19.4	249.3	31720	26220	0.83
CD (P=0.05)	0.39	0.26	NS	NS	NS	NS	NS	-	5245	0.18
Nutrient management										
Organic	4.39	6.54	5.34	0.96	280.7	18.4	249.8	36665	39782	1.09
Inorganic	3.96	5.88	5.26	0.93	328.2	21.4	281.1	28395	30736	1.08
Integrated	4.61	6.81	5.27	0.94	295.8	19.7	260.1	31733	37161	1.18
Farmer's Practice	3.25	4.86	5.30	0.92	256.8	16.3	222.9	27011	21710	0.80
CD (P=0.05)	0.25	0.33	NS	NS	24.2	2.5	20.7	-	3696	0.12

Table 2. Interaction effect of treatments on grain yield (t ha-1) of paddy

Nutrient management	Main ecosystems	
	Direct seeded	**Transplanted**
Organic	3.90	4.87
Inorganic	3.82	4.10
Integrated	3.80	5.41
Farmer's practice	3.30	3.20
To compare nutrient management practices at same ecosystem		0.35
To compare ecosystem at same or different nutrient management practices		0.47

3.6 Cost of Cultivation

The maximum cost of cultivation (Rs. 31720 ha^{-1}) was incurred in direct seeded ecosystem as compared with transplanted (Rs. 30182 ha^{-1}). Among nutrient management treatments, maximum cost of cultivation (Rs. 36665 ha^{-1}) was involved with organic treatment because of the more cost of organic sources of nutrients and were followed by integrated (Rs. 31733 ha^{-1}), inorganic (Rs. 28395 ha^{-1}) and control (Rs. 27011 ha^{-1})

3.7 Net Returns

Net returns were significantly highest (Rs. 38475 ha^{-1}) in transplanted ecosystem as compared with the direct seeded (Rs. 26220 ha^{-1}). Among different nutrient management treatments, organic treatment recorded significantly higher net returns of Rs. 39782 ha^{-1} as compared with inorganic (Rs. 30736 ha^{-1}) and control (Rs. 21710 ha^{-1}). However, it was at par with integrated (Rs. 37161 ha^{-1}). These findings are in conformity with [32], they concluded that net returns was significantly higher under organic fertilization compared with inorganic fertilization.

3.8 Net Returns per Rupee Invested

With regard to ecosystems, transplanted paddy resulted in significantly higher net returns per rupee invested (1.25) over direct seeded (0.83). Among nutrient management treatments, integrated nutrient management treatment has recorded significantly higher net returns per rupee invested (1.18) over control (0.80) but it was statistically at par with organic (1.09) and inorganic (1.09) Table 1. These results were in accordance with [9] where they reported that the highest B:C ratio was obtained with Integrated nutrient management treatment over farmer's practice.

4. CONCLUSIONS

Transplanted ecosystem in organic (soil treatment with jeevamrit, seed treatment with *Azospirillum* + PSB, vermicompost 10 tonnes ha^{-1} and 3 sprays of vermiwash) and integrated nutrient management (VC 5 tonnes ha^{-1} + 50% recommended NPK) practices in paddy cultivation proved to be significantly better for recording higher values for different growth parameters, yield attributes and resulted in significantly higher yield which had finally led to higher net returns per rupees invested in these approaches.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous. Monthly updates of selected rice export prices are available on the FAO Rice Price; 2014. Available:http://www.fao.org/economic/RPU (Accessed 11th April, 2014)
2. FAO. Food and Agriculture Organization of the Unit-ed Nations; 2014. Available:http://FAOSTAT.fao.org (Accessed 18 April, 2014)
3. Gill MS, Pal SS, Ahlawat IPS. Approaches for sustainability of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system in Indo-Gangetic plains of India. Indian Journal of Agronomy. 2008;53(2):81-96.
4. Siavoshi M, Nasiri A, Laware SL. Effect of organic fertilizer on growth and yield components in rice. Journal of Agricultural Science. 2011;3(3):217-224.
5. Wang CH. Effects of different organic materials on crop production under a rice–corn cropping sequence. Communications in Soil Science and Plant Analysis. 2013;44:2987-3005.
6. Ram M, Davari MR, Sharma SN. Direct residual and cumulative effects of organic manures and biofertilizers on yields, NPK uptake, grain quality and economics of wheat (*Triticum aestivum* L.) under organic farming of rice-wheat cropping system. Journal of Organic Systems. 2014;9(1):24-30.
7. Sharma SK, Sharma SN. Integrated nutrient management for sustainability of rice-wheat cropping system. Indian Journal of Agricultural Sciences. 2002;72:573-576.
8. Dass A, Sudhishri S, Lenka NK. Integrated nutrient management in Eastern Ghasts of Orissa. Oryza. 2009;46(3):220-226.
9. Jackson ML. Soil chemical analysis (II Edn.) Prentice Hall of India Private Limited, New Delhi. 1967;798.
10. Walkley A, Black CA. An estimation of the method for determination of soil organic

matter and a proposed modification of chromic acid titration method. Soil Science. 1934;37:29-39.
11. Subbiah BV, Asija CL. A rapid procedure for the estimation of available nitrogen in soil. Current Science. 1956;25:258-260.
12. Olsen SR, Cole CV, Watanbe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular. 1954;939:19-33.
13. Black CA. Methods of soil analysis Part-I, American Society of Agronomy, Madison, Wisconsin, USA; 1965.
14. Gomez KA, Gomez AA. Statistical procedures for agricultural research (second ed.) John Willey & Sons, Inc., New York, USA;1976.
15. Nigam AK, Gupta VK. Handbook on analysis of agricultural experiments. IASRI publication, New Delhi, India; 1979.
16. Chaudhary SK, Singh JP, Jha S. Effect of integrated nitrogen management on yield, quality and nutrient uptake of rice (*Oryza sativa*) under different dates of planting. Indian Journal of Agronomy. 2011;56(3): 228-231.
17. Ghosh A. Comparative study on combined and individual effects of farmyard manure and green-manuring with fertilizer N on growth and yield of rice (*Oryza sativa*) under submergence-prone situation. Indian Journal of Agronomy. 2007;52(1):43-45.
18. Hossaen MA, Shamsuddoha ATM, Paul AK, Bhuiyan MSI, Zobaer ASM. Efficacy of different organic manures and inorganic fertilizer on the yield and yield attributes of boro rice. The Agriculturists. 2011;9(2): 117-125.
19. Lund ZF, Doss BD. Residual effects of dairy cattle manure on plant growth and soil properties. Agronomy Journal. 1980;72:123-130.
20. Magdoff F, Lanyon L, Liebhardt B. Nutrient cycling, transformations and flows: Implications for a more sustainable agriculture. Advances in Agronomy. 1997; 60:1-73.
21. Sharma S. Studies on nutrient dynamics on soil-plant in a long-term Lantana amended rice-wheat sequence. Ph D Thesis. Department of Soil Science, Himachal Pradesh Krishi Vishvavidyalaya, Palampur, India; 2004.
22. Gupta V, Sharma RS, Vishvakarma SK. Long-term effect of integrated nutrient management on yield sustainability and soil fertility of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. Indian Journal of Agronomy. 2006;51(3): 160-164.
23. Urkurkar JS, Tiwari A, Shrikant C, Bajpai RK. Influence of long-term use of inorganic and organic manures on soil fertility and sustainable productivity of rice (*Oryza sativa*) and wheat (*Triticum aestivum*) in Inceptisols. Indian Journal of Agricultural Sciences. 2010;80(3):208-212.
24. Kumar A, Yadav DS. Use of organic manure and fertilizer in rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system for sustainability. Indian Journal of Agricultural Sciences. 1995;65(10):703-707.
25. Chettri GB, Ghimirary M, Floyd CN. Effects of farmyard manure, fertilizers and green manuring in rice-wheat systems in Bhutan: Results from a long term experiment. Experimental Agriculture 2003;39(2):129-144.
26. Singh YV, Singh BV, Pabbi S, Singh PK. Impact of organic farming on yield and quality of basmati rice and soil properties. Paper presented at Zwischen Tradition and Globaliserung-9 Wissenchaftsagung Okologischer Landbau, Universitat Hohenheim, Stuttgart, Deutschland, Germany; 2007.
27. Chaudhary SK, Thakur RB. Efficient farmyard management for sustained productivity of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. Indian Journal of Agricultural Sciences. 2007;77(7):443-444.
28. Kumar R, Singh G, Walia SS. Long term effect of manures and fertilizers on rice yield and soil fertility status in rice-wheat system. Environment and Ecology. 2000; 18(3):546-549.
29. Yadav MP, Aslam M, Kushwaha SP. Effect of integrated nutrient management on rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system in central plains zone of Uttar Pradesh. Indian Journal of Agronomy. 2005;50(2):89-93.
30. Kumar SD, Singh HJ. Comparative studies on organic fertilizers and chemical fertilizers with tall scented rice in rice-wheat sequence. Haryana Agricultural University Journal of Research. 1997; 29(1-2):7-10.

31. Hegde DM. Integrated nutrient management effect on rice (*Oryza sativa*)-wheat (*Triticum aestivum*) system productivity in sub humid ecosystem. Indian Journal of Agricultural Sciences. 1998;68(3):144-148.

32. Yadav BK, Christopher LA. Effect of organic manures and panchagavya spray on yield attributes, yield and economics of rice (*Oryza sativa* L).. Crop Research 2006;31(1):1-5.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/19698