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Effect of different sources and levels of organic manures on nitrogen mineralization and enzymatic activities of soil in entisol

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Abstract
An incubation study was conducted during 2024-2025 with three sources of organic manures *viz*., FYM, vermicompost and pressmud compost and three levels of organic manures i.e., 2, 4 and 6 t ha^{-1} along with a separate control treatment. The soil samples were analysed periodically at 15 day intervals up to 90 days of incubation (DAI) for release of nitrate nitrogen. Vermicompost as a source of organic manures and the manure levels @ 6 t ha^{-1} recorded significantly highest NO_3^--N over all the incubation period except at 0 days of incubation. At 90 days of incubation, vermicompost application shows the highest NO_3^--N of 108.88 mg kg^{-1} over other sources, while the manure application @ 6 t ha^{-1} 113.04 mg kg^{-1}. The sources and levels of organic manure interaction was non-significant at all incubation stages, still they were superior over control treatment. Incubation the soil with FYM recorded significantly higher bacterial population, urease and dehydrogenase enzyme activities at 90 days of incubation (17.30 $x10^6$ cfu g^{-1} soil, 11.81 µmol NH_4^+ g^{-1} soil h^{-1} and 20.50 µg TPF g^{-1} soil 24 hr^{-1}, respectively).

Keywords: Organic manures, nitrogen, mineralization, enzyme activities

Introduction

Nitrogen is an essential nutrient for plant growth, development, and reproduction. It has a noticeable role to play in plant metabolic system. Nitrogen, being an essential constituent of protein, most of the vital processes in plants are governed by nitrogen. Nitrogen not only enhances the yield but also improves the food quality (Ullah *et al.* 2010) [10]. Most of the nitrogen added to the soil is present in organic forms; the remaining is in inorganic forms (NH_4^+ and NO_3^-). The mineralization rate determines the availability of nitrogen for plant growth. Mineralization of N is controlled by some crucial factors such as temperature, rainfall, soil properties, chemical composition of crop residues, structure and composition of microbial communities, and the C: N ratio in soil after the application of organic matter (Grzyb *et al*., 2020) [3]. Indian soil typically contains between 0.02% to 0.1% nitrogen, while hill soil ranges from 0.01% to 0.319% (Shafreen *et al.,* 2021) [7]. Microbial communities have an important role in regulating nitrogen cycling and its release. The presence of specific microbial taxa, such as Nitrosomonas and Aspergillus, was positively correlated with nitrogen release (Wang *et al.* 2022) [11].

Materials and Methods

An incubation study was conducted at the Division of Soil Science, RCSM College of Agriculture, Kolhapur during 2024-2025. The bulk soil sample from 0-15 cm belonging to the Entisol was collected from the Zonal Agricultural Research Station (ZARS), Shenda Park, Kolhapur. The soil sample was collected, air-dried, grounded with a wooden mortar and pestle, and then sieved through 2.0 mm sieve. The experiment was laid out in FCRD design with three replications. The treatments are three sources of organic manure *viz*., FYM, Vermicompost and Press mud compost; and three levels of organic manures *viz*., 2, 4 and 6 t ha^{-1} with a separate control treatment.

The experimental soil was neutral in reaction, medium in organic carbon, low in available nitrogen, medium in phosphorus and moderately high in potassium. The incubation study was conducted by discard method for 90 days. The soil samples were analysed for nitrate nitrogen at 0,15, 30, 45, 60, 75 and 90 days after incubation (DAI). The bacterial count was determined at 0, 45 and 90 days of incubation. After completion of incubation, the soil samples were analysed for urease and dehydrogenase enzymes.

Results and Discussion

Release of Nitrate nitrogen (NO_3^--N)

The periodical nitrate nitrogen (NO_3^--N) content in soil was differed significantly with different sources and levels of organic manures during the incubation period except at 0 days of incubation. The cumulative release of nitrate nitrogen during incubation increased consistently in all the treatments (Table 1). Over the incubation period, application of vermicompost recorded the highest amount of NO_3^--N, and it was followed by PMC and FYM. At 90 days of incubation, incubating the soil with vermicompost showed 108.88 mg kg^{-1} of NO_3^--N, which was 12.52 and 24.47 percent higher than PMC and FYM, respectively. Among the levels of organic manures, application of manures @ 6 t ha^{-1} recorded the highest amount of NO_3^--N over the rest of the levels at each incubation period, except at 0 days. The interaction effect of sources and levels of organic manures was found to be non-significant over the incubation period; however, all the treatment combinations of sources and levels of organic manures are significantly superior to the control treatment. Within the combination of sources and levels, application of FYM @ 2 t ha^{-1} reported the lower NO_3^--N, however, the control treatment recorded the lowest cumulative NO_3^--N over the period.

The consistent superiority of vermicompost application @ 6 t ha^{-1} is attributed to the favourable biochemical properties of vermicompost, including a narrower C:N ratio, higher nitrogen content, and enhanced microbial activity promoting sequential mineralization and nitrification. The release pattern peaked at 45 DAI and plateaued afterwards, indicating the completion of active mineralization phase. These results corroborate findings by Singh and Aulakh (2001), who observed increased mineral N accumulation from low C:N ratio residues. Similar findings were reported by Azeez and Averbeke (2010) who observed that cumulative nitrogen release was highest at 70-90 days of incubation.

Soil Dehydrogenase activity: The significantly higher dehydrogenase activity at 90 days of incubation (20.5 µg TPF g^{-1} soil 24 hr^{-1}) was recorded with FYM application and at par with PMC (19.74 µg TPF g^{-1} soil 24 hr^{-1}) over vermicompost (18.6 µg TPF g^{-1} soil 24 hr^{-1}) (Table 2). Manure application @ 6 t ha^{-1} recorded significantly the highest dehydrogenase activity in soil (23.66 µg TPF g^{-1} soil 24 hr^{-1}) after completion of the incubation, over other lower levels of manures. The interaction effect of different manures and its quantity was reported to be non-significant for dehydrogenase activity in soil after completion of incubation. Though interactions of sources and levels of manures are non-significant, all the combinations of sources and levels of manures are statistically superior over control (7.47 µg TPF g^{-1} soil 24 hr^{-1}) at 90 days of incubation.

The increase in dehydrogenase activity under FYM and PMC treatments is attributed to elevated microbial oxidative activity and respiration resulting from improved carbon and nutrient availability. These results are supported by Murugan and Swarnam (2013) [5] and Hadas *et al*., (1996) [4].

Urease activity of soil

Among the various sources of organic manures, FYM recorded significantly the highest urease activity (11.81 µmol $NH_4^+g^{-1}$ soil h^{-1}) over PMC and vermicompost (10.70 and 11.09 µmol $NH_4^+g^{-1}$ soil h^{-1}, respectively) (Table 3). Application of higher quantity of manure @ 6 t ha^{-1} recorded significantly the highest urease activity in soil (12.43 µmol $NH_4^+g^{-1}$ soil h^{-1}) after completion of the incubation over other lower levels of manures. The interaction of sources and levels of manures was non-significant for urease activity in soil after completion of incubation, still all the combinations are statistically superior over control (4.48 µmol $NH_4^+g^{-1}$ soil h^{-1}). Elevated urease activity associated with farmyard manure (FYM) can be attributed to the increased microbial biomass, which promote the activity of urease-producing microbes and the production of enzymes. These results agree with Ozdemir *et al.,* (2000) [6] who reported that urease activity was enhanced through mixing of organic residues with soil. The results are well supported by Bonmati *et al.,* (1991) [2].

Bacterial population of soil

The bacterial populations at 90 days of incubation were quite comparable among the different treatments, with values ranging from 8.24 to 19.74 $x10^6$ cfu g^{-1} soil (Table 4). Among the different sources of organic manures, application of FYM recorded the highest bacterial count at 90 days of incubation (17.30 $x10^6$ cfu g^{-1} soil). Organic manures application @ 6 t ha^{-1} reported the highest bacterial population at 90 days of incubation (17.94 $x10^6$ cfu g^{-1} soil).

The bacterial count rose with higher manure application rates, showing that more organic inputs promote microbial growth. Vermicompost at 6 t ha^{-1} was the most effective in enhancing microbial populations during early decomposition, while farmyard manure at the same rate sustained activity longer. This conforms with the reports of Singh and Reddy (2012) [9], who observed that the slow release of nutrients from FYM ensures long-term soil fertility and reduces the risk of nutrient leaching.

Table 1: Effect of different sources and levels of organic manures on release of nitrate nitrogen (NO_3^--N) during incubation

A. Sources		NO_3^--N (mg kg^{-1})						
		Days of incubation						
		0	15	30	45	60	75	90
M_1-FYM		7.63	19.07	33.19	50.48	65.73	77.98	87.47
M_2-Vermicompost		8.40	22.41	40.91	62.24	80.95	96.47	108.88
M_3-PMC		8.06	20.28	36.97	56.13	72.8	86.56	96.76
SEm$\pm$		0.32	0.79	0.79	1.44	1.86	1.2	1.69
CD @ 0.05		NS	1.67	1.67	3.02	3.9	2.51	3.55
B. Levels								
L_1- 2 t ha^{-1}		7.61	18.42	31.99	47.42	61.31	72.73	81.6
L_2- 4 t ha^{-1}		8.06	20.62	37.14	56.78	73.67	87.58	98.47
L_3- 6 t ha^{-1}		8.42	22.72	41.95	64.66	84.5	100.7	113.04
SEm$\pm$		0.34	0.84	0.84	1.53	1.97	1.27	1.79
CD @ 0.05		NS	1.77	1.77	3.21	4.14	2.66	3.77
Sources & levels Interaction								
M_1L_1	FYM 2 tha^{-1}	7.11	16.85	28.44	41.94	54.37	64.43	72.11
M_1L_2	FYM 4 tha^{-1}	7.67	19.08	33.26	50.91	66.05	78.36	87.80
M_1L_3	FYM 6 tha^{-1}	8.11	21.29	37.88	58.60	76.78	91.16	102.51
M_2L_1	VC 2 tha^{-1}	8.04	20.38	35.94	53.38	69.49	82.61	92.89
M_2L_2	VC 4 tha^{-1}	8.44	22.46	41.06	62.73	81.6	97.17	109.88
M_2L_3	VC 6 tha^{-1}	8.73	24.38	45.74	70.60	91.75	109.63	123.86
M_3L_1	PMC 2 tha^{-1}	7.69	18.03	31.59	46.94	60.08	71.16	79.80
M_3L_2	PMC 4 tha^{-1}	8.07	20.33	37.08	56.69	73.36	87.22	97.73
M_3L_3	PMC 6 tha^{-1}	8.43	22.49	42.24	64.76	84.97	101.31	112.74
Control		4.44	8.03	12.12	16.09	19.18	21.84	24.02
SEm$\pm$		0.47	1.19	1.19	2.16	2.79	1.79	2.54
CD @ 0.05		NS	NS	NS	NS	NS	NS	NS
Control vs rest								
SEm$\pm$		0.41	1.03	1.023	1.86	2.39	1.543	2.182
CD @ 0.05		0.86	2.15	2.15	3.9	5.04	3.24	4.58

Table 2: Dehydrogenase activity of soil after 90 days of incubation as influenced by different sources and levels of organic manures

Manures	Dehydrogenase (µg TPF g^{-1} soil 24 hr^{-1})			
	Manure levels (t ha^{-1})			
	L_1: 2 t ha^{-1}	L_2: 4 t ha^{-1}	L_3: 6 t ha^{-1}	Mean
M_1:FYM	16.02	20.84	24.62	20.50
M_2:Vermicompost	13.92	18.95	22.94	18.60
M_3:PMC	15.94	19.85	23.42	19.74
Mean	15.29	19.88	23.66	19.61
Control				7.47
Factors		**SEm$\pm$**	**CD @ 0.05**	
Manures		0.49	1.03	
Quantity		0.52	1.09	
Manures & Quantity interaction		0.74	NS	
Control vs rest		0.63	1.33	

Table 3: Urease activity of soil after 90 days of incubation as influenced by different sources and levels of organic manures

Manures	Urease (µmol NH_4^+g^{-1} soil h^{-1})			
	Manure levels (t ha^{-1})			
	L_1: 2 t ha^{-1}	L_2: 4 t ha^{-1}	L_3: 6 t ha^{-1}	Mean
M_1:FYM	10.44	11.90	13.08	11.81
M_2:Vermicompost	9.56	10.72	11.80	10.70
M_3:PMC	9.62	11.26	12.41	11.09
Mean	9.87	11.29	12.43	11.20
Control				4.48
Factors		**SEm$\pm$**	**CD @ 0.05**	
Manures		0.25	0.53	
Quantity		0.27	0.56	
Manures & Quantity interaction		0.38	NS	
Control vs rest		0.33	0.69	

Table 4: Bacterial population of soil at 90 days after incubation as influenced by different sources and levels of organic manures

Manures	Bacteria (x10^6 cfu g^{-1} soil)			
	Manure levels (t ha^{-1})			
	L_1: 2 t ha^{-1}	L_2: 4 t ha^{-1}	L_3: 6 t ha^{-1}	Mean
M_1:FYM	14.75	17.41	19.74	17.30
M_2:Vermicompost	11.16	14.04	15.75	13.65
M_3:PMC	13.63	16.40	18.34	16.12
Mean	13.18	15.95	17.94	15.69
Control				8.24
Factors		**SEm$\pm$**	**CD @ 0.05**	
Manures		0.51	1.07	
Quantity		0.54	1.14	
Manures & Quantity interaction		0.77	NS	
Control vs rest		0.66	1.39	

Conclusion

Application of vermicompost as a source and levels of organic manure @ 6.0 t ha^{-1} found to be better for higher release of nitrate nitrogen, whereas application of FYM is found better for bacterial population, urease and dehydrogenase enzymes activities at 90 days of incubation.

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