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Effect of hybrids and fertilizer levels on urease and dehydrogenase activity in cotton soils under high density planting system in medium black soils

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Abstract
Soil enzymatic activity plays a crucial role in nutrient transformation and availability in agricultural systems. This study evaluates the impact of cotton hybrids and different fertilizer regimes on urease and dehydrogenase activity in soil during the 2021 and 2022 cotton-growing seasons. Among the fertilizer levels, the highest urease activity was observed in the STCR-based fertilizer application targeting a yield of 32 q ha^{-1}, with values of 88.671 µg NH_4^+ g^{-1} 2 hrs^{-1} in 2021 and 96.612 µg NH_4^+ g^{-1} 2 hrs^{-1} in 2022 at flowering. Similarly, dehydrogenase activity was highest under the same fertilizer regime, reaching 7.513 µg TPF g^{-1} day^{-1} in 2021 and 8.384 µg TPF g^{-1} day^{-1} in 2022 at flowering. Among the hybrids, NCS-2778 exhibited superior enzymatic activity compared to RCH-665, indicating its better suitability for enhancing soil microbial function. The results underscore the importance of optimized fertilization strategies for maintaining soil microbial activity and nitrogen transformation efficiency.

Keywords: Cotton hybrids, fertilizer regimes, urease activity

Introduction
Soil enzyme activity is a key indicator of soil health and microbial function, playing a crucial role in nutrient cycling and overall crop productivity. This is especially important in high-density cotton cultivation, where efficient nutrient management is essential for sustainable yields (Kumar *et al*., 2018) [3]. Among these enzymes, urease facilitates nitrogen mineralization by breaking down urea into ammonium, while dehydrogenase activity reflects microbial metabolic activity and soil biological health.
Balanced fertilization can enhance enzyme activity and improve nutrient availability, whereas excessive nutrient inputs may disrupt microbial balance and degrade soil health (Rao *et al*., 2019; Sharma *et al*., 2020) [4, 6]. Understanding how different fertilizer regimes and crop hybrids influence these enzymatic processes is crucial for optimizing soil fertility management in cotton-based agricultural systems.
This study examines the impact of different cotton hybrids and fertilizer levels on urease and dehydrogenase activity in medium black soils under a high-density planting system. The goal is to identify fertilization strategies that support soil microbial function and nutrient transformation, ultimately enhancing cotton productivity.

Materials and Methods
The study was conducted at the College Farm, College of Agriculture, Rajendranagar, during the Kharif seasons of 2021 and 2022. Two cotton hybrids, NCS-2778 (Nuziveedu) and RCH-665 (Rasi), were evaluated under a split-plot design with two main plots (hybrids) and six subplots (nutrient levels), replicated three times, resulting in 36 treatment combinations. The RDF applied was 120:60:60 kg ha^{-1} (N:P:K), supplemented with FYM @ 5 t ha^{-1} and Zn @ 50 kg ha^{-1}. The soil type was medium black with a sandy loam texture.

Soil Sample Collection and Analysis
Soil samples were collected at two critical growth stages: flowering and harvest. To ensure accurate representation, plants were carefully uprooted, and soil samples were taken from the

rhizosphere (root zone) at a depth of 0-15 cm. The collected samples were air-dried, sieved through a 2 mm mesh, and stored at 4 °C until enzyme analysis.

Urease Activity Determination

Urease activity was assessed using the method outlined by Tabatabai and Bremner (1972) [2]. Soil samples were incubated with a urea solution at 37°C for 2 hours, after which the ammonium released was quantified using sodium phenate and sodium hypochlorite reagents. The concentration of ammonium was measured spectrophotometrically at 630 nm. The initial soil analysis indicated urease activity levels of 48.86 µg NH_4^+ released g^{-1} soil 2 hrs^{-1} in 2021 and 50.2 µg NH_4^+ released g^{-1} soil 2 hrs^{-1} in 2022. Dehydrogenase Activity Determination

Dehydrogenase activity was determined using the method described by Casida *et al*. (1964) [1]. Soil samples were incubated with triphenyl tetrazolium chloride (TTC) at 37°C for 24 hours. The resultant triphenyl formazan (TPF) was extracted using methanol and measured spectrophotometrically at 485 nm. The results were expressed as µg TPF g^{-1} soil per day, providing an estimate of microbial oxidative potential. The recorded dehydrogenase activity was 2.8 µg TPF produced g^{-1} soil day^{-1} in 2021 and 2.95 µg TPF produced g^{-1} soil day^{-1} in 2022.

Results and Discussion

The cotton hybrids NCS2778 and RCH665 had no significant impact on soil urease and dehydrogenase activity during the 2021 and 2022 growing seasons. While NCS2778 showed slightly higher enzyme activity at both flowering and harvest compared to RCH665, the differences were minor, indicating that microbial activity is primarily influenced by fertilization rather than hybrid selection. Nitrogen fertilization significantly affected urease and dehydrogenase activity, both peaking at flowering and declining at harvest and The data corresponding to the results is presented in Table 1. The highest urease activity at flowering was recorded under S_6 (STCR-based fertilization for a 32 q ha^{-1} target), with pooled values of 92.641 µg NH_4^+-N g^{-1} soil h^{-1}, while the lowest was seen in S_1 (100% RDF) at 72.104 µg NH_4^+-N g^{-1} soil h^{-1}. A similar trend was observed at harvest, where S_6 maintained the highest enzyme activity (45.470 µg NH_4^+-N g^{-1} soil h^{-1}), and S_1 recorded the lowest (35.590 µg NH_4^+-N g^{-1} soil h^{-1}). The overall decline from flowering to harvest reflects reduced nitrogen transformation as the crop matured. Urease activity, a key indicator of nitrogen mineralization, increased with higher nitrogen applications, consistent with findings in Telangana soils (Rao, 2019) [4]. STCR-based treatments exhibited more stable enzyme activity than RDF-based treatments, highlighting the importance of balanced nitrogen management. Excessive urease activity can lead to nitrogen losses through volatilization, reducing efficiency (Kumar, 2018; Reddy, 2021; Sharma, 2020) [3, 5, 6].

Similarly, dehydrogenase activity followed the same trend, peaking at flowering and decreasing at harvest. S_6 had the highest dehydrogenase activity at flowering (pooled mean 7.948 µg TPF g^{-1} soil d^{-1}) and harvest (3.911 µg TPF g^{-1} soil d^{-1}), while S_1 recorded the lowest values (5.627 and 2.778 µg TPF g^{-1} soil d^{-1}, respectively). The data corresponding to the results is presented in Table 2. This decline reflects the natural slowdown in microbial respiration as the crop matures. Higher nitrogen inputs stimulated microbial activity, with STCR-based treatments supporting a more stable microbial environment (Kumar *et al*., 2018; Sharma *et al*., 2020) [3, 6]. Overall, nitrogen fertilization was the dominant factor shaping soil enzyme activity, with STCR-based treatments promoting sustained microbial health. These findings emphasize the need for optimized fertilization strategies that enhance soil microbial activity while minimizing nitrogen losses, ensuring long-term soil fertility and agricultural productivity (Verma *et al*., 2020) [7].

Table 1: Soil urease (µg NH_4^+- N g^{-1} soil $2hr^{-1}$) at flowering and at harvest as influenced by different hybrids and fertiliser levels under HDPS Cotton during kharif, 2021 and 2022

Treatments	2021	2022	POOLED	2021	2022	POOLED
Main Plot	**at flowering**			**at harvest**		
M_1: NCS2778	81.8	90.5	86.1	40.9	43.9	42.4
M_2: RCH665	76.7	81.8	79.2	38.3	39.7	39.0
SE m±	1.48	1.49	1.48	0.84	0.84	0.84
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Sub Plot						
S_1: 100% RDF (120-60-60 kg ha^{-1} $N:P_2O_5:K_2O$)	69.4	74.8	72.1	34.7	36.5	35.6
S_2: 120% RDF (144-72-72 kg ha^{-1} $N:P_2O_5:K_2O$)	75.4	81.9	78.6	37.7	39.7	38.7
S_3: 140% RDF (168-84-84 kg ha^{-1} $N:P_2O_5:K_2O$)	82.0	89.2	85.6	41.0	43.2	42.1
S_4: STCR based fertiliser application (TY: 27 q ha^{-1}) (149-64-73 kg ha^{-1} $N:P_2O_5:K_2O$)	76.9	83.8	80.4	38.5	40.7	39.6
S_5: STCR based fertiliser application (TY: 30 q ha^{-1}) (173-72-87 kg ha^{-1} $N:P_2O_5:K_2O$)	83.0	90.4	86.7	41.5	43.8	42.7
S_6: STCR based fertiliser application (TY: 32 q ha^{-1}) (189-77-97 kg ha^{-1} $N:P_2O_5:K_2O$)	88.7	96.6	92.6	44.3	46.6	45.5
SE m±	2.52	2.50	2.51	1.43	1.42	1.43
CD (p=0.05)	7.42	7.37	7.39	4.22	4.20	4.21
Main plot at same level of Subplot						
SE m±	3.57	3.55	3.56	2.03	2.02	2.02
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Sub plot at same level of Main plot						
SE m±	3.56	3.53	3.55	2.02	2.01	2.02
CD (p=0.05)	NS	NS	NS	NS	NS	NS

(TY: targeted yield)

Table 2: Soil Dehydrogenase (µg TPF g^{-1} soil day^{-1}) at flowering and at harvest as influenced by different hybrids and fertiliser levels under HDPS during kharif, 2021 and 2022

Treatments	2021	2022	POOLED	2021	2022	POOLED
Main Plot	at flowering			at harvest		
M_1: NCS2778	6.736	7.399	7.068	3.368	3.594	3.481
M_2: RCH665	6.271	6.926	6.598	3.135	3.359	3.247
SE m±	0.085	0.088	0.086	0.039	0.051	0.039
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Sub Plot						
S_1: 100% RDF (120-60-60 kg ha^{-1} $N:P_2O_5:K_2O$)	5.435	5.820	5.627	2.717	2.838	2.778
S_2: 120% RDF (144-72-72 kg ha^{-1} $N:P_2O_5:K_2O$)	6.058	6.552	6.305	3.029	3.178	3.103
S_3: 140% RDF (168-84-84 kg ha^{-1} $N:P_2O_5:K_2O$)	6.651	7.261	6.956	3.325	3.522	3.423
S_4: STCR based fertiliser application (TY: 27 q ha^{-1}) (149-64-73 kg ha^{-1} $N:P_2O_5:K_2O$)	6.370	7.141	6.756	3.185	3.463	3.324
S_5: STCR based fertiliser application (TY: 30 q ha^{-1}) (173-72-87 kg ha^{-1} $N:P_2O_5:K_2O$)	6.994	7.819	7.406	3.497	3.792	3.644
S_6: STCR based fertiliser application (TY: 32 q ha^{-1}) (189-77-97 kg ha^{-1} $N:P_2O_5:K_2O$)	7.513	8.384	7.948	3.757	4.066	3.911
SE m±	0.200	0.221	0.210	0.109	0.116	0.113
CD (p=0.05)	0.581	0.640	0.610	0.316	0.338	0.327
Main plot at same level of Subplot						
SE m±	0.166	0.171	0.169	0.089	0.131	0.089
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Sub plot at same level of Main plot						
SE m±	0.157	0.161	0.159	0.088	0.132	0.088
CD (p=0.05)	NS	NS	NS	NS	NS	NS

(TY: targeted yield)

Conclusion
Optimized fertilizer application plays a crucial role in maintaining soil enzymatic activity and nutrient transformation efficiency. The STCR-based fertilizer regime targeting a yield of 32 q ha^{-1} was the most effective in enhancing urease and dehydrogenase activity. Additionally, the hybrid NCS-2778 exhibited superior performance over RCH-665 in terms of microbial function. These findings suggest that precise fertilization strategies and hybrid selection are key factors in improving soil health and crop productivity.

Future Line of Work
Further studies should investigate the long-term impact of different fertilization regimes on microbial diversity and soil health. Additionally, exploring site-specific nutrient management strategies could enhance the sustainability of cotton-based agricultural systems.

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