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Effect of Different Rice-based Cropping System on Available Nutrient of Soil under Various Nutrient Management Practices

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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

The present investigation was conducted during two consecutive year of 2019-20 and 2020-21 entitled effect of rice-based cropping system on available nutrient like N_2o, P_2o_5 and K_2o of soil under various nutrient management sources. The maximum available nutrient (273.95, 14.10, 296.86 kg ha-1NPK) was found in 100% organically based nutrient management practices than after 75% organic nutrient management followed by rest of treatments respectively. The available nutrient of soil was slightly changed by nutrient management practices, whereas available NPK was found not significant under rice-based cropping systems. During the research work, available nutrient gradually changed by initial status value but it was not significantly affected by rice-based cropping system.

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Keywords: Cropping system; available nutrient; productivity; NPK and INM.

1. INTRODUCTION

"The rice-wheat cropping system is considered as the backbone for food grain security. The use of inorganic fertilizer to sustain cropping was found to increase yield only for some few years but on long-term, it has not be effective and leads to soil degradation" (Satyanarayana et al., 2002). According to (Jat et al.,2014) for "India's food security and the livelihood of its farming community, the productivity and sustainability of the rice-wheat cropping systems are vital. However, a number of significant issues are now becoming more and more apparent in RWCS, such as the deterioration of soil native fertility and multinutrient deficiencies, the drop in water table, the development of hard pan, and the accumulation of various weeds in rice and wheat crops". In addition, system productivity and profitability have been stagnating in recent years (Nandan et al., 2018). One of the most significant and reliable food crops in the world is rice (*Oryza sativa* L.). "For 40% of people worldwide, it is their main source of calories" (Virdia and Mehta, 2009). "Rice-based cropping systems outperformed fields without organic manure application when green manure and farmyard manure were added. The term "Integrated Nutrient Management System" also describes the balanced use of chemical fertilisers along with crop wastes, organic manures, bio fertilizers, and other biological sources. Seasonal management of nutrients also affects system productivity and resource availability, especially the physical, chemical, and water-holding capacities of soil" (Kumar et al., 2016).

"In rice-based cropping systems, organic nutrient management can significantly increase the soil's fertility condition, accessible N, P, and K organic matter content, and nutrient usage efficiency for profitable changes. The crop sequences' economics" (Swapana et al., 2012,). "In addition to supporting the improvement of the physical and biological qualities of soil, organic methods are thought to be an excellent source of all the important components (primary, secondary, and micronutrients) for plant growth. In other words, create favourable physical conditions for the soil, preserve soil nitrogen, and make other nutrients more accessible. By improving the synthesis and distribution of metabolites to reproductive organs, it also aids in the mineralisation of nutrients in the rhizosphere, which boosts crop development and improves the source-sink relationship" (Kanwar and Sharma, 2014).

"When wheat is planted after pigeon peas in a cropping system, the use of farm yard waste, potassium and zinc increases grain output" (Khalid et al., 2011). Rice-based cropping systems outperformed fields without organic manure application when green manure and farmyard manure were added. The physical, chemical, and water availability of soil, as well as the productivity of systems, are all significantly impacted by integrated nutrient management across seasons (Kumar et al., 2016).

2. MATERIALS AND METHODS

At the Instructional Research Farm, Department of Agronomy, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India, a field experiment was carried out from 2019–20 to 2020–21. There are 260 kg of available nitrogen, 12.5 kg of available phosphorus, and 283 kg of available potassium in the medium to deep, black, sandy clay loam soil in the area. Its pH is 7.19 and its electrical conductivity is 0.381 $^{dSm-1}$. In terms of their potential yield and resistance to insect pests, the hybrids and cultivars that were most popular among local farmers were employed. The varieties of different crops and their duration in the field, recommended fertilizer dose applied and planting spacing. Twenty-four treatment combinations of six distinct nutrient management and four rice-based farming systems were used in the split-plot design of the experiment. Using a random distribution with three replications, different treatments were assigned to distinct plots at random. Cropping systems were considered subplots, and nutrient management techniques were considered the main storyline. 100% organic NM1, 75% organic NM2, 50% organic + 50% inorganic NM3, 75% organic + 25% inorganic NM4, Farmer practices NM5, and 100% inorganic NM6 comprise the main plot. Rice (PB-1)-Wheat-Green manure (Sunhemp) subplot CS1, Rice (PB-1)-Chickpea (JG-14)-Maize (African Tall), and Rice (PB-1)-Egyption clover, F+S (JB-1) subplot CS4 (Sorghum (MP chari), rice (PB-1), and vegetable pea (Arkel). "For rice, wheat, and chickpeas, maize, sorghum, sunhemp, and vegetable peas, the row-to-row spacing was 20 cm; for Egyption clover, it was disseminated. All of the suggested techniques were implemented for the irrigated conditions in all of the rabi, zaid, and kharif crops. The following techniques were used to assess the N, P, and K as well as the microbial population in soil samples: Olsen's method" (Olsen et al. 1954), the Alkaline Permanganate method (Subbiah and Asija, 1956), and the Walkley and Black method (1934).

3. RESULTS AND DISCUSSION

3.1 Available Nitrogen

Furthermore, the amount of nitrogen that was accessible during the two experiment years was significantly impacted by the application of diverse nutrition sources. In comparison to other combinations such as 75% organic nutrient management (269.16 kg ha^{-1}), integrated nutrient management (INM 75:25) (264.28 kg ha^{-1}), integrated nutrient management (50:50) (262.35 kg ha ha^{-1}), and 100% inorganic nutrient management (260.97 kg ha^{-1}), 100% organic nutrient management recorded significantly higher values of 273.95 kg ha ha^{-1} among the organic, inorganic, and integrated nutrient management. Nevertheless, farmer methods have the lowest amount of accessible nitrogen (251.44 kg ha^{-1}). Table 1 makes it clear that when various nutrient management techniques were completed in both years, the amount of nitrogen that was accessible in the soil progressively increased from its starting value of 260 kg ha^{-1}.

The data showed that alternative rice-based cropping systems did not significantly alter the amount of nitrogen that was available. The value of accessible nitrogen was observed on average. In the final year, the rice-chickpea-maize cropping system had the highest available nitrogen value (263.98 kg ha^{-1}), while the other cropping systems, such as the rice-egyption clover (fodder+seed) cropping system (263.91 kg ha^{-1}), the rice-wheat-green manuring cropping system (263.59 kg ha^{-1}), and the rice-vegetable pea-sorghum (fodder) cropping system, showed no differences. Because sorghum (fodder) has used more nitrogen than peas have added, there was less accessible soil nitrogen (263.29 kg ha^{-1}) in the rice, vegetable pea, and sorghum (fodder) cropping sequence. Similar findings were also reported by Singh et al. (2004). During the two experimental years, rice-egyption clover (fodder+seed) produced the most nitrogen accessible in the soil. According to Devi and Thakur (1994), "adding legumes to a series has been shown to increase soil nitrogen". According to Narkhede et al. (2011), "the soybean-onion cropping system also preserved the soil's fertility level". "Enhanced root shoot biomass and the berseem (nodules) crop's ability to fix atmospheric nitrogen may therefore be the causes of the enhanced availability of nitrogen compared to the rice-wheat copping system" (Dwivedi et al., 2003). According to Porpavai et al. (2011) and Gangwar and Ram (2005), "adding leguminous crops to the system enhanced the amount of nitrogen that was accessible".

The interaction between cropping systems and varying nutrition management at the same level of nutrient management was shown to be substantial, as shown in Table 1. Different nutrient management practices at the same cropping system level had an impact on the cropping systems. Higher available nitrogen (274.35 kg ha^{-1}) was recorded in the interaction between 100% organic nutrient management and the rice-egyption clover (fodder+seed) cropping system. However, this was statistically comparable to 100% organic nutrient management in the rice-chickpea-maize cropping system (273.85 kg ha^{-1}), followed by 75% organic nutrient management in the rice-chickpea-maize cropping system (269.60 kg ha^{-1}). With 251.44 kg ha^{-1}, the farmer's nutrient management practices in the rice-wheat-green manure cropping system produced the least amount of nitrogen available.

The lowest available nitrogen was obtained in the interaction of farmer practices nutrient management in rice-wheat-green manure cropping system with 250.73 kg ha^{-1}. This might be due to poor performance of crop giving less yield. N uptake was lesser due to lesser nutrient mining from the soil thus available N status was lowest.

3.2 Available Phosphorus

The management of nutrients had an impact on the amount of phosphorous that was accessible. It was statistically comparable to 13.06 kg ha^{-1}in 75% organic nutrient management, integrated nutrient management INM (75:25) (12.32 kg ha^{-1}), and integrated nutrient management INM(50:50) (12.18 kg ha^{-1}). The values ranged from 11.41 to 14.10 kg ha^{-1}, with the highest available phosphorous being obtained in 100% organic nutrient management with

Table 1. Available nitrogen of soil as affected by different nutrient management practices and rice-based cropping system

Nutrient Management	Cropping System(kg ha-1)				
	Initial Status 260				
	CS_1	CS_2	CS_3	CS_4	Mean
100% Organic	273.50	273.85	274.35	274.08	273.95
75% Organic	269.26	269.60	269.19	268.59	269.16
INM (50% organic+50%inorganic)	263.38	262.42	261.73	261.88	262.35
INM (75% organic+25% inorganic)	263.34	264.42	264.91	264.44	264.28
Farmer Practices	251.86	251.66	251.52	250.73	251.44
100% Inorganic	260.20	261.93	261.73	260.02	260.97
Mean	263.59	263.98	263.91	263.29	
			Interaction		
	Nutrient Management	Cropping System	Factor B at same level of A	Factor A at same level of B	
Sem±	0.27	0.23	0.40	0.39	
CD (p =0.05)	1.07	0.82	1.41	1.40	

Where, CS_1 is Rice-wheat-green manure, CS_2 is Rice-chick pea-maize, CS_3 is Rice-egyption clover (F+S), CS_4 is Rice-vegetable pea-sorghum

14.10 kg ha^{-1}, followed by 13.14 kg ha^{-1}in 100% inorganic nutrient management. During both years, the farmer's nutrient management strategies yielded the lowest available phosphorus, at 11.41 kg ha^{-1}.

The availability of phosphorous was not altered by different cropping systems, and the greater value was obtained in the rice-wheat-green manuring cropping system with (12.71 kg ha^{-1}); there was no significant difference in the remainder of cropping systems. The rice-chickpea-maize cropping system (12.67 kg ha^{-1}) was followed by the rice-egyption clover (fodder+seed) cropping system (12.54 kg ha^{-1}). The lowest available phosphorus was reported in the rice-vegetable pea-sorghum (fodder) cropping system (12.53 kg ha^{-1}) for both years. This could be owing to crops' relatively poor phosphorus uptake compared to total application. Though a significant amount of applied 'P' was fixed in the soil, mineralisation of fixed 'P'

Table 2. Available phosphorus of soil as affected by different nutrient management practices and rice-based cropping system

Nutrient Management	Cropping System				
	Initial Status-12.5 kg ha-1				
	CS_1	CS_2	CS_3	CS_4	Mean
100% Organic	14.12	14.27	13.98	14.05	14.10
75% Organic	13.14	13.11	12.97	13.01	13.06
INM (50% organic+50%inorganic)	12.18	12.19	12.13	12.20	12.18
INM (75% organic+25% inorganic)	12.49	12.35	12.23	12.19	12.32
Farmer Practices	11.63	11.43	11.37	11.21	11.41
100% Inorganic	13.26	13.04	13.13	13.15	13.14
Mean	12.71	12.67	12.54	12.53	
	Nutrient Management	Cropping System	Interaction		
			Factor B at same level of A	Factor A at same level of B	
Sem±	0.02	0.03	0.04	0.05	
CD (p =0.05)	0.09	0.09	0.16	0.18	

Where, CS_1 is rice-wheat-green manure, CS_2 is rice-chick pea-maize, CS_3 is rice-egyption clover (F+S), CS_4 is rice-vegetable pea-sorghum

Table 3. Available Potash of soil as affected by different nutrient management practices and rice-based cropping system

Nutrient Manage ment	Cropping System				
	Initial Status-283 kg ha-1				
	CS_1	CS_2	CS_3	CS_4	Mean
100% Organic	297.02	296.75	297.11	296.57	296.86
75% Organic	292.75	293.25	292.96	292.91	292.97
INM (50%organic+ 50%inorganic)	286.04	286.19	285.81	285.17	285.80
INM (75% organic+ 25% inorganic)	287.30	287.96	287.82	287.04	287.53
Farmer Practices	280.94	281.67	281.32	281.88	281.45
100% Inorganic	284.37	284.29	284.41	284.09	284.29
Mean	288.07	288.00	288.24	287.94	
	Nutrient Management	**Cropping System**	**Factor B at same level of A**	**Factor A at same level of B**	
Sem±	0.17	0.22	0.37	0.35	
CD (p =0.05)	0.67	0.77	1.33	1.23	

Where, CS_1 is Rice-wheat-green manure, CS_2 is Rice-chick pea-maize, CS_3 is Rice-berseem (F+S), CS_4 is Rice-vegetable pea-sorghum

occurred at a slower rate, and the significance of organic materials cannot be overlooked. Many scientists also determined availability of phosphorus in the soil by using various organic materials and their findings supported the above results. (Pattanayak et al., 2001, Parmer and Sharma, 2002 and Singh et al., 2002) also reported that increase in P availability by legume crops due to improvement in physico-chemical properties and microbial condition in soil which helped to solublized fixed P in soil.

Different nutrient management practices and cropping sequences interact to influence soil phosphorus availability. Different nutrient management strategies had an impact on cropping systems at the same scale. The interaction between 100% organic nutrient management and rice-chickpea-maize cropping system recorded the higher available nitrogen (14.27 kg ha^{-1}), but statistically at par with 100% organic nutrient management in rice-wheat-green manure (14.12 kg ha^{-1}), followed by 100% organic nutrient management with rice-vegetable pea-sorghum (fodder) (14.05 kg ha^{-1}) and 100% inorganic nutrient management in rice-wheat-green manure cropping system with (13.26 kg ha^{-1}). The interplay of farmer nutrient management methods in the rice-vegetable pea-sorghum (fodder) cropping system resulted in the lowest available phosphorus (11.21 kg ha^{-1}).

3.3 Available Potassium

Furthermore, the use of different nutrient sources had a substantial impact on available potash observed during both years of study. Among organic, inorganic, and integrated nutrient management, 100% organic nutrient management had significantly higher values of available potassium (296.86 kg ha^{-1}) than other combinations such as 75% organic nutrient management (292.97 kg ha^{-1}), followed by integrated nutrient management (INM 75:25) (287.53 kg ha^{-1}), integrated nutrient management INM (50:50) (285.80 kg ha^{-1}), and inorganic nutrient management (284.29 kg ha^{-1}). However, the lowest accessible potash is present in farmer practices (281.45 kg ha^{-1}). Table 3 shows that the available potash in soil steadily grew over the initial value (283 kg ha^{-1}) and was completed after varied nutrient management during both years.

The findings demonstrated that there was no substantial difference with different rice-based farming systems. The average value of available potash was noted. The rice-egyption clover (fodder+seed) cropping system had the highest available potash value (288.24 kg ha^{-1}), while no differences were found between rice-wheat-green manuring cropping system (288.07 kg ha^{-1}a) and (288 kg ha^{-1}) under rice-chickpea-maize cropping system, and the lowest available potash was found in rice-vegetable pea-sorghum (fodder) cropping system (287.94 kg ha^{-1}) during both years.

Kumar et al. (2001), Gangwar and Ram (2005) found that including leguminous crops in the system boosted the available potassium in the soil. Kumar et al. (2012) found that growing basmati or hybrid rice during the kharif season was more profitable and productive. In the rabi season, replacing wheat with mustard or pulses is a superior option for increased profitability, productivity, and long-term potassium availability. Upadhyay et al. (2011) reported the availability of P, K, S, Zn, and B in soil.

The interaction between 100% organic nutrient management and rice-egyption clover (fodder+seed) cropping system recorded the higher available potash (297.11 kg ha^{-1}), but statistically at par with 100% organic nutrient management in rice-wheat-green manure (297.02 kg ha^{-1}) and rice-chickpea-maize cropping system (296.75 kg ha-1), followed by 75% organic nutrient management in rice-egyption clover (fodder+seed) cropping system (293.25 kg ha^{-1}). The interplay of farmer practices nutrient management in rice-wheat-green manure system yielded the lowest available potash (280.94 kg ha^{-1}).

4. CONCLUSION

Based on the findings of this study, it is possible to conclude that the soil has the highest accessible NPK under 100% organic nutrient management with a rice-egyption clover (F+S) cropping system. These nutrient management strategies increase soil health in the current setting of a rice-egyption clover (F+S) cropping system.

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.

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COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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