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GP Leelavathi
Department of Soil Science and Agricultural Chemistry, S.V. Agricultural College, Acharya N.G. Ranga Agricultural University, Tirupati, Andhra Pradesh, India

MVS Naidu
Professor and Head, Department of Soil Science and Agricultural Chemistry, S.V. Agricultural College, Acharya N.G. Ranga Agricultural University, Tirupati, Andhra Pradesh, India

Corresponding Author:
MVS Naidu
Professor and Head, Department of Soil Science and Agricultural Chemistry, S.V. Agricultural College, Acharya N.G. Ranga Agricultural University, Tirupati, Andhra Pradesh, India

Vertical distribution of nutrients in groundnut growing soils in semiarid region of Yerpedu mandal in Chittoor district, Andhra Pradesh

GP Leelavathi and MVS Naidu

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Abstract
A survey was undertaken to study vertical distribution of nutrients in the soil profiles/ pedons arranged in groundnut growing areas of Yerpedu mandal in Chittoor district, Andhra Pradesh to understand nutrients supplying capacity of lower layers of soil profiles. The results revealed that, the available P in groundnut growing soils was sufficient in the surface and subsurface horizons of all pedons except pedon 5 wherein P was deficient in subsurface horizon while the available K was sufficient in surface horizons but deficient to sufficient in subsurface horizons in all the pedons. The exchangeable Ca and Mg and available S in groundnut growing soils were sufficient in surface and subsurface horizons of all the pedons. However, the available S in groundnut growing soils was high in surface horizons than in subsurface horizons whereas exchangeable Ca and Mg showed an irregular trend with depth. The DTPA-extractable Zn, Fe, Cu and Mn in groundnut growing soils were found to be above their critical limits in surface and subsurface horizons in all the pedons except in pedons 4 and 5 for Fe in surface and subsurface horizons and Mn in subsurface horizons. All the micronutrients were higher in surface soils than subsurface soils except in pedons 4 and 5 for Fe.

Keywords: Macronutrients and micronutrients, organic carbon, pH, subsoil and surface soil

Introduction

Knowledge of vertical distribution of plant nutrients in soil is useful as roots of most of the crops go beyond the surface layer and draw part of their nutrient requirement from the subsurface layers of the soil. Most of the researchers have limited their studies on fertility status of surface layer only. Very few have attempted to study layer wise fertility status of soils, which is very important for effective nutrient application. For efficient nutrient management the depth wise distribution of nutrients in soil profiles is highly essential for achieving sustainable yields (Ramalakshami and Sheshagiri Rao, 2000). Though sporadic information is available regarding depth wise distribution of macro and micronutrients, however detailed information regarding the vertical distribution of macro and micronutrients status in groundnut growing soils of Chittoor district in particular and in general in Andhra Pradesh is very much lacking. Hence, present survey was conducted to study the depth wise distribution of nutrients in groundnut growing soils of Yerpedu mandal in Chittoor district, Andhra Pradesh, since groundnut is the major crop in study area.

Materials and Methods

Location and Agro-climate: Yerpedu mandal of Chittoor district, Andhra Pradesh lies in between 13°36′ and 13°40′ North latitude and 79°18′ and 79°28′ East longitude covering an area of 18971.00 ha. The climate of the study area is semi-arid monsoonic with mean annual rainfall of 1203.66 mm, of which 90 per cent is received during June to December. The mean annual temperature is 27°C with mean summer temperature of 31°C and the mean winter temperature of 27°C. The maximum temperature is recorded in the month of May that rises to 39°C and the minimum temperature is 25°C in the month of December. The soil moisture regime is ustic and soil -temperature regime iso-hyperthermic.

Field survey and Taxonomic classification: Reconnaissance soil survey was conducted and five pedons were arranged in the groundnut growing areas of Yerpedu mandal in Chittoor district, Andhra Pradesh. The taxonomy of these five pedons *viz.*, Pallam pedon (P1- Fine, kaolinitic, iso-hyperthermic, Typic Haplustepts), Gudimallam pedon (P2- Fine-loamy, mixed, iso-hyperthermic, Ultic Haplustalfs), Merlapaka pedon (P3- Fine, smectitic, iso-hyperthermic, Typic Haplustepts), Pennagadam pedon (P4-Sandy, siliceous, iso-hyperthermic, Typic Ustisamments) and Munagalapalem pedon (P5 – Fine-loamy, siliceous, iso-hyperthermic, Typic Ustifluvents). The horizon wise soil samples were collected for detailed analysis. The pedons P1 and P3 belongs to Inceptisols, P4 and P5 were grouped under Entisols and P2 was classified into Alfisols. The soil samples were processed and analyzed for available macronutrients, available and total micronutrients using standard methods as described by Jackson (1973) [4].

The critical limits proposed by Patel and Savani (1987) [7] for available P (13 kg P ha^{-1}), Aulakh *et al.* (1988) [2] for available K (150 kg K ha^{-1}), Tandon (1991) [14] for exchangeable Ca (1.5 cmol (p^+) kg^{-1}), Mg (1.0 cmol (p^+) kg^{-1}) and available S (10 mg kg^{-1}), Anon (1977) [1] for Zn (0.75 mg kg^{-1}), and Tandon (1993) [15] 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 with respect to above nutrients for groundnut.

Results and Discussion

The groundnut growing soils were slightly acidic to strongly alkaline in reaction (6.54-8.99) and this 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 (Devi *et al.* 2015) [3]. The texture of the groundnut growing soils varied from sand to sandy clay and this wide textural variation was caused by topographic position, nature of parent material, *in situ* weathering and translocation of clay (Leelavathi *et al*. 2009) [6]. The EC in groundnut growing soils ranged from 0.03 to1.24 dSm^{-1} indicating the non-saline. The low EC of groundnut growing soils was due to free drainage conditions which favoured the removal of released bases by percolating and drainage water (Sashikala *et al*. 2019) [11]. The organic carbon content of the groundnut growing soils was low (0.05 to 0.44 per cent), which might be attributed to the prevalence of tropical condition, where the degradation of organic matter occurs at a faster rate coupled with low vegetation cover, there by leaving less organic carbon in the soils (Supriya *et al.* 2019) [13].

Macronutrients: The available phosphorus varied from 10.37 to 19.17 kg ha^{-1} in all the pedons of groundnut growing areas with a mean of 14.93 kg ha^{-1} (Table 1). Taking 13 kg P ha^{-1} as critical level, the available P status was sufficient in the surface and subsurface soils except in pedon 5 (Munagalapalem) showing deficiency in subsurface horizons. In all the pedons of groundnut growing areas, the available P content decreased with depth, which might possibly be due to the confinement of crop cultivation to the rhizosphere and supplementing the depleted phosphorus by external sources *i.e.*, fertilizers and presence of free iron oxide and exchangeable Al^{3+} in smaller amounts. The lower phosphorus content in sub-surface horizons could be attributed to the fixation of released phosphorus by clay minerals and oxides of iron and aluminum (Kumar and Naidu, 2012) [5].

The available potassium content of groundnut growing soils varied from 30.24 to 669.76 kg ha^{-1} with a mean value 212.5 kg ha^{-1}. Based on 150 kg ha^{-1} as a critical limit, the highest available potassium content was observed in the surface horizons and showed more or less a decreasing trend with depth in pedon 2 (Gudimallam), pedons 3 (Merlapaka) and pedon 4 (Pennagadam). This could be ascribed to more weathering of the potassium bearing minerals, application of K fertilizers and upward translocation of potassium from lower depths along with capillary raise of ground water (Vedadri and Naidu, 2018) [17].

The exchangeable Ca in groundnut growing soils ranged from 2.10 to 16.86 cmol (p^+) kg^{-1} of soil with a mean of 8.27 cmol (p^+) kg^{-1} of soil. Similarly the exchangeable Mg in groundnut growing areas was found to vary from 0.80 to 5.80 cmol (p^+) kg^{-1} of soil with a mean of 3.43 cmol (p^+) kg^{-1} of soil (Table 1). Taking 1.5 cmol (p^+) kg^{-1} of soil for Ca and 1 cmol (p^+) kg^{-1} of soil for Mg as critical limits, the exchangeable Ca and Mg in both the surface and sub-surface horizons of all the pedons of groundnut growing areas, were found to be sufficient. The exchangeable Ca was found to be the dominant cation followed by Mg on the exchange complex, because of its higher mobility, earlier removal than the later and also Ca dominates in the prevailing semi-arid weathering environment and consequently occupied the major portion on the exchange complex in the groundnut growing soils (Reddy and Naidu, 2016) [10].

The available sulphur in groundnut growing soils varied from 12.50 to 58.75 mg kg^{-1} with a mean of 36.66 mg kg^{-1} (Table 1). Taking 10 mg S kg^{-1} soil as critical value, the available sulphur was sufficient in all surface and subsurface horizons of groundnut growing areas. Surface horizons in the peodns of groundnut growing areas contained more available sulphur than subsurface horizons except Bw2 horizon of pedon 3 (Merlapaka profile) which could be due to higher amount of organic matter in surface layers than in deeper layers. A significant correlation between organic carbon and available sulphur confirmed the above trend. Similar type of correlation was also observed by Thangasamy *et al.* (2005) [16].

Micronutrients: The total zinc content in the soil profiles of groundnut growing areas was varied from 9.05 mg kg^{-1} to 28.00 mg kg^{-1} with a mean of 14.83 mg kg^{-1}, while available Zn in groundnut growing areas varied from 0.20 mg kg^{-1} to 1.30 mg kg^{-1} with a mean of 0.79 mg kg^{-1} (Table 2). Further, by taking 0.75 mg Zn kg^{-1} soil as critical limit, surface horizons in all pedons of groundnut growing areas are above the critical limit and sub-surface horizons of all pedons of groundnut growing areas except pedon 2 (Gudimallam profile) exhibited lower values than critical limit. Lower available Zn in deeper layers was due to low amount of organic carbon in these deeper layers which was confirmed by significant and positively correlation ($r = +0.404$) of Zn with organic carbon. Similar findings were reported by Sireesha and Naidu (2013) [12].

The total iron status of all the pedons of groundnut growing areas was found to be varied between 0.83 and 4.96 per cent with an average of 2.53 per cent whereas available Fe in the same groundnut growing areas varied from 0.46 to 10.13 mg kg^{-1} soil with a mean of 3.09 mg kg^{-1} soil (Table 2). According to critical limit of 4 mg kg^{-1} soil, the groundnut growing soils were deficient in available Fe content except Ap horizon of pedons 1, 2, 3, 5 and A1, E and Bt1 horizons of pedon 2 (Gudimallam profile). The distribution of available iron in all the pedons of groundnut growing areas did not show a definite 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 iron by chelation effect might have protected the iron from oxidation and precipitation, which consequently increased the availability of iron (Prasad and Sakal, 1991) [8].

Total copper content in the pedons of groundnut growing areas varied from 1.75 to 20.00 mg kg^{-1} with a mean of 5.98 mg kg^{-1} while available copper in the pedons of groundnut growing areas was ranged from 0.21 to 2.56 mg kg^{-1} with an average of 1.24 mg kg^{-1}. Based on 0.5 mg Cu kg^{-1} soil as a critical limit the available copper in groundnut growing areas was sufficient in the horizons of all pedons except C2 horizon of pedon 5 (Munagalapalem profile). Available copper was positively correlated (r=+0.344) with organic carbon because accumulation of more organic carbon could fixed more copper. Similar findings were also reported by Venkatesu *et al*. (2002) [18].

The total manganese in the pedons of groundnut growing areas varied from 45 to 727 mg kg^{-1} with a mean of 292.33 mg kg^{-1} while available Mn in groundnut growing soils varied from 0.89 to 19.93 mg kg^{-1} with a mean of 8.33 mg kg^{-1}. The available Mn in all the pedons of groundnut growing areas, except Bw2 horizons in pedon 1 (Pallam) and pedon 2 (Gudimallam) and sub-surface horizons of pedon 4 (Pennagadam) was found to be adequate as per the critical limit of 2 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 = +0.666).

Conclusion

The study revealed that the groundnut growing soils of Yerpedu mandal of Chittoor district, Andhra Pradesh were classified into Entisols (Typic Ustisamments and Typic Ustifluvents), Inceptisols (Typic Haplustepts) and Alfisols (Ultic Haplustalfs). The groundnut growing soils were slightly acidic to strongly alkaline, non-saline and low in organic carbon. The groundnut growing soils were sufficient in available phosphorus, sulphur and exchangeable calcium and magnesium in surface and subsurface soils. However, the available phosphorus was sufficient in surface soils but sufficient to deficient in subsurface soils. The DTPA-extractable Zn, Fe, Cu and Mn in groundnut growing soils were found to be above their critical limits in surface and subsurface horizons in all the pedons except in pedons 4 and 5 for Fe in surface and subsurface horizons and Mn in subsurface horizons. Hence, judicious use of organics with in-organics not only sustains soil fertility of groundnut growing soils but also sustains productivity of groundnut growing soil.

Table 1: Macronutrient status of groundnut growing soils of Yerpedu mandal of Chittoor district, Andhra Pradesh

Depth (cm)	Horizon	Available (kg ha^{-1})		Exchangeable c mol(p^+)kg^{-1}		S (mg kg^{-1})
		P	K	Ca	Mg	
Pedon 1: Pallam						
0.00-0.25	Ap	16.82	241.92	9.4	2.4	43.70
0.25-0.50	A_1	14.87	156.80	10.8	4.9	12.50
0.50-0.85	Bw_1	14.09	199.36	16.71	5.8	33.75
0.85-1.17	Bw_2	13.31	207.20	16.86	5.4	33.75
1.17-1.51	Bw_3	14.87	183.68	10.26	4.3	37.50
1.51-1.90+	C	14.87	47.04	6.8	2.0	31.25
Pedon 2: Gudimallam						
0.00-0.12	Ap	18.77	669.76	6.4	1.9	46.25
0.12-0.25	A_1	18.59	596.96	6.8	2.2	38.75
0.25-0.49	E	14.87	588.00	5.5	3.3	33.75
0.49-0.78	Bt_1	14.09	424.48	7.6	1.6	43.75
0.78-1.11	Bt_2	14.87	246.40	7.6	3.3	33.75
1.11-1.40	C	13.31	262.08	7.0	2.2	33.75
Pedon 3: Merlapaka						
0.00-0.22	Ap	19.17	196.00	6.7	4.0	43.75
0.22-0.56	Bw_1	17.23	127.68	9.8	5.5	38.75
0.56-0.78	Bw_2	15.66	90.72	12.6	5.5	58.75
0.78-0.96	Bw_3	13.31	31.36	10.3	3.8	38.75
0.96-1.20+	C	12.90	39.20	9.6	3.2	40.00
Pedon 4: Pennagadam						
0.00-0.22	Ap	16.82	155.68	5.1	2.1	33.75
0.22-0.40	A_1	16.82	114.24	3.2	1.6	27.50
0.40-0.71	A_2	15.66	97.44	2.8	1.2	31.25
0.71-1.10+	A_3	12.90	87.36	2.1	0.8	33.75
Pedon 5: Munagalapalem						
0.00-0.20	Ap	14.87	320.32	9.1	4.7	43.75
0.20-0.46	A_1	12.90	234.08	9.4	5.3	38.75
0.46-0.70	A_2	12.90	150.08	9.1	4.8	38.75
0.70-1.03	C_1	17.74	30.24	7.8	4.3	35.00
1.03-1.37	C_2	10.37	57.12	7.0	3.4	31.25
1.37-1.90+	C_3	10.57	184.80	6.9	3.0	33.75
Mean		14.93	212.50	8.27	3.43	36.66
Range		10.37-19.17	30.24-669.76	2.1-12.6	0.8-5.5	12.50-58.75

Table 2: Micronutrient status of groundnut growing soils of Yerpedu mandal of Chittoor district, Andhra Pradesh

Depth (cm)	Horizon	Zn (mg kg^{-1})		Fe (mg kg^{-1})		Cu (mg kg^{-1})		Mn (mg kg^{-1})	
		Total	Available	Total (%)	Available	Total	Available	Total	Available
Pedon 1: Pallam									
0.00-0.25	Ap	11.35	1.04	2.70	6.75	6.75	2.00	432	14.10
0.25-0.50	A_1	13.10	0.76	4.96	2.78	8.50	1.81	200	13.21
0.50-0.85	Bw_1	10.65	0.61	1.52	0.59	5.75	1.00	182	4.40
0.85-1.17	Bw_2	14.30	0.20	3.28	0.46	8.50	0.45	300	1.60
1.17-1.51	Bw_3	10.33	0.31	3.63	1.16	5.00	0.59	187	2.84
1.51-1..90+	C	10.78	0.78	1.73	1.11	4.25	0.85	250	3.24
Pedon 2: Gudimallam									
0.00-0.12	Ap	15.90	1.30	2.20	5.94	2.75	1.12	322	14.55
0.12-0.25	A_1	9.70	0.99	1.78	6.66	2.75	1.43	402	7.14
0.25-0.49	E	11.78	1.21	2.06	10.13	3.00	2.51	325	16.05
0.49-0.78	Bt_1	26.40	1.10	1.89	5.84	8.75	1.83	560	13.55
0.78-1.11	Bt_2	20.85	1.20	3.91	4.39	8.25	2.44	727	19.91
1.11-1.40	C	18.40	1.09	2.91	2.95	7.00	2.28	540	19.93
Pedon 3: Merlapaka									
0.00-0.22	Ap	12.43	0.84	4.00	5.40	7.00	2.56	590	14.55
0.22-0.56	Bw_1	16.78	0.43	2.19	2.16	20.00	0.75	217	4.99
0.56-0.78	Bw_2	12.45	0.37	1.85	1.31	6.75	0.49	182	1.51
0.78-0.96	Bw_3	10.77	0.45	0.92	1.53	6.25	0.66	275	7.44
0.96-1.20+	C	15.23	0.35	1.80	1.21	7.00	0.48	380	6.15
Pedon 4: Pennagadam									
0.00-0.22	Ap	15.58	0.99	1.20	1.41	2.50	0.84	135	2.88
0.22-0.40	A_1	28.00	0.69	0.83	1.80	3.50	0.80	57	0.89
0.40-0.71	A_2	9.53	0.80	0.97	1.35	1.75	0.55	45	1.00
0.71-1.10+	A_3	9.05	0.74	1.83	1.38	2.25	0.51	47	1.29
Pedon 5: Munagalapalem									
0.00-0.20	Ap	18.40	1.28	4.42	4.65	7.75	1.66	362	12.58
0.20-0.46	A_1	10.30	0.83	3.66	2.45	4.50	1.91	162	12.09
0.46-0.70	A_2	18.80	0.71	4.14	2.06	6.25	1.39	282	7.53
0.70-1.03	C_1	14.73	0.78	2.61	2.99	5.25	1.71	240	11.01
1.03-1.37	C_2	20.08	0.69	1.47	2.23	5.00	0.21	275	6.90
1.37-1..90+	C_3	14.63	0.71	3.72	2.78	4.50	0.75	217	3.51
Mean		14.83	0.79	2.53	3.09	5.98	1.24	292.33	8.33
Range		9.05-28.00	0.20-1.30	0.83-4.96	0.46-10.13	1.75-20.00	0.21 – 2.56	45-590	0.89-19.93

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