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Effect of integrated nitrogen and phosphorus management on soil enzymatic activities

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Abstract

Soil enzymatic activities respond sensitively to nutrient management practices and provide valuable insights into soil microbial functioning and nutrient cycling. Dehydrogenase and urease enzymes are widely used indicators of overall microbial activity and nitrogen transformation in soils. A field experiment was conducted during two consecutive years (2022-23 and 2023-24) to evaluate the effect of nitrogen and phosphorus management practices on soil dehydrogenase and urease activities at different crop growth stages. The experiment consisted of six nitrogen management options involving integrated use of inorganic fertilizers, organic amendments, and bio-inputs, and four phosphorus management options involving basal and split applications, arranged in a factorial randomized block design. Soil samples were collected at 30 and 60 days after transplanting (DAT) and at harvest, and enzyme activities were determined using standard analytical procedures. Pooled analysis of data indicated that both dehydrogenase and urease activities increased significantly from 30 DAT to 60 DAT and declined at harvest. Integrated nitrogen management treatments recorded significantly higher enzymatic activities compared to conventional fertilizer practices at all stages. Among phosphorus treatments, application of 100 per cent recommended dose as basal application resulted in the highest enzyme activity. Interaction effects between nitrogen and phosphorus treatments were non-significant, indicating independent contributions of these nutrients to soil biological activity. Enhanced enzymatic activity under integrated nutrient management was attributed to improved substrate availability, increased microbial proliferation, and favorable soil conditions. The results emphasize the importance of balanced and integrated nitrogen and phosphorus management for improving soil biological health and sustaining nutrient cycling in intensive cropping systems.

Keywords: Dehydrogenase, urease, integrated nutrient management, nitrogen, phosphorus and soil enzymes

Introduction

Soil biological activity plays a crucial role in maintaining soil fertility and ecosystem sustainability. Soil enzymes catalyze biochemical reactions involved in organic matter decomposition and nutrient transformation and are therefore considered reliable indicators of soil health. Among them, dehydrogenase activity reflects total microbial oxidative activity, while urease plays a key role in nitrogen mineralization by catalyzing the hydrolysis of urea into ammonium. Nutrient management practices strongly influence soil enzymatic activity by altering organic carbon availability, microbial biomass, and soil physicochemical conditions. Excessive dependence on inorganic fertilizers may adversely affect soil biological properties, whereas integrated nutrient management combining inorganic fertilizers with organic sources and bio-inputs has been shown to enhance soil microbial activity. Nitrogen and phosphorus are primary nutrients that govern crop productivity as well as microbial metabolism. However, information on their combined influence on soil enzymatic activities under integrated management practices remains limited. Therefore, the present investigation was undertaken to study the influence of nitrogen and phosphorus management practices on soil dehydrogenase and urease activities at different crop growth stages.

Materials and Methods

A field experiment was conducted during the agricultural years 2022-23 and 2023-24 in a factorial randomized block design with three replications. The treatments consisted of six nitrogen management options involving varying proportions of recommended nitrogen dose through inorganic fertilizers, organic sources, and bio-inputs, and four phosphorus management options comprising basal and split applications of recommended phosphorus doses.

Soil samples were collected from each treatment plot at 30 DAT, 60 DAT, and at harvest. Dehydrogenase activity was estimated by measuring the reduction of 2,3,5-triphenyl tetrazolium chloride to triphenyl formazan following the procedure described by Casida *et al.* (1964) ^[1] and Tabatabai (1994) ^[8]. Urease activity was determined by quantifying ammonium released from urea hydrolysis as per the method outlined by Tabatabai and Bremner (1972) ^[9]. These enzymes are widely recognized as indicators of soil microbial activity and nitrogen transformation processes (Dick, 1997; Nannipieri *et al.*, 2012) ^[2, 7]. Year-wise data were pooled after testing for homogeneity of variance and statistically analyzed to assess treatment effects.

Results and Discussion

Dehydrogenase activity: Data on dehydrogenase activity (Table 1) indicated significant differences among nitrogen and phosphorus management practices at all stages of crop growth. Among nitrogen management options, treatment T5 recorded the highest pooled dehydrogenase activity at 30 DAT (77.59 $\mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$), 60 DAT (108.46 $\mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$), and at harvest (56.87 $\mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$). The enhanced activity may be attributed to improved microbial proliferation and availability of organic substrates supplied through integrated nutrient sources.

Phosphorus management involving 100% recommended dose of phosphorus (basal) recorded significantly higher dehydrogenase activity compared to reduced phosphorus levels. The increased enzyme activity under integrated nutrient management corroborates the findings of Nannipieri *et al.* (2003), who reported that organic amendments stimulate soil microbial activity and enzyme synthesis. Interaction effects between nitrogen and phosphorus management were non-significant.

Table 1: Influence of nitrogen and phosphorus management practices on dehydrogenase

Table: Dehydrogenase activity in soil									
Treatments	30 DAT			60 DAT			At Harvest		
Nitrogen Management Option									
	2022-23	2023-24	pooled data	2022-23	2023-24	pooled data	2022-23	2023-24	pooled data
T ₁	62.82	55.68	59.25	94.31	78.51	86.41	40.02	38.72	39.37
T ₂	69.30	61.24	65.27	101.17	87.27	94.22	45.22	43.97	44.60
T ₃	70.06	62.53	66.30	102.47	87.57	95.02	45.90	45.04	45.47
T ₄	71.00	63.63	67.31	103.69	88.57	96.13	47.45	46.89	47.17
T ₅	83.02	74.15	77.59	116.25	105.12	108.46	58.29	57.67	56.87
T ₆	77.09	69.15	73.12	110.09	96.91	103.50	52.61	52.64	52.63
SE(m)±	1.853	1.608	1.638	2.093	2.523	2.404	1.694	1.405	1.495
CD	5.327	4.622	4.708	6.016	7.252	6.908	4.868	4.037	4.298
Phosphorus Management Options									
100%RDP(Basal)	77.07	68.62	72.35	111.70	96.75	103.11	51.49	50.67	50.52
75%RDP(Basal) + PSB@ 2kg/ac	68.56	61.05	64.81	99.37	86.07	92.72	45.81	45.09	45.45
50%RDP(PT) + 25%RDP(Basal)	71.02	63.52	67.27	102.92	89.15	96.04	47.45	46.71	47.08
SE(m)±	1.311	1.137	1.158	1.480	1.784	1.700	1.198	0.993	1.057
CD	3.767	3.268	3.329	4.254	5.128	4.885	3.442	2.855	3.039
Interaction (TxP)									
SE(m)±	3.210	2.785	2.837	3.625	4.371	4.163	2.934	2.433	2.590
CD	NS	NS	NS	NS	NS	NS	NS	NS	NS
T ₁ -Burning +100% RDN (33.3% DT, 33.3% at MT and 33.3% at PIS), T ₂ - Incorporation + PJTAU Consortium+100% RDN (33.3% DT, 33.3% at MT and 33.3% at PIS), T ₃ - Incorporation + PUSA Decomposer+100% RDN (33.3% DT, 33.3% at MT and 33.3% at PIS), T ₄ - Incorporation + PJTAU Consortium+100% RDN (20% DT, 20% at 15 DAT, 30% at MT and 30% at PIS(60DAT)), T ₅ -Incorporation + PJTAU Consortium + Incorporation of Gliricidia leaves(15% RDN) +100% RDN (20% DT, 20% at 15 DAT, 30% at MT and 30% at (60DAT)) T ₆ - Incorporation +115% RDN (20% DT, 30% at 15 DAT, 35% at MT and 30% at PIS).									

Urease activity

Urease activity data (Table 2) followed trends similar to dehydrogenase activity. Nitrogen management treatment T5 recorded the highest pooled urease activity at 30 DAT (52.91 $\mu\text{g NH}_4^+ \text{ g}^{-1} \text{ soil h}^{-1}$), 60 DAT (104.02 $\mu\text{g NH}_4^+ \text{ g}^{-1} \text{ soil h}^{-1}$), and at harvest (38.86 $\mu\text{g NH}_4^+ \text{ g}^{-1} \text{ soil h}^{-1}$). Increased urease activity under integrated nutrient management could be due to enhanced

microbial biomass and greater availability of urea substrates.

Among phosphorus management options, 100% RDP (basal) resulted in significantly higher urease activity across all growth stages. These results are in agreement with Dick *et al.* (1996), who reported that integrated nutrient management practices improve enzyme-mediated nitrogen transformations in soil. Interaction effects were non-significant.

Table 2: Influence of nitrogen and phosphorus management practices on urease activity

Table: urease activity in soil									
Treatments	30 DAT			60 DAT			At Harvest		
Nitrogen Management Option									
	2022-23	2023-24	pooled data	2022-23	2023-24	pooled data	2022-23	2023-24	pooled data
T ₁	41.69	32.16	36.93	84.90	78.66	81.78	24.22	21.55	22.88
T ₂	46.22	37.47	41.84	91.80	86.02	88.91	29.92	25.71	27.82
T ₃	46.92	38.93	42.92	92.24	87.43	89.84	30.82	26.06	28.44
T ₄	47.56	39.42	43.49	93.87	88.25	91.06	31.76	27.11	29.44
T ₅	56.10	49.73	52.91	104.72	103.33	104.02	42.51	35.20	38.86
T ₆	51.90	44.62	48.26	99.26	95.57	97.41	37.30	31.20	34.25
SE(m)±	1.254	1.036	1.299	1.814	2.386	2.159	0.902	1.076	1.126
CD	3.605	2.978	3.732	5.328	6.859	6.206	2.592	3.092	3.238
Phosphorus Management Options									
100%RDP(Basal)	51.53	43.09	47.31	100.54	79.17	98.23	34.91	29.67	32.29
75%RDP(PT) + PSB@ 2kg/ac	46.63	38.35	42.49	91.01	84.50	88.17	31.57	26.40	28.99
50%RDP(Basal) + 25%RDP(Basal)	47.03	39.72	43.38	91.84	89.32	90.11	31.78	27.35	29.56
SE(m)±	0.887	0.733	0.918	1.311	2.39	1.527	0.638	0.761	0.797
CD	2.549	2.106	2.639	3.767	6.87	4.388	1.833	2.186	2.289
Interactions (F1 x F2)									
SE(m)±	2.173	1.795	2.249	3.211	4.133	3.740	1.562	1.863	1.951
CD	NS	NS	NS	NS	NS	NS	NS	NS	NS
T ₁ -Burning +100% RDN (33.3% DT, 33.3% at MT and 33.3% at PIS), T ₂ - Incorporation + PJTAU Consortium+100% RDN (33.3% DT, 33.3% at MT and 33.3% at PIS), T ₃ - Incorporation + PUSA Decomposer+100% RDN (33.3% DT, 33.3% at MT and 33.3% at PIS), T ₄ - Incorporation + PJTAU Consortium+100% RDN (20% DT, 20% at 15 DAT, 30% at MT and 30% at PIS(60DAT)), T ₅ -Incorporation + PJTAU Consortium + Incorporation of Gliricidia leaves(15% RDN) +100% RDN (20% DT, 20% at 15 DAT, 30% at MT and 30% at (60DAT)) T ₆ - Incorporation +115% RDN (20% DT, 30% at 15 DAT, 35% at MT and 30% at PIS).									

Conclusion

The study demonstrated that integrated nitrogen and phosphorus management practices significantly enhanced soil dehydrogenase and urease activities throughout the crop growth period. Application of recommended nutrient doses in combination with organic sources proved superior in improving soil microbial activity and soil biological health. Adoption of integrated nutrient management practices is essential for sustaining soil enzymatic activity and long-term soil fertility under intensive cropping systems.

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