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Effect of different sources of organic manures on phosphorus release rate, microbial population and enzyme activities in vertisol

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Abstract
An incubation study entitled "Enzymatic Activities and Phosphorus Availability as Influenced by Different Organic Manures in Vertisol" was conducted during 2024–2025 at the Division of Soil Science, College of Agriculture, Kolhapur. The experiment was laid out in a CRD with six treatments and four replications. The treatments included: Absolute Control, GRDF (50:75:45 N:P_2O_5:K_2O kg ha^{-1} + FYM 10 t ha^{-1}), RD NK + 100% RD-P_2O_5 + PMC 2.0 t ha^{-1}, RD NK + 75% RD-P_2O_5 + PMC 4.0 t ha^{-1}, RD NK + 100% RD-P_2O_5 + PROM 0.5 t ha^{-1}, and RD NK + 75% RD-P_2O_5 + PROM 1.0 t ha^{-1}. The study was conducted for 90 days using the discard method under laboratory conditions.
The phosphorus release rate peaked between 30 and 45 days of incubation, with the highest release (5.23 mg kg^{-1}) observed under RD NK + 75% RD-P_2O_5 + PROM 1.0 t ha^{-1}. In the later phase (75–90 days), GRDF treatment showed the highest phosphorus release rate (1.78 mg kg^{-1}). In respect of enzymatic activity the higher alkaline (67.65 µg PNP g^{-1} soil hr^{-1}) and acid phosphatase (20.91 µg PNP g^{-1} soil hr^{-1}) activities were recorded at 45 days under RD NK + 75% RD-P_2O_5 + PROM 1.0 t ha^{-1}. However, the GRDF treatment recorded the highest alkaline phosphatase activity (59.59 µg PNP g^{-1} soil hr^{-1}) at 90 days. Microbial populations also responded positively to organic amendments. At 45 days, RD NK + 75% RD-P_2O_5 + PROM 1.0 t ha^{-1} recorded significantly higher bacterial (25.83 $\times 10^6$ cfu g^{-1} soil) and PSB populations (13.32 $\times 10^5$ cfu g^{-1} soil).

Keywords: Organic manures, phosphorus, phosphatase enzyme and microbial

Introduction
Phosphorus (P) is a vital macronutrient for plant growth and is crucial for various biological processes within plants. It plays a key role in cell division, root development, and seed formation. The availability of soil phosphorus is largely governed by microflora and soil enzymes. Soil enzymes like acid and alkaline phosphatase are mainly involved in the mineralization of this fixed phosphorus. The acid phosphatase is predominant in acid soil, and alkaline phosphatase is predominant in alkaline soil.
Soil organic amendments can increase the availability of phosphorus in several ways. Soils that are rich in organic matter are expected to have a higher availability of phosphorus due to increased biological activity. This is accomplished by synthesizing and releasing organic acids during decomposition, which in turn promotes microbial activity and blocks phosphorus-fixing sites on soil particles. Additionally, organic matter contributes between 20% to 80% of the organic phosphorus in the soil (Richardson, 1994) [6]. Organic manures, such as FYM, PMC and PROM, demonstrate a slow and sustained release of phosphorus.

Materials and Methods
An incubation study was conducted at Division of Soil Science, RCSM College of Agriculture, Kolhapur during 2024-2025. The experiment was laid out in CRD design with six treatments *viz.,* Absolute control, GRDF (50:75:45 N: P_2O_5:K_2O Kg ha^{-1} + FYM 10 t ha^{-1}), RD NK+100% RD- P_2O_5 + PMC 2.0 t ha^{-1}, RD NK+75% RD- P_2O_5 + PMC 4. 0 t ha^{-1}, RD NK +100% RD- P_2O_5 + PROM 0.5 t ha^{-1} and RD NK + 75% RD- P_2O_5 + PROM 1.0 t ha^{-1} with four replications. The experimental soil was alkaline in reaction, medium in available nitrogen, moderately high in phosphorus and very high in potassium.

The incubation study was conducted for 90 days in a laboratory by discard method. The soil samples were analysed for available phosphorus at 0, 15, 30, 45, 60, 75 and 90 days after incubation (DAI). The microbial population and acid and alkaline phosphatase activity were analysed at 0, 45 and 90 days of incubation.

Result and Discussion

Effect on periodical phosphorus release

The periodical release rate of phosphorus (Table.1 and Fig.1) varied with different treatments and period of incubation. The release rate of phosphorus was higher during early stage of incubation *i.e.* 0-15 DAI and it was declined thereafter during 15-30 DAI. At 30-45 the rate was increased showing second peak of phosphorus release rate and thereafter it was decreased at regular interval up to 90 DAI. The increased phosphorus release at early stage of incubation of 0–15-day might be due to the readily available water-soluble P from single superphosphate and at 15 to 30 days incubation period the inorganic fertilizer phosphorus gets fixed in soil as Ca-P and get converted to unavailable form. The phosphorus release was higher at 30-45 days period of incubation, driven by the rapid mineralization of organic manures due to microbial activity and higher alkaline phosphatase activity.

Application of RD-NK + 75% RD- P_2O_5 + PROM 1.0 t ha^{-1} showed maximum phosphorus release rate at 0-15, 30-45 and 45-60 days of incubation period (5.36, 5.23 and 3.65 mg kg^{-1}, respectively). The treatment RD-NK + 75% RD- P_2O_5 + PMC 4.0 t ha^{-1} recorded highest phosphorus release rate at 15-30 and 60-75 DAI (2.70 and 2.05 mg kg^{-1}, respectively), however GRDF recorded the highest release rate at 75-90 DAI (1.78 mg kg^{-1}). At early stage of incubation up to 45 days the phosphorus release rate was in the order as PROM > PMC > FYM. However, at 90 days of incubation the trend was FYM > PMC > PROM. Similar results were obtained by Diwale *et al.,* (2020) [2], Bhanwaria and Yadav., (2016) [1].

Effect on phosphatase enzyme activities

Alkaline phosphatase:

The alkaline phosphatase activity was varied significantly with different treatment at 45 and 90 DAI and ranged between 36.67-67.65 and 34.10-59.59 µg PNP g^{-1} soil hr^{-1}, respectively (Table. 2). At 45 DAI, application of RD-NK+75% RD-P_2O_5 + PROM 1.0 t ha^{-1} recorded significantly higher (67.65 µg PNP g^{-1} soil hr^{-1}) alkaline phosphatase activity and was at par with treatments GRDF and RD-NK+100% RD-P_2O_5 + PROM 0.5 t ha^{-1} (65.09 and 64.62 µg PNP g^{-1} soil hr^{-1}, respectively). However, application of GRDF exhibited significantly higher activity (59.59 µg PNP g^{-1} soil hr^{-1}) at the 90th day of incubation due to wide C:N ratio of FYM which enhances the long-term sustainability of the microbial activity (Meshram *et al.,* 2014) [3].

The highest Alkaline phosphatase activity at the 45th day it might be due to alkaline soil pH and higher rate of decomposition of organic sources. The gradual release of phosphorus from PROM fosters conditions that are favourable for the growth of microorganisms and enzymatic activity. These results were in conformity with Parham *et al*., (2002) [4].

Acid Phosphatase

The acid phosphatase activity differed significantly with different treatments at 45 and 90 DAI. Application of RD-NK+75% RD-P_2O_5 + PROM 1.0 t ha^{-1} recorded significantly higher acid phosphatase activity at 45 and 90 DAI (20.91 and 17.58 µg PNP g^{-1} soil hr^{-1}, respectively) and at par with RD-NK+100% RD-P_2O_5 + PROM 0.5 t ha^{-1} (19.23 and 16.55 µg PNP g^{-1} soil hr^{-1}, respectively).

Microbial population

The Bacterial and PSB population was significantly higher with RD NK+75% RD- P_2O_5 + PROM 1.0 t ha^{-1} at 45 days of incubation (25.83 x10^6 cfu g^{-1} soil and 13.32 x10^5 cfu g^{-1} soil, respectively) over rest of the treatments, however at 90 days of incubation, the treatment GRDF recorded higher (20.94 x10^6 cfu g^{-1} soil and 9.68 x10^4 cfu g^{-1} soil) bacterial and PSB population, respectively (Table.3). Significantly the higher fungi population (17.25 and 11.75 x10^5 cfu g^{-1} soil, respectively) was found with application of 75% RD-P_2O_5 + PMC 4.0 t ha^{-1} at 45 and 90 days of incubation period over rest of the treatments. Similar results were obtained by Richard *et al.,* (2016) [5] and Zhang *et al.,* (2012) [7].

Table 1: Effect of organic manure treatments on periodical phosphorus release

Tr. No.	Treatments	Available phosphorus release (mg kg^{-1}) in 15 days interval					
		0-15	15-30	30-45	45-60	60-75	75-90
T_1	Absolute control	0.05	0.12	0.17	0.20	0.18	0.11
T_2	GRDF	4.67	1.10	3.60	3.11	2.03	1.78
T_3	RD-NK+ 100% RD- P_2O_5 + PMC 2.0 t ha^{-1}	5.10	0.98	2.73	1.34	0.89	0.57
T_4	RD-NK+ 75% RD- P_2O_5 + PMC 4.0 t ha^{-1}	3.92	2.70	3.87	2.98	2.05	1.43
T_5	RD-NK+ 100% RD- P_2O_5 + PROM 0.5 t ha^{-1}	5.34	1.42	4.38	3.43	1.05	0.46
T_6	RD-NK+ 75% RD- P_2O_5 + PROM 1.0 t ha^{-1}	5.36	2.26	5.23	3.65	1.21	0.39

Table 2: Effect of different organic manures on activity of alkaline and acid phosphatase enzymes

Tr. No.	Treatments	Alkaline phosphatase (µg PNP g^{-1} soil hr^{-1})		Acid phosphatase (µg PNP g^{-1} soil hr^{-1})	
		45 Day	90 Day	45 Day	90 Day
T_1	Absolute control	36.67	34.10	10.12	10.19
T_2	GRDF	65.09	59.59	17.05	14.91
T_3	RD-NK+ 100% RD- P_2O_5 + PMC 2.0 t ha^{-1}	59.68	51.97	14.32	12.45
T_4	RD-NK+ 75% RD- P_2O_5 + PMC 4.0 t ha^{-1}	61.68	53.78	15.79	13.93
T_5	RD-NK+ 100% RD- P_2O_5 + PROM 0.5 t ha^{-1}	64.62	55.95	19.23	16.55
T_6	RD-NK+ 75% RD- P_2O_5 + PROM 1.0 t ha^{-1}	67.65	57.63	20.91	17.58
	SEm±	1.58	1.64	0.68	0.49
	CD @ 0.05	4.69	4.88	2.02	1.45

Table 3: Effect of different sources of organic manures on soil microbial population

Tr. No.	Treatments	Total bacterial population ($x10^6$ cfu g^{-1} soil)		Total fungi population ($x10^5$ cfu g^{-1} soil)		Total PSB population ($x10^4$ cfu g^{-1} soil)	
		45 DAI	90 DAI	45 DAI	90 DAI	45 DAI	90 DAI
T_1	Absolute control	11.46	10.04	11.92	9.09	7.16	5.36
T_2	GRDF	24.32	20.94	14.71	10.47	11.85	9.68
T_3	RD-NK+ 100% RD- P_2O_5 + PMC 2.0 t ha^{-1}	21.94	16.66	17.08	11.21	10.92	8.46
T_4	RD-NK+ 75% RD- P_2O_5 + PMC 4.0 t ha^{-1}	22.81	18.23	17.25	11.72	11.49	8.71
T_5	RD-NK+ 100% RD- P_2O_5 + PROM 0.5 t ha^{-1}	25.08	19.56	12.88	8.83	12.36	8.98
T_6	RD-NK+ 75% RD- P_2O_5 + PROM 1.0 t ha^{-1}	25.83	20.33	13.42	9.01	13.32	9.31
	SEm±	0.6	0.43	0.43	0.29	0.26	0.25
	CD @ 0.05	1.77	1.29	1.29	0.85	0.77	0.73

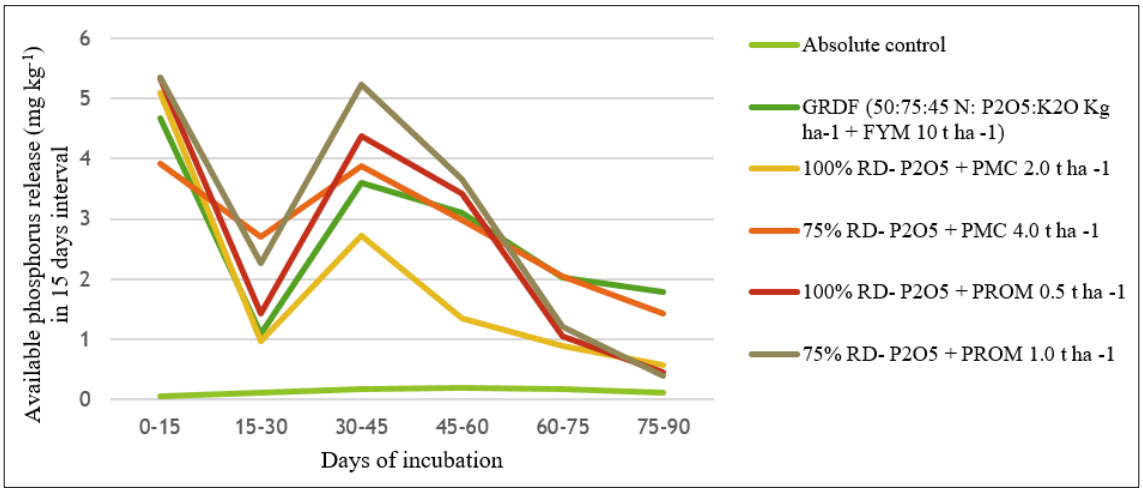

Fig 1: Effect of different organic manures on periodical release of Phosphorus

Conclusion

Application of RD NK+75% RD - P_2O_5 + PROM 1.0 t ha^{-1} found beneficial for higher phosphorus release rate, bacterial population and alkaline phosphatase activities in Vertisol soil during 90 days of incubation.

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