The Andhra Agric. J 71 (2): 210-216, 2024
doi :10.61657/aaj.2024.118

Soil physico-chemical properties and nutrient status of Tekkali mandal of Srikakulam district, Andhra Pradesh

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ABSTRACT

Seven representative soil profiles of Telinelapuram, Thirlangi, Lingalavalasa, Parasurampuram, Ravivalasa, Narsingapalli and Naupada villages from Tekkali mandal of Srikakulam district of Andhra Pradesh were exposed and horizon-wise soil samples were collected from each profile and analyzed for soil pH, EC, organic carbon, CEC and available micro and macro nutrients. The data revealed that the soils exhibit slighty acidic to moderately alkaline (soil pH 6.32 to 8.65) in nature, non saline (EC 0.07 to 0.89 dS m^{-1}), low to medium in organic carbon content (0.08 to 0.75 per cent). Cation exchange capacity of soils ranged from 8.30 to 19.15 Cmol/kg soil. The exchangeable calcium in profiles of study area was the most dominant cation, which ranged from 2.40 to 11.00 cmol (p^+) kg^{-1} soil. The results of laboratory data revealed that soil exchangeable complex of all the profiles studied was dominated by base cations in the order of$Ca^{2+}>Mg^{2+}>Na^+>K^+$. The percent base saturation of the soils ranged from 43.48 to 81.54 per cent. The soils were low to medium in available nitrogen (46.3 to 285.7 kg ha^{-1}), low to medium in available phosphorus (6.16 to 44.40 kg ha^{-1}), medium to high in available potassium (170.61 to 597.13 kg ha^{-1}) and sufficient in sulphur (12.09 to 27.78 mg kg^{-1}). About available micronutrient status, soil available zinc content ranged from 0.07 to 0.86 ppm, available iron ranged from 2.03 to 15.32 ppm, available manganese ranged from 3.11 to 18.07 ppm, and available copper ranged from 0.45 to 3.92 ppm. The available micronutrient status of soils indicated the soils were deficient in available zinc (except surface layer of profile3), sufficient in iron, manganese and copper. The statistical analysis of the results for correlation coefficients (r) revealed that available nitrogen, phosphorous, potassium, zinc, iron, copper and manganese were positively correlated with organic carbon content, while available phosphorous and micronutrients were negatively correlated with soil pH.

Key words: *Available nutrients, Organic carbon, pH, E.C and Tekkali mandal.*

Soil is the most important basic natural resource that determines the ultimate sustainability of any agricultural system. Study of soil today has assumed an increased importance due to rapidly declining land area under agriculture, declining of soil fertility and increasing soil degradation through unbridled population increase, urbanization, improper land use policies and irrational use of agricultural inputs (Kanwar *et al.,* 2004). Appropriate management of the soil with minimal adverse environmental influence is necessary for strategic development and can be best utilized effectively and gainfully through watershed approach (Ghose *et al*., 2008). A thorough and proper understanding of morphological, physical, and chemical characteristics of the soil gives greater insight of the dynamics of the soil. Soil inventory provides soil characters and they support the decision making system of soil management. Not much information is available on the available nutrient status of soils in Tekkali mandal in particular. A necessity is always felt for more soil inventory database for proper planning and execution of crop plans.

MATERIAL AND METHODS

Tekkali mandal of Srikakulam dstrict was located between 18^0 12' 820'' to18^0 32' 876'' N latitude and 83^0 29'889'' to 83^0 37' 727'' E longitude covering 14,786 ha and comprises of fifty four revenue villages. A reconnaissance soil survey was conducted in the area of Tekkali mandal during April to June, 2021 using toposheets of 1: 50,000 scale as per the procedure outlined by AIS&LUS (1970). Auger bores, mini pits, road cuts of 15 profiles located on uplands and plains were studied. Soil correlation exercise resulted in seven representative profiles viz., Telinelapuram, Thirlangi, Lingalavalasa, Parasurampuram, Ravivalasa, Narsingapalli and Naupada villages. These seven soil profiles were exposed and horizon-wise soil samples were collected. In each horizon bulk density was determined by core sampler method. Representative soil samples were dried in shade and pulvarised and passed through a 2 mm sieve and the fine earth fraction was analyzed in laboratory for soil fertility characters by following chemical standard procedure. Soil reaction (pH) and soluble salt concentration (EC) were estimated by the procedures outlined by Jackson (1973). The organic carbon content of the soil samples was estimated by wet digestion method described by Gurumurthy (2023). Exchangeable basses and cation exchange capacity (CEC) were determined by a centrifuge extraction procedure using neutral normal ammonium acetate as described by Bower *et al.* (1952). Available nitrogen was determined by modified alkaline potassium permanganate method (Subbiah and Asija, 1956). Available phosphorous and sulphur in soil was extracted with 0.5M $NaHCO_3$ of pH 8.5 and 0.15% $CaCl_2$ respectively, both are measured in spectrophotometer (Olsen *et al*., 1954). Available soil potassium was extracted with neutral normal ammonium acetate and measured in flame photometer (Jackson, 1973). The available zinc, copper, iron and manganese in soils were extracted by DTPA and measured by using atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Soil Physico-chemical properties

The soil pH of various horizons of all the seven profiles studied ranged from 6.32 to 8.65 (Table 1) exhibits slightly acidic to moderately alkaline in nature. Profile 1 exhibited Neutral to slightly alkaline pH, profile 2 exhibits neutral to moderately alkaline nature, profiles 3, 4, 5 and 6 exhibits slightly acidic to neutral, while profile 7 exhibits neutral reaction, In general, all the profiles showed an increasing trend in soil pH with depth, which could be due to continuous removal of basic cations by crop plants and or leaching of basic cations to deeper layers along with percolating water as well as release of organic acids in surface layers during decomposition of organic matter. Increase of soil pH with depth due to accumulation of base cations with soil depth. Similar observations were also recorded by Mahapatra *et al.,* (2019) that the acidic and neutral nature of surface soil layers is due to the reasons of leaching and accumulation of base cations.

The soluble salt concentration in the form of electrical conductivity of the soil profiles ranged from 0.07 to 0.89 dS m^{-1}. All the profiles studied were non saline in nature. The profiles 3, 4, and 6 recorded relatively low EC, while profiles 2 and 5 recorded relatively high EC. The lower electrical conductivity could be due to the relative coarse texture, which encouraged leaching of soluble salts, while high EC is due to finer texture which caused poor drainage and subsequent accumulating of salts.

The organic carbon content of study area ranged from 0.08 to 0.75 per cent. The organic carbon status of the soils in general was low except in the surface layer of all the profiles wherein it was medium status. The organic carbon content showed a decreasing trend with soil depth. The decrease trend of organic matter with soil depth is due to low biological activity in lower soil layers. Srinivasan *et al.,* (2020) also found similar observations in mango growing soils of Ananthpuramu district. Cation exchange capacity (CEC) of soils ranged from 8.30 to 19.15 Cmol/kg soil. Highest value of CEC was observed in lower horizons of profile 5(Ravivalasa) and lowest value was observed in upper horizon of profile 4 (Parasurampuram). The CEC trend was observed as increased with increasing soil depth.

The exchangeable calcium in profiles of study area was the most dominant cation, which ranged from 2.40 to 11.00 cmol (p^+) kg^{-1} soil. In general, all the profiles exhibited increasing trend in exchangeable calcium content with depth. Magnesium was the second dominant cation on the exchange complex of soils studied. The exchangeable Mg, Na & K values varied from 0.41 to 3.60, 0.22 to 1.70 & 0.10 to 0.80 cmol (p^+) kg^{-1} soil respectively. All the profiles did not follow specific trend in magnesium, sodium and potassium distribution with soil depth. The bivalent cations, like Ca^{2+} and Mg^{2+} are relatively less mobile, yet among the two, Mg^{2+} ions are more mobile than

Ca^{2+} ions. As such, Mg^{2+} ions are leached out earlier than the Ca^{2+} ions leading to the dominance of Ca^{2+} on exchange complex. The results of laboratory data revealed that soil exchangeable complex of all the profiles studied was dominated by base cations in the order of$Ca^{2+}>Mg^{2+}>Na^{+}>K^{+}$. Exchangeable potassium was low in the soils which might be due to less predominance of micaceous minerals in the study area. The percent base saturation of the soils ranged from 43.48 to 81.54 per cent. Profiles 4 and 6 showed relatively low base saturation due to coarse texture and low pH while high base saturation in profiles 2 and 5 due to alkaline pH. Similar results were reported by Meena *et al*. (2014).

Available macro nutrient status of soils

The available nitrogen content in the soils studied ranged from 46.3 to 285.7 kg ha^{-1} (Table 2). It was found that relatively highest available N in surface horizons and decreased regularly with depth which is due to decreasing trend of organic carbon with depth and the cultivation of crops is mainly confined to the surface horizon (rhizosphere) only Among profiles not much deviation of available nitrogen was observed since all profiles were in the semi-arid climate to sub-humid climate. Statistical data showed a significant positive correlation (r = 0.882*) between available nitrogen and organic carbon (table 3). Similar observations were reported by Himabindu *et al*. (2019).

The available phosphorus (P_2O_5) content ranged from 6.16 to 44.40 kg ha^{-1}. Wide variations were observed within the profiles. All the seven profiles exhibited decreasing trend of available phosphorous with depth. High organic matter in the surface and addition of phosphotic fertilizers to crops were the causes for high phosphorus content in the surface soils. A significant positive correlation (r =0.579**) was recorded between organic carbon and available phosphorus content of soil. Similar results were also observed by Sekhar *et al*. (2014).

The available potassium content of the soils ranged from 170.61 to 597.13 kg ha^{-1}. Profiles 3 and 5 exhibited a decreasing trend with depth and the remaining profiles 1, 2, 4, 6 and 7 did not show any definite pattern with change in depth. Similar observations are recorded by Vedadri *et al.* (2015). The decreasing trend of available K with depth, which might be attributed to more intense weathering, release of labile K from organic residues, upward translocation of potassium from lower depths along with capillary rise of ground water and application of K fertilizers.

The sulphur content of the soils ranged from 12.09 to 27.78 mg kg^{-1}. All profiles exhibited a decreasing trend with depth. In general, all the profiles had recorded sufficient sulphur content which might be due to regular addition of organic matter and sulphur containing complex fertilizers fertilizers and pesticides. More or less all pedons showed a decreasing trend with increasing depth was observed. Surface layers contained almost more available sulphur than sub-surface layers which might be due to higher amount of organic matter in surface layers than in deeper layers.

Available micronutrient status of soils

The available zinc content ranged from 0.07 to 0.86 ppm. Generally with increase in depth the distribution of available zinc decreases in all the profiles, which could be ascribed to decrease trend of organic carbon in soil profiles. The statistical data showed significant and positive correlation (r = +0.620**) between soil organic carbon and available zinc. Relatively low available zinc in profiles 1, 2 and 5 was due to high soil pH and low organic matter which have resulted in the formation of insoluble compounds of zinc or insoluble calcium zincate. The availability of zinc had a negative correlation with soil pH(r=-0.708**). The results were in conformity with Sreedharreddy and Naidu (2016).

The available iron content ranged from 2.03 to 15.32 ppm. Generally decreasing trend of available iron content with soil depth was recorded in all the profiles. Considering the critical limit of 4.5 ppm suggested by Lindsay and Norvell (1978), the low iron content in profiles 1, 2 and 5 might be due to precipitation of Fe^{2+} owing to alkaline pH of these soils. The statistical data showed positive correlation of available iron with organic carbon (r = 0.626**) and negative correlation between available iron content and soil pH (r= -0.625**). This findings, are in accordance with Himabindu et al (2019).

The available manganese content ranged from 3.11 to 18.07 ppm ,which is sufficient (above the critical limit of 1.0 ppm) in all the soils of study area. Available manganese in soils was relatively high in the surface horizons and observed decreased trend with depth, which might be due to comparatively higher biological activity in the surface horizons and the chelating of Mn by organic compounds, released during the decomposition of organic matter. These observations are similar by Vedadri *et al.* (2015). The available copper content varied from 0.45 to 3.92 ppm, the values are more than critical level (0.2 ppm) thus sufficient in availability. Available Cu in soils was positively correlated with organic carbon content (r =0.433*) and negatively correlated with pH (r = -0.436*).

CONCLUSION

The soil reaction of *Tekklai* soils was acidic to alkaline in reaction, non saline in soluble salt concentration, low to medium in organic carbon content. The soils in general were low in available nitrogen, low to medium in available phosphorus, medium to high in available potassium and sufficient in sulphur while the micronutrients were sufficient in iron, manganese and copper however remaining deficient in zinc. The statistical analysis of the results for correlation coefficients (r) revealed that there was significant positive correlation of soil organic carbon with available nitrogen status, available phosphorous, available potassium, available zinc, available manganese, available copper and available iron. Soil pH was negatively correlated with available phosphorous and micronutrients. The results indicated that the soil were widely varied in soil physic-chemical and fertility characters and hence suggestive of soil test based fertilizer management for sustainable crop production.

ACKNOWLEDGEMENTS

The authors are indebted to Acharya NG Ranga Agricultural University for providing financial support and infrastructural facilities for the study.

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Table.1: Soil physic- chemical properties of *Tekkali* mandal soils

Profile No. &Horizon	Depth (m)	pH	E.C(dS m^{-1})	OC (%)	CEC (Cmol/ kg)	Exchangeable base cations (Cmol/kg)				Base saturation (%)
						Ca	Mg	Na	K	
1.Telinelapuram										
Ap	0.00-0.22	7.32	0.22	0.60	12.17	3.80	2.40	1.26	0.50	65.41
Bw1	0.22-0.34	7.58	0.26	0.42	13.48	4.80	2.60	1.04	0.74	68.10
Bw2	0.34-0.55	7.70	0.31	0.30	15.43	5.20	3.00	1.68	0.74	68.83
Bw3	0.55-0.73	8.02	0.50	0.30	14.57	5.90	2.60	1.70	0.50	73.44
Bw4	0.88-1.02+	7.98	0.38	0.29	15.43	6.50	2.80	1.42	0.80	74.66
2.Thirlangi										
Ap	0.00-0.16	7.23	0.31	0.75	15.48	6.40	3.40	1.56	0.21	74.26
Bw1	0.16-0.28	7.92	0.53	0.30	16.74	7.20	3.60	1.56	0.24	75.27
Bw2	0.28-0.47	7.98	0.74	0.15	17.83	7.60	3.60	1.56	0.29	73.19
Bw3	0.47-0.72	8.37	0.74	0.15	17.83	8.10	3.40	1.44	0.26	74.03
Ck	0.72-0.97+	8.65	0.89	0.08	16.74	8.30	3.60	1.51	0.24	81.54
3.Lingalavalasa										
Ap	0.00- 0.15	6.32	0.15	0.75	9.13	3.40	0.65	0.36	0.22	50.71
Bt1	0.15-0.34	6.57	0.16	0.53	12.17	4.40	0.85	0.52	0.24	49.38
Bt2	0.34-0.50	6.40	0.16	0.30	13.48	4.80	1.20	0.76	0.21	51.71
Bt3	0.50-0.70	6.55	0.14	0.30	13.48	4.80	1.60	0.85	0.26	55.71
Bt4	0.70-0.90+	6.58	0.13	0.09	14.57	4.60	2.00	0.80	0.29	52.78
4.Parusurampuram										
Ap	0.00-0.12	6.43	0.09	0.30	8.30	2.40	0.85	0.32	0.12	43.48
A1	0.12-0.24	6.68	0.07	0.15	8.30	2.60	1.05	0.38	0.14	50.24
A2	0.24-0.34	7.15	0.08	0.15	9.13	2.40	1.05	0.42	0.10	44.46
C	0.34-0.74+	7.02	0.09	0.08	10.17	3.10	1.35	0.42	0.18	49.66
5.Ravivalasa										
Ap	0.00-0.14	7.32	0.39	0.53	14.57	6.80	1.60	1.02	0.42	67.54
Bw1	0.14-0.28	7.47	0.59	0.42	16.48	8.20	2.50	0.78	0.34	71.72
Bw2	0.28-0.52	7.81	0.61	0.30	17.83	10.60	1.80	0.78	0.24	75.27
Bw3	0.52-0.72	8.22	0.79	0.15	19.15	11.00	1.40	1.32	0.53	74.41
Ck	0.72-0.94+	8.36	0.72	0.15	17.83	10.60	2.00	1.08	0.56	79.87
6.Narsingapalli										
Ap	0.00-0.21	6.38	0.07	0.60	6.55	2.40	0.41	0.22	0.10	47.79
Bt1	0.21-0.43	7.14	0.15	0.30	8.65	3.02	0.92	0.22	0.18	50.17
Bt2	0.43-0.77	7.18	0.22	0.30	10.65	3.60	1.06	0.30	0.18	48.26
Bt3	0.77-0.94+	7.63	0.20	0.15	10.65	3.55	1.06	0.33	0.15	47.79
7.Naupada										
Ap	0.00-0.23	6.53	0.41	0.53	12.65	3.85	1.06	0.85	0.33	48.14
Bw1	0.23-0.45	6.95	0.48	0.23	13.30	4.22	1.25	0.85	0.33	50.00
Bw2	0.45-0.60	7.19	0.55	0.15	14.57	3.80	1.80	1.22	0.56	50.65
Bw3	0.60-0.92+	7.36	0.53	0.15	15.48	4.82	1.60	0.85	0.44	49.81

Table.2: Nutrient status of *Tekkali* mandal soils

Profile No. &Horizon	Depth (m)	Available macronutrients				Available micronutrients			
		N	P_2O_5	K_2O	S	Zn	Cu	Fe	Mn
		(kg ha^{-1})			(mg kg^{-1})				
1.Telinelapuram									
Ap	0.00-0.22	108.2	35.66	224.6	26.38	0.44	3.79	6.33	5.13
Bw1	0.22-0.34	53.7	19.31	239.3	24.34	0.12	2.11	6.97	7.27
Bw2	0.34-0.55	60.0	16.16	254.0	20.84	0.11	3.14	5.93	6.13
Bw3	0.55-0.73	44.2	11.29	597.1	19.50	0.11	1.32	4.27	5.29
Bw4	0.88-1.02+	22.1	8.57	398.1	17.41	0.10	0.45	4.82	4.00
2.Thirlangi									
Ap	0.00-0.16	153.2	22.37	472.0	22.75	0.21	3.11	3.39	5.12
Bw1	0.16-0.28	88.5	16.75	243.6	18.86	0.12	2.51	3.09	4.46
Bw2	0.28-0.47	91.6	16.75	260.6	17.14	0.12	2.33	3.03	4.15
Bw3	0.47-0.72	75.8	7.94	237.9	16.26	0.12	2.13	2.22	3.11
Ck	0.72-0.97+	75.8	6.67	175.3	12.09	0.07	2.32	2.91	4.08
3.Lingalavalasa									
Ap	0.00- 0.15	142.2	38.49	341.2	26.54	0.86	3.92	12.91	12.26
Bt1	0.15-0.34	88.5	25.64	312.8	24.84	0.32	3.26	12.85	10.88
Bt2	0.34-0.50	75.8	12.31	199.0	23.33	0.12	3.55	13.91	10.88
Bt3	0.50-0.70	56.9	6.16	170.6	23.89	0.13	1.99	12.55	12.45
Bt4	0.70-0.90+	50.8	8.41	170.6	22.38	0.11	2.09	11.99	12.45
4.Parusurampuram									
Ap	0.00-0.12	145.4	28.75	234.6	21.44	0.51	3.85	14.27	11.0
A1	0.12-0.24	126.4	15.92	211.8	17.26	0.32	2.74	15.32	12.39
A2	0.24-0.34	98.5	19.52	223.2	14.45	0.14	2.47	15.19	14.0
C	0.34-0.74+	75.8	10.18	193.4	12.99	0.10	2.31	14.74	12.02
5.Ravivalasa									
Ap	0.00-0.14	242.2	26.44	468.7	19.29	0.43	3.58	2.31	4.59
Bw1	0.14-0.28	120.1	22.85	254.9	18.79	0.48	3.42	2.92	4.45
Bw2	0.28-0.52	116.9	16.83	241.2	16.15	0.21	2.20	3.53	3.25
Bw3	0.52-0.72	82.2	10.2	227.5	15.59	0.12	1.14	2.31	4.93
Ck	0.72-0.94+	60.0	10.2	199.0	15.78	0.12	1.11	2.03	3.23
6.Narsingapalli									
Ap	0.00-0.21	125.4	42.8	383.4	21.05	0.55	2.09	14.27	8.23
Bt1	0.21-0.43	74.7	21.55	298.4	20.68	0.14	2.23	14.02	18.07
Bt2	0.43-0.77	58.4	23.11	269.7	19.16	0.13	2.18	14.02	17.97
Bt3	0.77-0.94+	46.3	9.75	284.6	19.55	0.12	2.12	14.22	16.49
7.Naupada									
Ap	0.00-0.23	285.7	44.4	341.2	27.78	0.51	2.18	11.91	9.92
Bw1	0.23-0.45	156.9	13.10	341.2	23.59	0.13	2.15	10.31	8.49
Bw2	0.45-0.60	125.3	13.10	255.9	21.96	0.12	2.04	8.05	8.22
Bw3	0.60-0.92+	119.0	10.20	227.5	19.34	0.12	2.01	8.05	8.20

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Table 3. Correlation coefficients between different soil properties

S. No	Variables	Correlation coefficient (r)
1	Soil pH vs available phosphorus content	-0.632**
2	Soil pH vs available zinc content	-0.708**
3	Soil pH and available iron	-0.625**
4	Soil pH vs available copper content	-0.436*
5	Soil pH vs available manganese content	-0.514**
6	Soil organic carbon content vs available nitrogen content	0.882**
7	Soil organic carbon content vs available phosphorus	0.579**
8	Soil organic carbon content vs available potassium	0.508**
9	Soil Organic carbon content vs available zinc	0.620**
10	Soil organic carbon content vs available copper	0.433*
11	Soil organic carbon content vs available manganese	0.384*
12	Soil organic carbon content vs available iron	0.626**

*significant at 5% level; ** significant at 1% level.

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Received on 24.01.2024 and Accepted on 06.03.2024