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RELATIONSHIP BETWEEN SOIL PH AND AVAILABLE NITROGEN UNDER DIFFERENT LAND USE SYSTEMS IN DHARMASAGAR MANDAL, WARANGAL DISTRICT, TELANGANA, INDIA

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ABSTRACT

Soil reaction (pH) is a master variable governing nitrogen transformation and availability in soil. The present study examined the relationship between soil pH and available nitrogen in soils under eight land use systems are maize, cotton, red gram, forest, pasture, mango, vegetable and rice in Dharmasagar Mandal, Warangal District, Telangana. Paired surface (0-15 cm) and subsurface (15-30 cm) soil samples (n = 208) were analysed for pH (1:2.5 soil-water suspension) and available nitrogen (alkaline potassium permanganate method), and the relationship between the two variables was assessed using Pearson's correlation coefficient. Soil pH ranged from 6.01 to 8.54 and available nitrogen from 108.28 to 382.38 kg ha^{-1} across the land use systems and depths. Pearson correlation analysis revealed a significant negative correlation between soil pH and available nitrogen ($r = -0.374$, $p < 0.01$, $n = 208$), indicating that available nitrogen declined as soil reaction became more alkaline. The alkaline, calcareous Vertisol pedons (cotton and rice) combined comparatively high pH with variable nitrogen status, while the near-neutral red soils under forest and pasture combined comparatively lower pH with the highest available nitrogen. These findings indicate that soil reaction is an important factor conditioning nitrogen availability across land use systems and should be considered while formulating land use-specific nitrogen management strategies.

Key words : Soil pH, Available nitrogen, Pearson correlation, Land use systems, Dharmasagar, Warangal.

Introduction

Soil reaction (pH) is one of the master variables of soil chemistry, governing the solubility, transformation and availability of most plant nutrients, including nitrogen (Brady and Weil, 2017). Nitrogen availability in soil is regulated by microbially mediated processes such as mineralisation, nitrification, immobilisation and denitrification, nearly all of which are markedly sensitive to soil pH. Nitrification proceeds most rapidly between pH 7 and 8 but slows sharply below pH 5, while at pH values above 7 ammoniacal nitrogen is increasingly susceptible to loss through ammonia volatilisation and the resulting nitrate is more prone to leaching under the rapid nitrification that alkaline conditions favour. Soil pH also regulates the activity of the heterotrophic microbial community responsible for organic matter decomposition and nitrogen mineralisation, so that both strongly acidic and strongly alkaline soils tend to constrain the release of plant-available nitrogen relative to near-neutral soils. Land use systems differ widely in vegetation cover, organic matter input and management, and these differences are frequently accompanied by contrasting soil reaction and nitrogen status. In Telangana, Ramulu *et al*. (2024) identified soil reaction and available nitrogen as important, spatially variable soil fertility constraints of the erstwhile Warangal district, while Rajashekhar *et al*. (2025) reported widespread nitrogen deficiency across the Southern Telangana agro-climatic zone linked to organic carbon status and land management. The soils of Dharmasagar mandal range from near-neutral, red Alfisols and

Inceptisols under forest, pasture and annual cropping to strongly alkaline, calcareous Vertisols under cotton and rice, offering a suitable gradient over which to examine the pH-nitrogen relationship. Gudla *et al*. (2023) similarly reported significant negative correlations of soil pH with several available macronutrients in the semi-arid soils of Anantapur district, Andhra Pradesh, showing the broader relevance of soil reaction as a nutrient-conditioning factor across the region, while Havlin *et al*. (1999) noted that soil reaction is among the most fundamental controls on the transformation and plant-availability of nitrogen in agricultural soils. The present investigation was therefore undertaken to quantify the relationship between soil pH and available nitrogen across eight land use systems and two soil depths in Dharmasagar mandal, using Pearson's correlation coefficient, with a view to informing land use and reaction-specific nitrogen management in the region.

Materials and Methods

The study was conducted in Dharmasagar Mandal of Warangal district, Telangana, which lies at approximately 17°59' N latitude and 79°27' E longitude and experiences a hot, semi-arid tropical climate with mean annual rainfall of about 900 to 1000 mm, received predominantly during the south-west monsoon. Surface (0-15 cm) and subsurface (15-30 cm) soil samples were collected from thirteen representative sites under each of eight major land use systems, namely maize, cotton, red gram, forest, pasture, mango, vegetable and rice, giving a total of 208 paired observations. Samples were air-dried, gently crushed and passed through a 2-mm sieve prior to analysis. Soil pH was determined in a 1:2.5 soil-water suspension using a glass electrode pH meter. Available nitrogen was estimated by the alkaline potassium permanganate method (Subbiah and Asija, 1956) and expressed in kg ha^{-1}. The relationship between soil pH and available nitrogen was assessed using Pearson's correlation coefficient (r), computed across all 208 paired observations pooled over land use systems and depths, and tested for significance at the 5% and 1% levels of probability (Snedecor and Cochran, 1967).

Results and Discussion

Soil pH and available nitrogen status

Soil pH across the land use systems and depths ranged from 6.01 to 8.54, the lowest values being recorded under forest and maize and the highest under rice, while available nitrogen ranged from 108.28 to 382.38 kg ha^{-1}, the lowest values being recorded under cotton and the highest under forest (Table 1). In general, the near-neutral to slightly acidic red soils under forest, pasture and mango combined comparatively lower pH with comparatively higher available nitrogen, whereas the alkaline, calcareous Vertisol pedons under cotton and rice combined comparatively higher pH with more variable and in the case of cotton, comparatively lower available nitrogen.

Table 1 : Descriptive statistics of soil pH and available nitrogen (kg ha^{-1}) under different land use systems.

Land use system	Depth (cm)	pH (Mean±SD)	Available N (Mean ± SD, kg ha^{-1})
Maize	0-15	6.75 ± 0.32	199.09 ± 12.28
	15-30	6.82 ± 0.33	176.11 ± 12.43
Cotton	0-15	7.37 ± 0.38	187.34 ± 30.71
	15-30	7.57 ± 0.35	154.32 ± 33.08
Red gram	0-15	7.44 ± 0.30	194.08 ± 13.62
	15-30	7.54 ± 0.29	173.96 ± 15.32
Forest	0-15	6.75 ± 0.49	317.27 ± 17.83
	15-30	6.88 ± 0.48	309.48 ± 34.11
Pasture	0-15	6.91 ± 0.49	283.95 ± 24.40
	15-30	7.03 ± 0.50	268.99 ± 23.26
Mango	0-15	6.99 ± 0.29	236.08 ± 34.14
	15-30	7.18 ± 0.32	213.27 ± 36.27
Vegetable	0-15	7.19 ± 0.56	197.57 ± 17.95
	15-30	7.24 ± 0.65	174.47 ± 15.33
Rice	0-15	7.97 ± 0.30	203.18 ± 19.63
	15-30	8.10 ± 0.31	180.34 ± 16.48

Table 2 : Pearson correlation coefficient between soil pH and available nitrogen.

Parameters correlated	n	Pearson r	r^2	Significance
Soil pH × Available N	208	-0.374	0.140	Significant at 1% level (**)

Correlation between soil pH and available nitrogen

Pearson correlation analysis across all 208 paired observations revealed a significant negative correlation between soil pH and available nitrogen (r = -0.374), significant at the 1% level of probability (Table 2 and Fig. 1). This indicates that, pooled across land use systems and depths, available nitrogen tended to decline as soil reaction became more alkaline. Soil pH regulates nitrogen availability through several interacting mechanisms: nitrification proceeds most rapidly between pH 7 and 8, but the resulting nitrate is highly susceptible to leaching, while ammoniacal nitrogen applied or mineralised in soils above pH 7 is increasingly prone to loss through ammonia volatilisation (Brady and Weil, 2017). Soil pH additionally

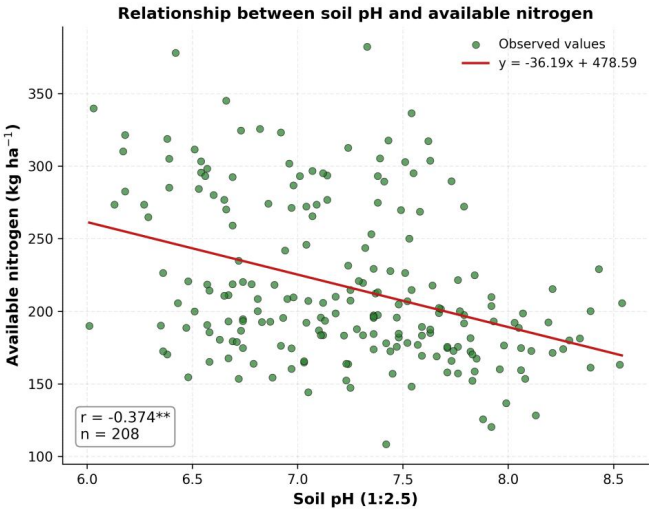


Fig. 1 : Relationship between soil pH and available nitrogen (kg ha^{-1}) in soil under different land use systems.

governs the activity of the heterotrophic microbial community responsible for organic matter decomposition and nitrogen mineralisation, so that the near-neutral reaction recorded under forest and pasture is likely to favour more efficient nitrogen cycling and retention than the strongly alkaline reaction recorded under rice and, at depth, cotton. Ramulu *et al*. (2024) similarly identified soil reaction and available nitrogen as interacting, spatially variable fertility constraints in the erstwhile Warangal district, while Rajashekhar *et al*. (2025) reported nitrogen deficiency across the Southern Telangana agro-climatic zone in soils of comparatively poor organic carbon and base status. Reddy and Naidu (2016) attributed the alkaline reaction of semi-arid Vertisols to their calcareous parent material and restricted internal drainage, conditions that, in the present study, coincided with the comparatively depleted nitrogen status of the cotton pedon in particular. Rana *et al*. (2025), studying cultivated land use systems in the neighbouring Nirmal district of Telangana, similarly reported the lowest available nitrogen under cotton among the systems studied, attributing this to the high nitrogen demand of cotton during its flowering and boll-development stages without adequate replenishment, and further reported the highest soil pH under rice, linking it to the predominance of exchangeable bases and the accumulation of basic cations under the periodically submerged conditions of paddy cultivation, a mechanism consistent with the elevated pH recorded under rice in the present study. Rana *et al*. (2025) further reported that available nitrogen, along with the other macronutrients and micronutrients studied, was negatively related to soil pH, a directional pattern consistent with the significant negative correlation between soil pH and available nitrogen obtained in the present study. Narsaiah *et al*. (2018), working on comparable soils of Warangal district, similarly recorded an increase in pH with depth under semi-arid conditions of restricted leaching, consistent with the depth-wise pH trend observed in the present study. Ramulu and Kamalakar (2022) and Ramulu and Reddy (2018) similarly reported nitrogen depletion under intensively cultivated soils of Warangal district relative to less-disturbed land uses, supporting the land use-driven nitrogen pattern recorded here. Dhaliwal *et al*. (2023) similarly reported that available nutrient status declined with depth and varied with land use and soil reaction across comparable semi-arid soils of North-Western India. Srinivasarao *et al*. (2021) further reported that integrated nutrient management and improved organic matter status enhanced nitrogen availability in semi-arid rainfed Inceptisols, suggesting that management practices could help offset the pH-driven nitrogen constraints identified in the present study. It should be noted that the coefficient of determination ($r^2 = 0.140$) indicates that soil pH alone accounts for a modest proportion of the total variability in available nitrogen, confirming that additional factors, most particularly organic carbon status, texture and land management, act alongside soil reaction in governing nitrogen availability across the land use systems studied. Still, the significant negative correlation obtained confirms that soil reaction is a useful, if partial, predictor of nitrogen status and merits consideration in land use-specific nitrogen management planning for the semi-arid soils of the region.

Conclusion

The present study revealed a significant negative correlation ($r = -0.374$, $p < 0.01$) between soil pH and available nitrogen across eight land use systems in Dharmasagar mandal, Warangal district, indicating that available nitrogen tends to decline as soil reaction becomes more alkaline. The near-neutral red soils under forest and pasture combined favourable pH with the highest nitrogen status, whereas the alkaline, calcareous Vertisols, particularly under cotton, showed comparatively depleted nitrogen. These findings underscore the value of monitoring soil reaction alongside nitrogen status and adopting reaction-specific nutrient management, including organic matter addition and split based nitrogen application to sustain soil fertility across the contrasting land use systems of the region.

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