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Vertical distribution of nutrients in ground nut growing soils in semiarid region of vepurikota microwatershed in Chittoor district of Andhra Pradesh

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Abstract
Soil survey was undertaken to study the vertical distribution of plant nutrients in the soil pedons of Groundnut growing areas of Vepurikota microwatershed in Chittoor district to understand nutrient supply capacity of soils. The results revealed that plant available N was deficient in all the pedons whereas P was sufficient in all the pedons. Available K and S in these soils were deficient to sufficient in all the pedons. The DTPA extractable Cu and Mn were found to be above critical limits in surface and sub-surface horizons of all the pedons. The available Zn was deficient to sufficient in all the pedons in both surface and sub-surface horizons except pedon 1 and the available Fe was found to be above the critical limits except in pedon 4. All the micronutrients were higher in surface soils than in subsurface soils except in pedon 1 for Zn, and pedon 4 for Fe.

Keywords: Macronutrients, micronutrients, organic carbon, pH, surface horizon and sub-surface horizon

Introduction
Understanding of vertical distribution plant nutrients in the soil is crucial for optimizing the nutrient management practices and achieving sustainable crop yields. This is because the roots of most crops extend beyond the surface layer and extract a significant portion of their nutrient requirements from the subsurface layers of the soil. However, previous studies have primarily focused on assessing the fertility status of the surface layer, neglecting the importance of studying the nutrient distribution in sub-surface layers. Limited information is available on the vertical distribution of both macro and micronutrients in soils, particularly in the groundnut-growing soils of Chittoor district in Andhra Pradesh. Consequently, a survey was conducted in the Vepurikota microwatershed of Chittoor district, Andhra Pradesh to know the vertical distribution of nutrients in groundnut growing areas of Vepurikota microwatershed.

Material and Methods
Location and Agro-climate: Vepurikota microwatershed of Chittoor district, Andhra Pradesh is spread over an area of 1026 ha. The climate of the area is semi-arid monsoonic with mean annual rainfall of 668.31 mm, of which 83.54 per cent is received during June-December. The mean annual temperature is 26.59 °C with mean summer temperature of 30.66 °C and the mean winter temperature of 23.38 °C. The maximum temperature was recorded in April that rises to 35.49 °C and the minimum temperature is 20.20 °C in December. The soil moisture regime is ustic and soil -temperature regime iso-hyperthermic.

Field survey and Taxonomic classification: Reconnaissance soil survey was conducted and four pedons were arranged in the ground nut growing areas of Vepurikota microwatershed in Chittoor district, Andhra Pradesh during 2021-22. The taxonomy of these five pedons *viz.*, Pedon 1: Fine loamy, mixed, isohyperthermic, Lithic Haplustepts Pedon 2: Fine loamy, mixed, isohyperthermic, Typic Haplustepts, Pedon 3: Fine loamy, mixed, isohyperthermic, Lithic Haplustalfs and Pedon 4: Fine loamy, mixed, isohyperthermic, Typic Haplustepts. The horizon wise soil samples were collected for detailed analysis. The soil samples were processed and analyzed for available macronutrients and micronutrients using standard methods as described by Jackson (1973). The critical limits proposed by Patel and Savani (1987) [9] available N (280 kg ha^{-1}) for available P (13 kg P ha^{-1}), Aulakh *et al.* (1988) [1] for available K (150 kg K ha^{-1}), Tandon (1991) [16] and available S (10 mg kg^{-1}), Anon (1977) for Zn (0.75 mg kg^{-1}), and Tandon (1993) for Fe (4 mg kg^{-1}), Cu (0.5 mg kg^{-1}) and Mn (2 mg kg^{-1}) were followed for classifying profile soil samples into sufficient or deficient for groundnut.

Results and Discussion

Physic-chemical properties

The groundnut growing soils were moderately acidic to moderately alkaline in their reactivity (5.88- 8.32) (Table 1) and wide variation in pH was attributed to the nature of the parent material, leaching, presence of calcium carbonate, exchangeable sodium and the release of organic acids during decomposition of organic matter. Similar findings were recorded by Leelavathy and Naidu (2020) [6]. The texture of the groundnut growing soils varied from sandy loam to sandy clay loam and this wider textural variation was caused by topographic position, nature of parent material, *in situ* weathering and translocation of clay (Leelavathi *et al.,* 2010) [5]. The EC in groundnut growing soils was ranged from 0.04 to 0.15 dSm^{-1} indicating their non-saline nature (Table 1). The low EC of groundnut growing soils was due to free drainage which favoured the removal of released bases by percolation and drainage (Sashikala *et al.* 2019) [13]. The organic carbon content of the ground nut growing soils was low to medium (0.07 to 0.70 per cent), which can be attributed to the prevalence of tropical condition, where the degradation of organic matter occurs at a faster rate coupled with low vegetative cover, thereby leaving less organic carbon in the soils (Supriya *et al.*, 2019) [15].

Macronutrients

The available N varied from 112.89-238.33 kg ha^{-1} in all the pedons of ground nut growing areas with a mean of 164.32 kg ha^{-1} (Table 2). Considering 280 kg ha^{-1} as critical level, the available N status was deficient in the surface and sub-surface soils and a decreasing trend with depth was observed in all the pedons. The low available nitrogen (N) in the soils could be attributed to the prevailing semiarid conditions in the area which could promote rapid oxidation and limit the accumulation of organic matter, leading to increased release of NO_3-N which is prone to leaching and subsequent loss from the soil. Similar results were reported by Borse *et al.* (2018) [2] and Lakshmi *et al.* (2020) [4].

The available P_2O_5 content varied from 55.17- 215.98 kg ha^{-1} in all the pedons of groundnut growing areas with a mean of 100.69 kg ha^{-1} (Table 2). Considering 13 kg ha^{-1} as critical level, the available P_2O_5 status was sufficient in the surface and sub-surface soils. In the pedons 1 and 3, the available P_2O_5 content decreased with depth, which might possibly be due to the confinement of crop cultivation to the rhizosphere and supplementing the depleted P by external sources *i.e.,* fertilizers to the surface soil as well as by phytocycling (Purandhar and Naidu, 2020) [11]. Variations in available P contents in remaining pedons, might be related to the intensity of soil disturbance and the degree of P- fixation with Fe and cations in the soil (Osujieke *et al.,* 2018) [8].

The available K_2O of ground nut growing soils varied from 47.57-303.34 mg kg^{-1} with a mean value 135.52 kg ha^{-1} (Table 2). Taking 150 kg ha^{-1} as a critical limit, the highest available K_2O content was observed in the surface horizons and showed a decreasing trend with depth in all the pedons. This could be ascribed for greater weathering of the K bearing minerals, application of K fertilizers and upward translocation of K from lower depths along with capillary movement of ground water (Vedadri and Naidu, 2018) [18].

The available S in ground nut growing soils varied from 7.26-28.32 mg kg^{-1} with a mean of 20.31 mg kg^{-1} (Table 2). Taking 10 mg S kg^{-1} soil as critical value, the available S was sufficient in all surface horizons and a decreasing trend was observed with the depth in all the pedons. Surface horizons in the peodns of ground nut growing areas contained more available S than subsurface horizons which could be due to higher amount of organic matter in surface layers than in deeper layers. A significant correlation (0.231*) between organic carbon and available S confirmed the above trend. Similar type of correlation was also observed by Thangasamy *et al.* (2005) [17] and Leelavathy *et al.* (2021) [7].

Table 1: Physico–chemical properties of soils

Pedon No. & Horizon	Depth (m)	Organic carbon (%)	$CaCO_3$ (%)	pH 1:2.5		EC(dS m^{-1})
				H_2O	*1N* KCl	
Pedon 1						
Ap	0.00-0.15	0.28	7.5	5.88	4.90	0.04
Bw	0.15-0.40	0.21	10.5	6.53	5.42	0.06
R	0.40	Hard weathered gneiss				
Pedon 2						
Ap	0.00-0.20	0.39	11	7.55	6.56	0.10
Bw1	0.20-0.44	0.10	10.5	7.35	5.80	0.05
Bw2	0.44-0.68	0.07	10.0	7.05	5.25	0.05
Cr	0.68	Weathered gneiss				
Pedon 3						
Ap	0.00-0.20	0.70	10.5	7.71	6.56	0.14
Bt	0.20-0.45	0.36	12.5	7.92	6.13	0.09
R	0.45	Hard weathered gneiss mixed with lime				
Pedon 4						
Ap	0.00-0.20	0.25	11.0	7.16	6.12	0.12
Bw1	0.20-0.40	0.15	11.5	8.10	6.91	0.15
Bw2	0.40-0.65	0.07	19.5	8.32	6.82	0.15
Cr	0.65	Weathered gneiss				
Mean		0.25	11.45	7.35	6.47	0.09
Range		0.07-0.70	7.5-19.5	5.88-8.32	4.90-6.91	0.04-0.15

Micronutrients

The available Zn content in the soil profiles of ground nut growing areas was varied from 0.03 mg kg^{-1} to 0.89 mg kg^{-1} with a mean of 0.53 mg kg^{-1} (Table 3). Further, by taking 0.75 mg Zn kg^{-1} soil as critical limit, the surface horizons of pedons 2, 3 and 4 were above the critical limit and surface and sub-surface horizons in all pedons of 1, 3 and 4 were below the critical limit exhibited lower values than critical limit. Lower available Zn in deeper layers can be ascribed to low amount of organic carbon in these deeper layers which was confirmed by significant and positively correlation (r =+0.133*) of Zn with organic carbon. Similar findings were reported by Sireesha and Naidu (2013) [14] and Leelavathy *et al.* (2021) [7].

The available Fe status in all the pedons was found to be varied from 2.52 and 12.06 mg kg^{-1} soil with a mean of 6.85 mg kg^{-1} soil (Table 3). According to critical limit of 4.0 mg kg^{-1} soil, the groundnut growing soils were sufficent in available Fe content except pedon 4. The distribution of available Fe in most of the pedons did not show a consistent pattern but abruptly decreased. It might be due to accumulation of organic carbon and prevalence of reduced conditions in the surface horizons. The organic carbon due to its affinity to influence the solubility and availability of Fe by chelation effect might have protected the Fe from oxidation and precipitation, which consequently increased the availability of iron (Prasad and Sakal, 1991) [10].

Available Cu in the pedons ranged from 0.62 to 1.32 mg kg^{-1} with an average of 0.92 mg kg^{-1} (Table 3). Considering on 0.5 mg Cu kg^{-1} soil as a critical limit the available Cu in ground nut growing areas was sufficient in the horizons of all the pedons. Available Cu was positively correlated (r=+0.096*) with organic carbon as accumulation of more organic carbon could have fixed more copper. Similar findings were also reported by supriya *et al.* (2019) [15].

The available Mn in groundnut growing soils varied from 7.18 to 45.84 mg kg^{-1} with a mean of 20.30 mg kg^{-1} (Table 3). The available Mn in all the pedons of groundnut growing areas was found to be adequate as per the critical limit of 2.0 mg Mn kg^{-1} soil. In general the higher Mn in surface horizons might be due to comparatively higher biological activity and the chelating of organic compounds released during the decomposition of organic matter left after harvest of crop. However, the higher Mn (*i.e.,* above critical limit) in subsurface horizons might be derived from the parent material. It is further supported by a positive correlation between available manganese with organic carbon (r = +0.236*). Similar findings were made by Reddy and Naidu (2016) [12].

Conclusions

Groundnut growing soils of Vepurikota microwatershed of Chittoor district, Andhra Pradesh were classified into Inceptisols (Lithic Haplustepts and Typic Haplustepts) and Alfisols (Lithic Haplustalfs). These soils were moderately acidic to moderately alkaline, non-saline and low in organic carbon. They were deficient in available nitrogen and sufficient in available P_2O_5 and S. However, the available K_2O was deficient to sufficient in these soils. The DTPA extractable Cu and Mn were found to be sufficient in surface and sub-surface horizons of all the pedons. The available Zn was deficient to sufficient in all the pedons in both surface and sub-surface horizons except pedon 1 and the available Fe was found to be sufficient and above the critical limits except pedon 4. Hence, judicious use of organics with inorganics not only sustains soil fertility of ground nut growing soils but also the productivity of ground nut growing soils in Vepurikota microwatershed of chittoor district in Andhra Pradesh.

Table 2: Macronutrient status of ground nut growing soils of Vepurikota microwatershed of Chittoor district

Pedon No. & Horizon	Depth (m)	Available macronutrients			
		N	P_2O_5	K_2O	S
		(Kg ha^{-1})			
Pedon 1					
Ap	0.00-0.15	238.33	67.73	303.07	18.49
Bw	0.15-0.40	225.79	55.17	191.52	7.26
R	0.40	Hard weathered gneiss			
Pedon 2					
Ap	0.00-0.20	137.98	123.78	135.07	28.32
Bw1	0.20-0.44	112.89	79.34	87.36	12.19
Bw2	0.44-0.68	112.89	85.97	65.18	7.82
Cr	0.68	Weathered gneiss			
Pedon 3					
Ap	0.00-0.20	175.61	215.98	303.34	15.24
Bt	0.20-0.45	137.98	115.40	64.64	9.11
R	0.45	Hard weathered gneiss mixed with lime			
Pedon 4					
Ap	0.00-0.20	188.16	107.49	106.71	21.35
Bw1	0.20-0.40	163.07	71.05	50.80	15.55
Bw2	0.40-0.65	150.52	84.98	47.57	9.54
Cr	0.65	Weathered gneiss			
Mean		164.32	100.69	135.52	14.48
Range		112.89-238.33	55.17 215.98	47.57-303.34	7.26-28.32

Table 3: Micronutrient status of groundnut growing soils of Vepurikota microwatershed of Chittoor district

Pedon No. & Horizon	Depth (m)	Available macronutrients			
		Zn	Cu	Fe	Mn

		(mg kg^{-1})			
Pedon 1					
Ap	0.00-0.15	0.15	1.16	9.43	45.84
Bw	0.15-0.40	0.11	0.95	8.31	45.51
R	0.40	Hard weathered gneiss			
Pedon 2					
Ap	0.00-0.20	0.87	0.80	6.53	9.02
Bw1	0.20-0.44	0.69	0.78	10.52	7.18
Bw2	0.44-0.68	0.62	0.63	12.06	10.24
Cr	0.68	Weathered gneiss			
Pedon 3					
Ap	0.00-0.20	0.77	0.97	7.37	27.30
Bt	0.20-0.45	0.03	0.62	4.38	8.13
R	0.45	Hard weathered gneiss mixed with lime			
Pedon 4					
Ap	0.00-0.20	0.89	1.32	4.22	24.13
Bw1	0.20-0.40	0.52	1.08	3.21	16.99
Bw2	0.40-0.65	0.50	0.91	2.52	8.72
Cr	0.65	Weathered gneiss			
Mean		0.53	0.92	6.85	20.30
Range		0.03-0.89	0.62-1.32	2.52-12.06	7.18-45.84

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