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Physico-chemical analysis of soils in Madanapalle block, Chittor district of Andhra Pradesh

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Abstract
Soil is a mixture of minerals, gases, liquids and organisms that together forms the basis of life. The inherent capacity of soil to provide essential nutrients to crops describes the soil in terms of fertility. In the present study physico-chemical analysis of soils in Madanapalle town was analysed by selecting eight different villages and from each village 3 surface (0-15cm) soil samples were collected and analysed for physical and chemical parameters by using standard laboratory techniques. Accordingly it is found that soils are low in available nitrogen and available sulphur content with a mean value of 248.7 kg ha^{-1} and 0.25 mg kg^{-1}, Medium to low in available phosphorus with a mean value of 13.7 kg/ha and medium to high in exchangeable potassium with a mean value of 481.6 kg ha^{-1}. The pH of the soil samples were found to be neutral to alkaline in nature with a mean value 7.54. The electrical conductivity of soils was found to be free from salinity as the mean value was 0.45 dSm^{-1}. The organic carbon status of soils was found to be medium to high with a mean value of 0.59. Nutrient index value of Madanapalle town was found to be high for organic carbon (2.45), low for nitrogen (1.41), low for phosphorus (1.62), high for potassium (2.58) and low for sulphur (1.00). The results strongly recommend that still improvement has to be done to improve the soil quality by practicing the better cropping systems instead of continuous cropping.

Keywords: Soil fertility, nutrient index, soil quality, salinity and alkaline

Introduction
The main source of nutrients for crops is soil. It provides support for plant growth in many ways. Knowledge on soil health is critical in sustaining crop productivity. Essential plant nutrients such as N, P, K, Ca, Mg and S are called macronutrients. Soil contains large amount of nutrient reserves in them but all or part of reserves may not be used by the crop because they may not be present in plant available form (FAO 2008) [6]. According to (Barker and Pilbeam 2007) [1] plant nutrition lies in use of diagnostic techniques for assessment of plant status with respect to plant nutrients. Intensive agricultural practices without balanced use of chemical fertilizers, excessive tillage practices, no use of organic manures caused deterioration of agricultural soils thereby declining the soil health and crop productivity (Bhupen *et al*., 2013) [3]. Among the techniques of the fertility evaluation such as plant analysis, soil analysis; soil test will provide accurate information on plant available nutrients (Singh *et al.*, 2017) [17]. Nitrogen is required for the plant growth and it a major constituent of chlorophyll, plant protein and nucleic acid. Phosphorus is a limiting nutrient in the soil which goes for fixation. It act as an energy storage and plays a major role in root development. It is known that over 60 enzymes need potassium for their activity. It plays major role in disease resistance, stomata regulation, ionic and osmatic balance (Swanti *et al.*, 2014) [22]. Calcium form an important component of cell wall and cell division. Magnesium plays an important role in chlorophyll synthesis and sulphur plays an important role in development of enzymes and vitamins. Whereas soil physical properties provide information on air and water movement through soils since many physical properties form foundation for biological and chemical processes (Varsha *et al.*, 2018) [23]. The present work deals with physico-chemical analysis of soils in Madanapalle block of Chittor district, Andhra Pradesh.

Materials and Methods

Study area: Madanapalle is a town in Chittor district of the Indian state of Andhra Pradesh. It comes under municipality of Madanapalle mandal and Madanapalle revenue division. There are total of 21 villages in this mandal. The soils of Madanapalle varies from medium to deep red loamy soils and medium black soils. But in the district, red loamy soils constitute 57% and red sandy soils 33%. The remaining 9% is accounted for by black clay, black loamy, black sandy and red clay soils. The major economy of the town is based on agriculture. The place is known for its tomato growing and is known as Tomato hub of Andhra Pradesh. Madanapalle has the biggest tomato market in Asia. Tomato, groundnut, mango and tamarind are the major crops grown in Madanapalle town. Tomato in red gram, red gram in groundnut, horse gram in mango are the new intercropping systems found in Madanapalle town.

Analysis of Physico-chemical parameters: Three soil samples were collected from eight different sites/villages i.e. a total of 24 surface soil samples were collected in Madanapalle Mandalam, Chittor district, Andhra Pradesh. Soil samples were taken using a spade. Firstly the area was cleaned from twigs, litter and stones. Then the soil was digged upto 15cm depth in the form of V-shape so that all horizons of the soil are shown up. From each field 5-7 representative samples were collected in the form of zigzag manner. In laboratory the soil samples were shade dried and crushed manually with the help of mortar and pestle and sieved through 2mm size sieve mesh. About 500g of soil sample was obtained after sieving and thus obtained soil sample was stored in a clean jute bag. The collected samples were analysed for major Physical and Chemical soil parameters. Bulk density and particle density were determined by using pycnometer (Black, 1965) [4]. Porosity was calculated from particle density and bulk density. Water holding capacity was determined by keen box method as suggested by (Piper, 1966) [12]. The pH was determined by potentiometric method by making 1:2.5 soil water suspension whereas electrical conductivity was measured by using EC meter (Jackson, 1973) [7]. Organic carbon was estimated by Walkley and Black method (Walkley and Black, 1934) [24]. Available nitrogen was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956) [21] by Kjeltech semi auto-analyser. Available phosphorus was determined by Olsen's method by using spectrophotometer instrument (Olsen *et al.,* 1954) [11]. Available potassium was determined by flame photometer using neutral normal ammonium acetate as extractant (Schollenberger and Simon, 1945) [14].Exchangeable calcium and magnesium were estimated by Versanate titration method (Jackson, 1973) [7]. Available sulphur was determined turbimetrically using spectrophotometer (Chesnin and Yien, 1950) [5].

Results and discussions

The results of the physical properties, physico-chemical parameters, primary macronutrients and secondary macronutrients of soil samples from different villages of Madanapalle town in Chittor district are given in the table 2.

Physico-chemical parameters

The pH of the soil samples ranges from 5.87 to 8.50 with a mean value of 7.54. The results concluded that 62.5% of the samples are alkaline in nature, 29.1% of the samples are neutral and 8.32% of the samples are acidic in nature. Similar results were reported by (Singh *et al.*, 2016) [19]. Electrical conductivity of soil samples ranges from 0.07 to 1.26 dSm^{-1} with a mean value of 0.45. Out of total soil samples 83.3% of the samples are in permissible range suitable for all type of crops and 16.6% of the samples are slightly higher than the permissible range suitable for most of the crops. Similar results were reported by (Singh *et al.,* 2016a) [18] in Varanasi district. The organic carbon content ranges from 0.24 to 0.95 with a mean value of 0.59. Based on the limits suggested by (Muhr *et al.,* 1963) [10] out of total soil samples 54.1% of the samples are in high organic carbon content range this may be due to low temperature in the region which suppress the microbial and enzymatic activity thereby less decomposition of the organic matter and accumulation on the surface of the soil, 8.3% of the soil samples are in low organic carbon content range and 37.5% of the soil samples are in medium range. Bulk density, particle density and porosity of soil samples ranged from 1.16-1.43 g/cm^3, 2.08-2.67 g/cm^3 and 38.3-51.8 % with a mean value of 1.30, 2.37 and 44.9, respectively. Water holding capacity of the soil ranges from 32.5-60.6 with a mean value of 46.6 similar findings were observed by (Khan *et al.,* 2017) [9] in Kanchanpur district, Far-Western Development Region of Nepal.

Status of primary macronutrients

The nitrogen content of soil samples ranges from 72.3 to 765.9 kg ha^{-1} with a mean value of 248.7. Based on the limits suggested by (Muhr *et al.,* 1963) [10] out of total soil samples 70.8% of the soil samples are in low nitrogen content, 16.6% of the samples are in medium range and 12.5% of the samples are in low range. Similar results were observed with (Ramana *et al.,* 2015 and Bharteey *et al.,* 2017) [16, 2]. Based on the limits suggested by (Ramamoorthy and Bajaj, 1969) [13] out of total soil samples 54.1% of the samples are in low phosphorus range this is due to if we look at the pH of soil samples 62.5% of the samples are in alkaline in nature which caused the higher fixation of phosphorus ion by Ca, Mg and Na oxides whereas 29.1% of the samples are in medium range and 16.6% are in high range. Potassium content of soil samples ranges from 89.6 to 1444.8 kg/ha with a mean value of 481.6. Based on the limits suggested by (Ramamoorthy and Bajaj, 1969) [13] out of total soil samples 66.6% of the samples are in high potassium range the reason may be due to presence of elite rich potassium minerals in these soils, 25% of the soil samples are in medium range and 8.33% of the soil samples are in low potassium range. Similar results were observed with (Singh *et al.,* 2017) [15] who studied on soil fertility status of Lahar block in Bhind district of Madhya Pradesh.

Status of secondary macronutrients

The exchangeable calcium content of soil samples ranges from 0.40-9.08 Meq/100g with a mean value of 2.96. Based on the limits suggested by (Ramamoorthy and Bajaj 1969) [13] out of total soil samples 25% of the samples are in low range whereas 75% of the samples are in high range. Exchangeable magnesium content of soil samples ranges from 0.04 to 3.70 Meq/100g with a mean value of 1.05. Based on the limits suggested by (Ramamoorthy and Bajaj, 1969) [13] out of total soil samples 58.3% of the samples are in low range whereas 41.6% of the samples are in high range. Available sulphur content in soil samples ranges from 0.14 to 0.45 mg kg^{-1} with a mean value of 0.25. Based on the limits similar results by (Singh *et al.,* 2018) [20]. In Madanapalle region there is a lesser concentration of sulphur and results reported that all 24 soil samples are deficient in sulphur.

Soil nutrient index

In order to compare the levels of soil fertility of one area with those of another it was necessary to obtain a single value for each nutrient. Nutrient index (N.I) value is a measure of nutrient supplying capacity of soil to plants (Singh *et al.*, 2016) [19]. The Nitrogen, Phosphorus, Potassium and Sulphur Index calculated value is given in the Table 1. The nutrient index is calculated by using the formula as given by (Muhr *et al.*, 1963) [10].

$$\text{Nutrient Index (N.I.)} = \frac{\text{NL} \times 1 + \text{NM} \times 2 + \text{NH} \times 3}{\text{NT}}$$

Where, NL: Indicates number of samples falling in low class of nutrient status

NM: Indicates number of samples falling in medium class of nutrient status

NH: Indicates number of samples falling in high class of nutrient status

NT: Indicates total number of samples analyzed for a given area.

The nutrient index value of less than 1.5 is rated as low, 1.5 to 2.5 is rated as medium and more than 2.5 is rated as high fertility status as suggested by (Ramamoorthy and Bajaj 1969) [13].

Correlation between physico-chemical properties of soil

The correlation between the soil quality parameters were given in the Table 3. The bulk density of the soil is negatively non-significantly correlated water holding capacity (r = -0.282), pH (r = -0.09) organic carbon (r = -0.106), nitrogen (r = -0.11), potassium (r = -0.218), calcium (r = -0.204), magnesium (r = -0.210), sulphur (r = -0.096), negatively significantly correlated with porosity (r = -0.664), EC (r = -0.403), phosphorus (r = -0.539) and positively non significantly correlated with particle density (r = 0.128). The pH of the soil is negatively non significantly correlated with nitrogen(r = -0.105), organic carbon(r = -0.055) positively significantly correlated with calcium(r = 0.512) and positively non significantly correlated with EC(r = 0.375), phosphorus(r = 0.041), potassium(r = 0.291), magnesium(r = 0.226) and sulphur (r = 0.032). The organic carbon content of soil is positively non significantly correlated with magnesium (r= 0.119) nitrogen (r = 0.077), phosphorus (r = 0.132), potassium (r = 0.189) and calcium (r = 0.227) whereas negatively non significantly correlated with sulphur (r =-0.172). The macronutrients of the soil i.e. nitrogen status of the soil is negatively non significantly correlated with potassium (r = -0.042), phosphorus (r = -0.002) and magnesium (r = -0.262) and positively non significantly correlated with calcium(r = 0.005) and sulphur (r = 0.255). The phosphorus status of the soil is positively non significantly correlated with calcium (r = 0.352), magnesium (r =0.070). Positively significantly correlated with potassium (r = 0.416). Negatively significantly correlated with sulphur (r = -0.402). The potassium status of the soil is positively non significantly correlated with sulphur (r = 0.156). Positively significantly correlated with magnesium (r = 0.478) and calcium (r = 0.583). The secondary macronutrients i.e. calcium content of the soil is negatively non significantly correlated with sulphur (r = -0.141) and positively non significantly correlated with magnesium(r = 0.106). The magnesium status of the soil is positively non significantly correlated with sulphur (r = 0.188). Similar results were observed with (Singh *et al.*, 2017a) [15] who studied on soil fertility status of Lahar block in Bhind district of Madhya Pradesh.

Table 1: Nutrient Index values of Madanapalle town in Chittor district of Andhra Pradesh

Sl. No	Available nutrients	Nutrient index values	Category
1	Nitrogen	1.41	Low
2	Phosphorus	1.62	Low
3	Potassium	2.58	High
4	Sulphur	1	Low
5	Organic carbon	2.45	High

Table 2: Soil quality parameters of different villages of Madanapalle town of Chittor district in Andhra Pradesh

Sample no	Name of Villages	BD g/cm^3	PD g/cm^3	Porosity %	WHC%	pH	EC dSm^{-1}	OC %	N Kg/ha	P Kg/ha	K Kg/ha	Ca^{2+} Meq/100g	Mg^{2+} Meq/100g	S mg kg-1
S_1	Chipilli	1.24	2.08	40.2	45.9	7.82	0.326	0.95	075.4	14.6	268.8	0.76	1.18	0.19
S_2	Chipilli	1.36	2.41	43.4	41.6	7.84	0.288	0.65	132.2	5.38	403.2	3.46	2.86	0.25
S_3	Chipilli	1.33	2.38	44.2	50.9	8.11	0.297	0.42	97.06	3.50	436.8	4.90	0.82	0.20
S_4	Ponnugutupalem	1.36	2.30	41.0	41.0	7.96	0.664	0.72	144.5	1.25	257.6	3.10	0.80	0.32
S_5	Ponnugutupalem	1.39	2.26	38.3	36.8	6.65	0.241	0.31	765.9	3.38	392.0	1.42	0.12	0.34
S_6	Ponnugutupalem	1.36	2.36	42.2	32.5	8.16	0.072	0.24	178.9	11.7	268.8	0.94	0.24	0.23
S_7	Nayabandapalli	1.43	2.33	38.6	47.5	6.89	0.216	0.83	413.2	3.25	448.0	0.96	0.04	0.31
S_8	Nayabandapalli	1.32	2.39	44.8	35.4	7.68	0.339	0.53	134.2	8.26	347.2	2.40	0.50	0.45
S_9	Nayabandapalli	1.26	2.34	46.2	46.5	7.86	0.395	0.74	154.3	10.6	638.4	5.62	2.18	0.25
S_{10}	Kandlamadugu	1.28	2.28	43.8	51.7	7.46	0.230	0.47	117.8	5.44	459.2	3.42	0.24	0.26
S_{11}	Kandlamadugu	1.26	2.20	42.9	47.5	6.78	0.371	0.64	158.5	19.5	739.2	1.96	0.78	0.25
S_{12}	Kandlamadugu	1.29	2.41	46.5	53.0	7.56	0.259	0.39	84.78	31.1	728.0	4.00	0.90	0.14
S_{13}	Basinikonda	1.27	2.22	42.7	46.7	8.01	0.937	0.77	187.4	18.6	929.6	6.60	1.24	0.24
S_{14}	Basinikonda	1.30	2.67	51.2	54.4	8.47	0.806	0.91	564.7	31.1	896.0	7.54	0.44	0.16
S_{15}	Basinikonda	1.25	2.35	46.7	55.7	7.63	0.676	0.68	195.4	31.2	728.0	9.08	0.66	0.20
S_{16}	Ramacharlapallli	1.43	2.43	41.1	60.6	7.23	0.309	0.67	145.6	4.25	89.60	1.14	0.58	0.18
S_{17}	Ramacharlapallli	1.29	2.41	46.3	41.6	7.72	0.707	0.43	342.1	13.0	459.2	2.56	1.56	0.27
S_{18}	Ramacharlapallli	1.25	2.52	50.2	36.8	7.12	0.146	0.86	523.4	23.2	179.2	0.86	1.10	0.15
S_{19}	Ganganavaripalli	1.27	2.38	46.5	53.2	7.65	1.264	0.72	154.4	17.0	1448.8	3.00	3.70	0.41
S_{20}	Ganganavaripalli	1.16	2.40	51.8	48.3	7.90	1.221	0.57	732.3	7.07	369.6	3.46	1.24	0.43
S_{21}	Ganganavaripalli	1.33	2.54	47.4	47.7	5.87	0.107	0.71	125.7	7.51	089.6	0.40	0.56	0.18
S_{22}	Barlapalli	1.35	2.55	46.9	39.9	8.5	0.342	0.24	72.31	9.07	414.4	1.88	1.68	0.25
S_{23}	Barlapalli	1.19	2.43	50.8	57.9	7.45	0.243	0.48	342.1	20.0	257.6	1.16	0.08	0.29

S_{24}	Barlapalli	1.23	2.27	45.9	59.5	6.72	0.387	0.38	126.7	29.1	313.6	0.42	1.72	0.26
Mean		1.30	2.37	44.98	46.6	7.54	0.451	0.59	248.7	13.7	481.6	2.96	1.05	0.25
S.D		0.069	0.125	3.77	8.17	0.62	0.328	0.20	204.8	9.79	308.6	2.34	0.89	0.084
CV (%)		5.27	5.28	8.39	17.5	8.24	72.7	34.5	82.3	71.3	64.0	79.14	85.13	32.64
Range		1.16-1.43	2.08-2.67	38.3-51.8	32.5-60.6	5.87-8.50	0.072-1.264	0.24-0.95	72.31-765.9	1.25-31.2	89.6-1444.8	0.40-9.08	0.04-3.70	0.14-0.45

Note: BD=bulk density, PD=particle density, WHC=water holding capacity, N=nitrogen, P=phosphorus, K=potassium, EC=electrical conductivity, OC=organic carbon, Ca=calcium, Mg=magnesium, S=Sulphur

Table: 3: Correlation between physico-chemical properties of soil in different villages of Madanapalle town

Parameters	BD	PD	porosity	WHC	pH	EC	OC	N	P	K	Ca	Mg	S
BD	1												
PD	0.128	1											
Porosity	-0.664*	0.652*	1										
WHC	-0.282	0.0366	0.255	1									
pH	-0.091	0.147	0.180	-0.146	1								
EC	-0.403*	0.007	0.319	0.228	0.375	1							
OC	-0.106	-0.035	0.028	0.177	-0.055	0.258	1						
N	-0.114	0.224	0.233	-0.155	-0.105	0.243	0.077	1					
P	-0.539*	0.139	0.504	0.399	0.041	0.176	0.132	-0.002	1				
K	-0.218	-0.043	0.134	0.238	0.291	0.647*	0.189	-0.042	0.416*	1			
Ca	-0.204	0.120	0.252	0.246	0.512*	0.491*	0.227	0.005	0.352	0.583*	1		
Mg	-0.210	0.0006	0.174	0.027	0.226	0.468*	0.119	-0.262	0.070	0.478*	0.106	1	
S	-0.096	-0.197	-0.054	-0.232	0.032	0.442*	-0.172	0.255	-0.402*	0.156	-0.141	0.188	1

Note: '*' represents significant at 0.05 level

Conclusion

The results of soil analysis were interpreted using the literature and reported in terms of the nutrients to be supplemented. These analyses may help farmers to add deficient nutrients to obtain high quality products with high yield. According to the soil test results of Madanapalle block clearly states that the soil is alkaline to neutral in condition. The organic carbon content ranges from medium - high this is due prevailing low temperature and less decomposition of organic matter in the soil. The potassium content of the soil was medium to high in condition, stating that soils are efficient in potassium content in Madanapalle block. By considering nutrient index the soils of Madanapalle block are low in nitrogen, phosphorus and sulphur whereas high in potassium and organic carbon. Still improvement has to be done to improve the soil quality by practicing the better cropping systems instead of continuous cropping.

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