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Unearthing the Impact of Diverse Nutrient Sources on Soil Quality in Transplanted Rice in Eastern U.P., India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Agronomy Research Farm, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.) during Kharif season 2022 to assess the effect of different nutrient sources on physico-chemical properties of randomized block design and replicated three times with seven treatment combinations in rice crop. The treatment combinations were **T_1:-**Control, **T_2:-**100% RDF, **T_3:-**75% RDF + 25% N through Vermicompost+ Jeevamrit application at 30 DAT (Days after transplanting),**T_4:-**75% RDF+25%N through FYM+ Jeevamrit application at 30 DAT, **T_5:-** 50% RDF+50% N through Vermicompost + Jeevamrit application at 45

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DAT, **T_6:-**50% RDF+50%N through FYM + Jeevamrit application at 45 DAT and **T_7:-**50% RDF+25% N through Vermicompost +25% N through FYM + Jeevamrit application 30 and 45 DAT. Rice variety NDR- 2065 was taken as test crop. After harvesting soil was tested for physico- chemical parameters, according to which T_5 showed maximum available nitrogen, phosphorus and potassium, in a similar way T_5 also showed improved E.C., pH, organic carbon as well as bulk density and particle density.

Keywords: Rice; Jeevamrit; vermicompost; FYM and soil properties.

1. INTRODUCTION

Intensive farming methods that rely heavily on agrochemicals have contaminated land, water, and the environment, negatively impacting human health. In response, alternative farming systems, particularly organic agriculture, are gaining traction due to concerns over environmental sustainability, safe food, and resource conservation. The overuse of chemical fertilizers poses risks, including high costs, depletion of non-renewable energy, and negative effects on soil health and human safety. Chemical fertilizer inputs used carelessly and unevenly have risky impacts on soil health and occasionally end up in the food chain, endangering human health (Karmakar et al., 2013). Several nutrient management options have been practiced by the farmers, however, the best one is an integration of organic and inorganic sources. It is widely recognized that neither use of organic manures alone nor chemical fertilizers can achieve the yield sustainability under the modern intensive farming (Kumar et al. 2014). The combined use of vermicompost and chemical fertilizers help in keeping up yield stability through correction of minimal lacks of auxiliary and micronutrients, improving effectiveness of connected supplements and providing favorable soil physical conditions (Gill and Walia, 2014) Therefore, it is necessary to use organic manures in conjunction with fertilizers to meet nutrient requirement and obtain optimum yields. Inorganic fertilizers can improve soil health and promote higher rice growth and productivity when used in conjunction with organic sources like FYM and vermicompost (Ram et al., 2020). In order to reduce the need for chemical inputs while maintaining yields, organic inputs and bio-inoculants are combined (Giraddi, 2000). The main ingredients used to make several fermented organic inputs, including panchagavya, jeevamrit, beejamrit, and vermiwash, include cow dung, urine, pulse flour, jaggery, living soil, and extracts of nearby plants (Kulkarni and Gargelwar, 2019). Application of jeevamrit improves soil fertility while also enhancing microbial activity in the soil (Aulakh et al*.,* 2018). Utilizing liquid manures effectively promotes crop development and yields while improving the cycling of nutrients. Manjunatha et al. (2009) reported that the application of jeevamrit increased the activity of microbes by solubilization and also enhanced nutrient uptake. The use of liquid manures increases microbial activity in the soil, improving soil fertility and supplying sufficient amounts of nutrients for crop growth and pest control (Joshi, 2012). Despite the fact that these manures may not directly add nutrients to the soil where they are applied, they do speed up the activity of soil microbes, which helps to preserve the soil's fertility (Yadav and Mowade, 2004).

2. MATERIALS AND METHODS

The experiments were conducted at Agronomy Farm of the Acharya Narendra Deva University of Agriculture and Technology in Kumarganj, Ayodhya, which is located in the subtropical Indo Gangetic Plains climate zone at 26.470 N latitude, 82.120 E longitude, and an elevation of 113 meters above mean sea level.

The treatment combinations were **T_1 (**Control), **T_2 (**100% Recommended dose of fertilizer), **T_3 (**75% RDF + 25% N through Vermicompost+ Jeevamrit application at 30 Days after transplanting (DAT)),**T_4 (**75% RDF+25%N through Farm yard manure(FYM)+ Jeevamrit application at 30 DAT, **T_5 (**50% RDF+50% N through Vermicompost + Jeevamrit application at 45 DAT, **T_6 (**50% RDF+50%N through FYM + Jeevamrit application at 45 DAT) and **T_7 (**50% RDF+25% N through Vermicompost +25% N through FYM + Jeevamrit application 30 and 45 DAT). The rate of 100 % Recommended dose of fertilizer (RDF) is 150:60:40 NPK kg ha^{-1}.

Soil sampling randomly drawn from each replicated plot after, harvesting of crop. Collected samples were brought to the laboratory, air dried, grind and passed through 30 mesh sieve and representative sample were collected in polythene bag. The physico-chemical properties were analyzed.

Initial value of soil properties viz. Particle density, Bulk density, Soil pH, EC, organic C, available N, P, and K are 2.67 (Mg m^{-3}), 1.35 (Mg m^{-3}), 8.3, 0.23 (dsm^{-1}), 3.65%, 183.14 (Kg ha^{-1}), 12.15 (Kg ha^{-1}), 240.78(Kg ha^{-1}) respectively determined from the processed samples for each treatment as per the standard methods. Physico-chemical study of soil before and after harvesting of crop. Initial values of soil properties has been mentioned above.

Data collected were subjected to statistical analysis by using a computer program OPSTAT. Least Significant Difference test (LSD) at 5% probability level was applied to compare the differences among treatments means.

3. RESULT AND DISCUSSION

3.1 Physical Analysis

3.1.1 Bulk Density (BD)

The data for bulk density (Mg m^{-3}) in Table 1, showed that the treatment with the highest bulk density was T_1 (1.35) (control), which did not differ significantly from the other treatments. T_5 (1.31) had the lowest bulk density throughout the investigation. Due to the stabilization of the soil structure brought about by the addition of organic manure in the form of vermicompost, changes in bulk density have been noticed. The findings are very similar to those published by Kumar et al. (2022), Kashem et al., (2015) and Koushal et al. (2011).

3.1.2 Particle Density (PD)

The data for particle density (Mg m^{-3}) shown in Table 1, showed that the rice field in T_1 (control) had the maximum particle density after harvest (2.71), while T_5 (2.62) and T_7 (2.62) had the lowest particle density. The findings are very similar to those published by Koushal et al. (2011) and Kashem et al., (2015).

3.1.3 Soil pH

Table 2, data on pH showed that the highest pH was found in the T_1 (8.3) (Control) and the lowest pH was found in the T_5(8.2). In comparison to applying chemical fertilizer alone, applying it along with manures marginally lowered the pH of the soil. The generation of organic acids during the breakdown of manures may be responsible for the pH drop. Sharma et al. (2022), Kaur et al. (2004), and Kumar et al. (2022) have all reported similar findings.

3.1.4 Electrical Conductivity (EC)

According to the data on E.C. (Electrical Conductivity dsm^{-1}) shown in Table 2, the rice field with the greatest E.C. after harvesting was T_1 (0.35) (Control), which was statistically equal to T_2 (0.34) and significantly higher than T_3 (0.25). T_5 (0.21) had the lowest electrical conductivity throughout the investigation. Koushal et al. (2011), Kumar et al. (2022), and Sharma et al. (2022) have all found similar findings.

3.1.5 Organic carbon (%)

Examining the information in Table 2, showed that the soil's organic carbon content rose from 0.24% to 0.35%. The treatments T_5 had the highest value of organic carbon (0.35%), which was statistically comparable to T_7. However, compared to its initial value before 25% of the nitrogen in control and T_2 was replaced with manures, the content of organic carbon dropped. The soil's organic carbon content increased as the amount of nitrogen added by organic sources such FYM, vermicompost, and jeevamrit increased. It might be related to the organic source's sluggish degradation and the increased microbial activity in the soil. Vermicompost and FYM treatments differ in their organic carbon contents, which may be the cause of the variance. Umesha et al. (2011) concluded that organic matters caused better physical, chemical and biological function, which provided carbon as an energy source to soil microbial resulting in enhanced plant growth and yield. Additionally, Kaur et al. (2004), Kumar et al. (2022), Koushal et al. (2011), Zaman et al. (2018) and Sharma et al. (2022) observed similar findings.

3.1.6 Available N

Analyzing the information in Table 3, showed that all of the treatments had significantly higher accessible N contents than the control. The treatment T_5 had the highest observed available N content (155.6 kg ha^{-1}), which was statistically comparable to T_7's (153.1 kg ha^{-1}), and much better than the other treatments. The control had the lowest level (135.56 kg ha^{-1}). The treatment where nitrogen was applied by substituting vermicompost for 50% of the inorganic fertilizer showed the highest levels of accessible N.

Table 1. Effect of different nutrient sources on Bulk density and Particle density in soil after harvest

S. No.	Treatments	Bulk Density (Mg m^{-3})	Particle density (Mg m^{-3})
1	T_1 – Control	1.35	2.71
2	T_2 - 100% R.D. F	1.34	2.67
3	T_3 - 75% R.D.F + 25% N through Vermicompost+ Jeevamrit application at 30 DAT	1.32	2.64
4	T_4 - 75% R.D.F. +25%N through FYM+ Jeevamrit application at 30 DAT	1.32	2.64
5	T_5 - 50% R.D.F.+50% N through Vermicompost + Jeevamrit application at 45 DAT	1.31	2.62
6	T_6 - 50% R.D.F.+50%N through FYM + Jeevamrit application at 45 DAT	1.31	2.62
7	T_7 - 50% R.D.F. + 25% N through Vermicompost +25% N through FYM + Jeevamrit application 30 and 45 DAT	1.31	2.62
CD at 5%		NS	NS
SEm±		0.029	0.035

Table 2. Effect of different nutrient sources on pH, EC (dsm^{-1}) and organic carbon (%) in soil after harvest

S. No.	Treatments	pH	Electrical Conductivity (dsm^{-1})	Organic carbon (%)
1	T_1 – Control	8.30	0.35	0.24
2	T_2 - 100% R.D. F	8.24	0.34	0.28
3	T_3 - 75% R.D.F + 25% N through Vermicompost+ Jeevamrit application at 30 DAT	8.23	0.25	0.32
4	T_4 - 75% R.D.F. +25%N through FYM+ Jeevamrit application at 30 DAT	8.22	0.25	0.31
5	T_5 - 50% R.D.F.+50% N through Vermicompost + Jeevamrit application at 45 DAT	8.20	0.21	0.35
6	T_6 - 50% R.D.F.+50%N through FYM + Jeevamrit application at 45 DAT	8.20	0.23	0.32
7	T_7 - 50% R.D.F. + 25% N through Vermicompost +25% N through FYM + Jeevamrit application30 and 45 DAT	8.20	0.22	0.35
CD at 5%		NS	0.013	0.013
SEm±		0.173	0.004	0.004

Table 3. Effect of different nutrient sources on Available Nitrogen, Phosphorus and potassium in soil after harvest

S. No.	Treatments	Nutrient available in soil (kg ha^{-1})		
		N	P	K
1	T_1 – Control	135.56	12.34	250.54
2	T_2 - 100% R.D.F	141.70	14.15	257.33
3	T_3 - 75% R.D.F + 25% N through Vermicompost + Jeevamrit application at 30 DAT	144.30	15.01	264.60
4	T_4 - 75% R.D.F. +25%N through FYM+ Jeevamrit application at 30 DAT	143.70	14.68	260.69
5	T_5 - 50% R.D.F.+50% N through Vermicompost + Jeevamrit application at 45 DAT	155.60	16.99	280.35
6	T_6 - 50% R.D.F.+50%N through FYM +Jeevamrit application at 45 DAT	145.90	15.37	265.90
7	T_7 - 50% R.D.F. + 25% N through Vermicompost +25% N through FYM + Jeevamrit application at 30 and 45 DAT	153.10	16.45	275.40
CD at 5%		8.817	0.788	9.721
SEm±		2.83	0.253	3.120

Vermicompost has the capacity to supply nutrients more quickly than FYM, and it aids in the transformation of unavailable forms of nitrogen into available forms. It may be explained by the fact that the addition of organic manure increases the availability of organic matter to microorganisms, which leads to an increase in the activity of soil enzymes and microorganisms, increasing the amount of nitrogen (N) that is available in the soil. As more nitrogen was applied using organic sources, N became more readily available. It might be explained by the organic manure's sluggish breakdown and the plants' reduced absorption. Due of its gradual nutrient release pattern and lower nutritional content as compared to other organic manures, FYM may have a poor nitrogen availability. Kaur et al. (2004), Kumar et al. (2022), and Koushal et al. (2011) have reported similar findings.

3.1.7 Available P

Critical observation of the data of Table 3, revealed that there was a significant increase in the available P content in all the treatments as compared to the control. Except for the control, all of the treatments had higher available P content than their original values. The treatment T_5 had the highest available P content value (16.99 kg ha^{-1}), which was statistically comparable to T_7's (16.45 kg ha^{-1}), and the control had the lowest value (12.34 kg ha^{-1}). It may be caused by the creation of organic acid under the simultaneous application of organic and inorganic sources, the mineralization of soil organic matter, and the solubilizing action of acids created during respirations. These factors may boost the availability of nutrients. Due to low phosphorus use efficiency, the majority of applied phosphorus is fixed in the soil, although over time, a little amount is made accessible for use by plants. By covering sesquioxide molecules and rendering them inactive, the organic matter created by the breakdown of organic manures lowers the soil's capacity to fix phosphate, which ultimately aids in the release of a significant amount of phosphorus. Native P is also made more soluble by the organic acids and CO_2 created during the breakdown of organic material. Both Kumar et al*.* (2022) and Koushal et al*.* (2011) observed similar findings.

3.1.8 Available K

A further examination of the data of Table 3 follows similar pattern as like previous showed that all of the treatments had significantly higher levels of accessible K than the control. The T_1 (control) group had the lowest amount of available K (250.54 kg ha^{-1}). The treatment T_5 had the highest concentration of accessible K (280.35 kg ha^{-1}), which was statistically comparable to treatment T_7's (275.4). By reducing potassium fixation, releasing potassium due to the interaction of organic matter with clay, and adding directly to the pool of accessible potassium in the soil, potassium availability increased after the application of organic manure. Koushal et al. (2011) and Kumar et al. (2022) also reported results that were similar.

4. CONCLUSION

On the basis of the current analysis, it can be deduced that organic sources had a significant impact on the soil's nutritional status after the crop was harvested. Vermicompost provided more residual major nutrients than FYM, and both organic sources improved the soil's physical characteristics, reducing the soil's bulk density and particle density. In addition to these advantages, organic sources also increased the soil's organic carbon content and biological activity. Therefore, it can be inferred that regular application of a combination of inorganic and organic nutrient sources enhances soil physical and biological features as well as soil nutrient status.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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