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Assessment of Available Major and Micronutrient Status of Soils under Varied Cropping Systems of N.T.R district, Andhra Pradesh

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***Abstract*:** Assessment of soil properties and nutrient status is essential for addressing issues of soil health through which one can guide for maintaining sustainable crop productivity. In view of this, soil samples were collected from selected villages under different mandals of NTR district to assess physico chemical properties, macronutrients and micro nutrients status. A total of 144 soil samples (0-20 cm depth) were collected from Rice-Rice, Rice-Pulse, Cotton-Pulse, Maize-Pulse and agri-horticulture cropping systems and results revealed that the soils under investigation were slightly acidic to alkaline in reaction (pH 6.60 to 8.20), mostly non-saline and low too high in organic carbon status (0.18 to 1.52 %). The mean available nitrogen, phosphorus, potassium and sulphur content recorded were 298, 22.90, 196 and 45 kg $^{-1}$ ha Exchangeable Ca, Mg in the ranged from 1.90-10.20 and 1.20-5.50 C mol (p+) kg^{-1}. With respect to micronutrients, the mean available Zn, Mn, Cu, Fe and B content are 0.52, 3.50, 1.52, 5.50 and 0.85 mg kg^{-1} respectively. The nutrient index (NI) of studied samples for organic carbon (1.54), nitrogen (1.30) is categorized under low, sulphur (2.86) and magnesium (2.82) are categorized as high and K, Ca and micronutrients as medium.

Keywords: Fertility status, Nutrient Index, Correlation, Major, Secondary and micronutrients

Soil testing is often used to determine the available nutrient status and nutrient supplying power of soil which helps in developing cost effective nutrient management practices that serve as a basis for amendments and sound fertilizer recommendations, which in turn leads to sustainable long term agriculture production by way of adoption of good agronomic management practices by farmers in the study area (Subbaiah et al 2022). Macronutrients (N, P, K, S) and micronutrients (Zn, Fe, Cu, Mn and B) are very important soil elements that determine crop yields in general and physicochemical properties like pH, EC, Organic Carbon in particular under normal environmental conditions. Soil fertility is one of the important factors controlling crop yields and soil characterization in relation to evaluation of soil fertility of an area or a region is an important aspect in the text of sustainable production (Prasad et al 2020b). In present context, maintaining soil fertility is a key problem in Indian agriculture, especially under the country's rapidly growing population in recent decades. Erratic rainfall, minimal recycling of farm residues including livestock waste, non-adoption of soil and water conservation measures, continuous cultivation of exhaustive crops and imbalanced fertilizer application are some of the major causes of soil degradation in India. Soil is one of the most important natural resources for plant growth that deteriorates from its original status due to the imbalance fertilizer application, faulty management practices, incorrect crop rotation, excess or scanty irrigation and adverse climate conditions, thereby decreasing productivity of rice, pulses, wheat, mustard, maize and sugarcane. The decrease in soil productivity may be attributed to poor physical properties, low organic carbon content, buildup of salts leading to soil salinity/alkalinity, imbalanced fertilizer application and multi nutrient deficiencies. The presence of more salt in the rooting zone may have a germination effect or may be essential for crop development. The quantity of fertilizer supplementation is determined by knowing crop nutrition demand and nutrient supplying power of the soil. The improper nutrient management led to emergence of multinutrient deficiencies in the Indian soils. Without maintaining soil fertility, it is hard to enhance agricultural production and feed the alarmingly increasing population. In the last few decades, soil analysis and study of micronutrients level has become an important topic of research. Information on the available nutrient status of soils is a pre requisite for advising individual farmers on fertilizer scheduling and to monitor changes in soil fertility over a period. The available nutrients *viz.,* nitrogen, phosphorus, potassium, sulphur, iron, manganese, zinc and copper controls fertility and productivity of a particular soil. Land use induced changes in soil properties are essential for addressing the issue of agro eco system transformation and sustainable land productivity (Subbaiah and Rajasri 2020, Wani et al 2022). In NTR district, rice is cultivated under different irrigation sources like canal command, tank fed, lift irrigation schemes and filter points to an extent of 3 lakh hectares. Soil nutrient status of any cultivable soil is the primary indicator of productivity.

MATERIAL AND METHODS

The study area was situated in between Latitude 16° 86' N and 17° 14' N Longitude 15° 71' E and 16° 47' of E located in NTR district of Andhra Pradesh bordered with Krishna district and Eluru districts on the East, Palnadu district and Guntur districts on the South, Suryapet district of Telangana state on the West, Khammam district of Telangana state on the North and river Krishna flows towards East and acts as border between NTR and Palnadu. Surface (0-20 cm) soils are collected from different areas of NTR district, Andhra Pradesh. All together a total of 174 soil samples were collected from farmer's fields. The samples were air-dried, ground and passed through a 2 mm sieve for analysis of physicochemical, chemical properties and micronutrient content of soil. The pH and EC of the soils was determined in 1:2.5 soil water suspension using a glass electrode pH meter and EC meter as described by Jackson 1973. The Walkley and Black (1934) wet digestion method was used to determine soil organic carbon (SOC) content. During the delineation of the study 174 surface soil samples of different cropping systems were collected and the details are presented in Table 1. Collected samples were analyzed for pH, EC, organic carbon and available macro and micronutrients using standard protocols (Jackson, 1973). The available zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) in soil samples were estimated by atomic absorption spectrophotometer following DTPA extraction method (Lindsay and Norvell 1978). The deficiency and sufficiency areas were then delineated based on the critical limit given for Fe, Mn, Zn, Cu. Available boron was estimated by using Azomethine-H method. Soil test rating of available nutrients of standard protocol (Table 2) or critical limits of micronutrients will distinguish deficiency from sufficiency which could be employed to advice on need of fertilization (Sivaprasad et al 2022).

Table 1. Categories of soil samples of NTR district of Andhra Pradesh

Soils supporting crop	No of samples	% of total samples
Paddy	80	45.98
Maize	23	13.22
Cotton	17	9.77
Red gram/Bengal gram	27	15.52
Chilies	10	5.75
Tomato and other vegetables	12	6.89
Miscellaneous crops including surface samples of orchards	5	2.87
Grand total	174	100

Nutrient Index (NI)

Nutrients index (NI) was enumerated for surface soil samples as described by Motsara et al 1982.

$$\text{Nutrient Index (N.I)} = \frac{(Nl \times 1) + Nm \times 2 + Nh \times 3)}{(Nt)} \times 100$$

where,

Nt= total number of samples analyzed for a nutrient in given area

Nl= number of samples falling in the low category of nutrient status

Nm = number of samples falling in the medium category of nutrient status

Nh= number of samples falling in high category of nutrient status

The index values are rated into various fertility categories *viz*., low (<1.67), medium (1.67-2.33) and high (>2.33) for available N, P and K.

The correlation analysis of data was computed in relation to available micronutrients content with different physicochemical properties of the soils with SPSS Software and MS Excel.

RESULTS AND DISCUSSION

The pH of soil samples analyzed in the district ranged from 6.60-8.20. Thus, the soils of the district were categorized into acidic, neutral and alkaline. Higher values of pH in crop lands are due to release of bases and their deposition over a long period. These results are in conformity with the findings made by Altaf and Subbarayappa (2022). The electrical conductivity of analyzed soil samples were between 0.08-2.10 dS m^{-1} with a mean and median of 0.86 and 0.95 dS m^{-1}. It was observed that only ten per cent soils register EC more than 1 dS m^{-1} and EC of district soils is suitable for growing different types of crops. The organic carbon content of district soils was in the range of 0.18 to 1.52 %. The mean and median of organic carbon content in the studied soils was 0.56 and 0.61, respectively. Out of 174 soil samples of the district, 56 % were low in organic carbon content, 34 % were medium whereas only 10 % were with high in organic matter content. Low organic carbon in the soils of NTR district may be due to meager application of organic manuresa and may be due to rapid rate of decomposition because of continuous manipulation of surface soil due to intensive cultivation at every cropping season coupled with high soil temperature prevailing in the district. Similar reports are made by Prasad et al (2020b) and Altaf and Subarea (2022). The high content of organic carbon reported in the studied area might be due to addition of organic matter and its subsequent decomposition. These results are in confirmatory with Sathish et al (2017) and Subbaiah et al (2022).

Major and secondary nutrient status: The available nitrogen content ranged from 131.00 to 328.00 kg ha^{-1} with a mean and median of 298.00 and 312.00 kg ha^{-1}, respectively (Table 4). The soils contained low to medium nitrogen content. The low available nitrogen in most of the soils might be due to the higher temperature that might have increased volatilization loss of nitrogen. Rajeshwar et al (2009) and Subbaiah (2020) also observed similar trend in the soils of Krishna district, Andhra Pradesh.

The available phosphorus content ranged from 9.80 to 117.00 kg ha^{-1} with a mean and median of 22.90 and 20.20 kg ha^{-1}, respectively. The phosphorus content of the soils ranged from low to high. Phosphorus is present in soil as solid phase with varying degree of solubility. When water soluble P is added to the soil, it is converted very quickly to insoluble solid phase by reacting with soil constituents. These reactions affect the availability of P and as a result of these reactions, a very small amount of total P is present in soil solution at any time reflected by soil testing. High and continuous application of phosphatic fertilizers might have resulted in occurrence of high phosphorus soils in the district. Such build up in available phosphorus was also noticed in the soils of Kolar district (Prasad et al 2020b)

The available potassium ranged from 121.67 to 359.00 kg ha^{-1} with mean and median of 196.00 and 210.00 kg ha^{-1}, respectively. The potassium status ranges from low to high. Low potassium levels in soils are due to leaching and lessivage of this element to lower layers which lead to loss of K (Wani et al 2022) and in addition to this in majority areas there is no external soil application of K due to misconception that soils are rich in K. These results confirmed the findings of Prasad et al (2020b) in Kolar district of Karnataka. Adequate available K in these soils may be attributed to the prevalence of potassium rich minerals like Illite and Feldspars (Sharma et al 2008 and Sharma et al 2013). The variation in available potassium across the soils of different districts was noticed by several workers and was attributed to variation in mineralogical compositions. These reports are similar to the findings of Reza et al 2012. The available sulphur ranged from 5.00 to 180.00 kg ha^{-1} with mean and median of 45.00 and 59.00kg ha^{-1}, respectively. The sulphur content in the studied areas ranges from low to high. The exchangeable calcium ranges from 1.90 to 10.20c mol (p^{+}) kg^{-1} with mean

Table 3. Analytical values and percent distribution of Physico-chemical properties of soils

Parameter	pH	E.C (dS m^{-1})	O.C (%)
Range	6.60-8.20	0.08-2.10	0.18-1.52
Mean	7.59	0.86	0.56
Median	7.41	0.95	0.61
Low samples (%)	15 (Acidic)	68 (Normal)	56.00
Medium samples (%)	40 (Neutral)	22 (Non-saline)	34.00
High samples (%)	45 (Alkaline)	10 (Saline)	10.00

Table 2. Soil test rating of primary, secondary and cationic micronutrients of study area

Nutrients	Units	Soil testing rating		
		Low	Medium	High
Organic carbon	Percent	0.5	0.5-0.75	>0.75
Available N	Kg^{-1} ha	<280	280-560	>560
Available P_2O_5		< 23	23-56	> 56
Available K_2O		< 140	140-330	> 330
Available S		< 22.4	22.4 - 44.8	> 44.8
Exchangeable Ca	M.eq 100 g^{-1}	< 1.5		> 1.5
Exchangeable Mg		< 1		> 1
DTPA-extractable Fe	Mg kg^{-1}	<5.5	5.5-9.5	>9.5
DTPA-extractable Cu		<0.4	0.4-0.8	>0.8
DTPA-extractable Mn		<4.0	4.0-8.0	>8.0
DTPA-extractable Zn		<0.6	0.6-1.2	>1.2
Available boron		< 0.5	0.5- 1	> 1
Nutrient Index		<1.67	1.67 to 2.33	>2.33

and median of 4.20 and 3.90c mol (p^+) kg^{-1} soil. The exchangeable magnesium ranges from 1.20 to 5.50 with mean and median of 2.80 and 2.61c mol (p^+) kg^{-1} soil. All the soils were in the sufficiency range of Mg may be due to its genesis in the semiarid area.

Availability of micro nutrients: Available Zn content in soils of NTR district ranged from 0.18 to 2.96 mg kg^{-1} with mean and median of 0 .52 and 0.61 mg kg^{-1}, respectively. The soils of the district were low to high in zinc category. The Fe content ranged from 4.25 to 12.60 mg kg^{-1} with mean and median of 5.50 and 5.45 mg kg^{-1}, respectively. The soils were in low to high category. This might be due to its topography and amount of iron required by crops is being released by iron bearing minerals as many iron ores are existing in district. Similar trend of Fe was reported by Prasad et al (2020a) in soils of Chikkaballapura district of Karnataka.

The Mn status of district ranged from 2.25 to 9.45 mg kg^{-1}, respectively with mean and median of 3.50 and 3.16 mg kg^{-1}. The Mn content in soils was low to high. The Cu status ranged from 0.46 to 6.92 mg kg^{-1} with mean and median 1.52 and 1.64 mg kg^{-1}, respectively. The soils of the district were low to high in copper status and might be due to interactive effect of soil properties like pH, EC and OC which have managing role in the availability of Cu. The boron status of district ranged from 0.01to 5.29 mg kg^{-1} with mean and median of 0.85 and 0.71 mg kg^{-1}, respectively. The soils of the district were low to high in boron status.

Nutrient index: Considering the concept of soil nutrient Index, the soils of the studied area were grouped into three categories as low, medium and high index values (Table 5). The nutrient index (NI) of NTR district reveals that organic carbon (1.54) and available nitrogen (1.30) were categorized as low, available phosphorus (2.30), potassium (1.79), calcium (1.87), zinc (2.02), copper (2.05), iron (2.30) and boron (1.85) are categorized under medium, whereas exchangeable magnesium (2.82) and sulphur (2.86) was

Table 4. Available macro, secondary and micronutrient status of soils in diversified areas of NTR district

Parameter	Units	Range	Mean	Median
Available nitrogen	kg ha^{-1}	131.00 - 328.00	298.00	312.00
Available phosphorus		9.80 - 117.00	22.90	20.20
Available potassium		121.67- 359.00	196.00	210.00
Available sulphur		5.00 - 180.00	45.00	59.00
Exchangeable calcium	c mol (p^+) kg^{-1}	1.90 - 10.20	4.20	3.90
Exchangeable magnesium		1.20 - 5.50	2.80	2.61
Available zinc	mg kg^{-1}	0.18 - 2.96	0.52	0.61
Available manganese		2.25 - 9.45	3.50	3.16
Available copper		0.46 - 6.92	1.52	1.64
Available iron		4.25 - 12.60	5.50	5.45
Available boron		0.01 - 5.29	0.85	0.71

Table 5. Nutrient Index (NI) of studied soils of NTR district

Parameter	Low	Medium	High	N.I	N.I. Class
Organic carbon	81	49	14	1.54	Low
Available nitrogen	109	26	9	1.30	Low
Available phosphorous	20	60	63	2.30	Medium
Available potassium	59	56	29	1.79	Medium
Exchangeable calcium	33	96	14	1.87	Medium
Exchangeable magnesium	35	0	124	2.82	High
Available sulphur	32	0	127	2.86	High
Available zinc	43	55	46	2.02	Medium
Available manganese	22	79	43	2.15	Medium
Available copper	29	79	36	2.05	Medium
Available iron	14	72	58	2.30	Medium
Available boron	50	65	29	1.85	Medium

under high nutrient index category. Low content of soil nitrogen in different cropping systems is possibly due to recurrent tillage operations that causes quick mineralization of soil organic matter and organic N and transforms them into mineral N which is lost as gaseous nitrogen to the atmosphere and is from the soils. These results are similar to the findings of Wani et al (2022). For macronutrients these results are in conformity with the findings of Verma et al (2016) for soils of Punjab. For micronutrients the results are in conformity with the findings of Kumar et al (2017) and Prasad et al (2020[a]) at Jhabua district of Madhya Pradesh and Chikkaballapura district of Karnataka. This shows that majority of the studied soils are showing depletion of nutrients status which may be due to continuous cropping without application of balanced levels of manures and fertilizers to soils. The details regarding percent distribution of chemical properties of studied area of NTR district with categories are clearly depicted in Figure. 1.

Correlation study: Among the soil properties, soil pH and organic carbon has been identified as the most important soil factors controlling nutrient supplying power and the availability of nutrients in soil (Altaf et al 2022).In general, pH shows significant correlation with nutrients like macro and micronutrients (Table 6). There were significant and positive correlations between pH and Ca and Mg. Negative, significant correlation was between pH and N, P and S. Similarly, a significant and negative correlation was found between EC and N, P and S while significant and positive correlation was found with Ca and Mg. The organic carbon showed positive significant correlation with N and P. Organic carbon is positively correlated with P showing that organic matter tends to reduce P fixing capacity of soil by replacing phosphate ions by humate ions and forms protective humus coating on sesquioxide particles and decomposition of organic matter also releases acids that increase solubility of calcium phosphates besides forming humic-phosphor complexes (Wani et al 2022). The Zn availability is positively and significantly correlated with pH, EC and organic carbon. The influence of Organic carbon is more pronounced as seen from highest coefficient of correlation of organic carbon with Zn (Table 7). The Zn availability increased with increase in organic carbon content of soil and decrease in Zn availability with increase in pH but there was a tremendous increase in availability of Zn with increasing OC content from 0.5to0.75% followed by pH. At the same time, it can be inferred that uptake of Zn by plants is not merely a function of pH but it is controlled by other physiological factors and associated

Table 6. Relationship between available macronutrients and physicochemical properties of representative samples of study area

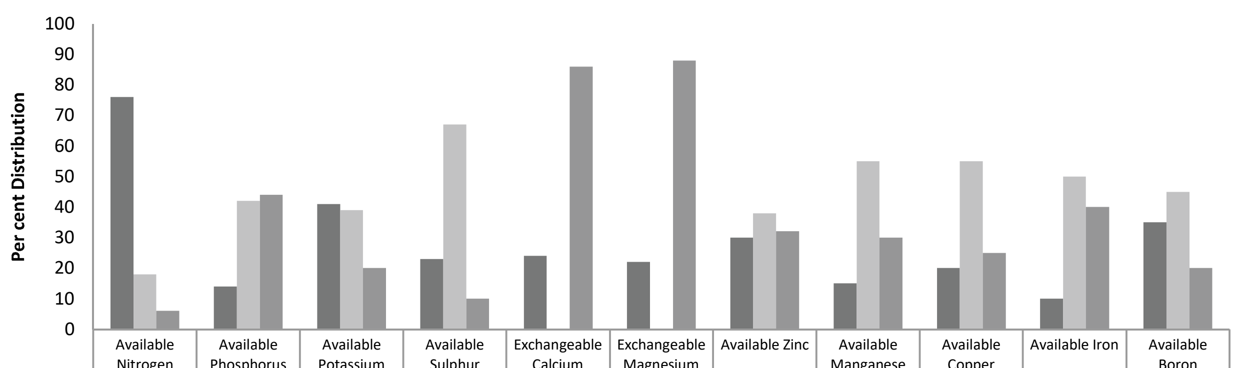
Available nutrient	pH	EC	OC
Nitrogen	-0.342**	-0.326**	0.285*
Phosphorus	-0.194*	-0.270*	0.538**
Potassium	-0.177	-0.135	0.099
Calcium	0.568**	0.538**	0.253
Magnesium	0.502**	0.426**	-0.132
Sulphur	-0.606**	-0.603**	0.167

Correlation is significant @ 0.05% **Correlation is significant @ 0.01%

Table 7. Relationship between available micro nutrients and physicochemical properties of representative samples of study area

Soil properties	Zn	Fe	Cu	Mn
pH	0.491*	NS	NS	-0.453*
EC	0.435*	0.437*	NS	NS
OC	0.636**	0.480*	0.628**	-0.438*

Correlation is significant @ 0.05% **Correlation is significant @ 0.01%



	Available Nitrogen	Available Phosphorus	Available Potassium	Available Sulphur	Exchangeable Calcium	Exchangeable Magnesium	Available Zinc	Available Manganese	Available Copper	Available Iron	Available Boron
Low (%)	76	14	41	23	24	22	30	15	20	10	35
Medium (%)	18	42	39	67			38	55	55	50	45
High (%)	6	44	20	10	86	88	32	30	25	40	20

Fig. 1. Percent distribution of chemical properties of studied soils

nutrients. Soil pH did not have a consistent effect on DTPA extractable Fe content of soils. However, organic carbon had influence on the DTPA-Fe content of soils. The results find support from positive and significant coefficient of correlation of DTPA-Fe with Organic carbon. A positive and significant correlation was obtained between DTPA-Fe with EC. Statistically there was no relationship of DTPA-Cu with pH but increasing Organic carbon content had a prominent effect on Cu availability as it is evident from a highly significant coefficient of correlatio) between Organic carbon and DTPA extractable Cu. It may be because complexing agents are generated by organic matter which in turn promoted Cu availability in soils. The availability of Mn decreased with increase in pH (Frierch and Catalano 2012). The DTPA-Mn of the soil was negatively correlated with OC and the availability of Mn decreased with increase in OC content.

CONCLUSION

The nutrient index (NI) of studied areas of NTR district revealed that in majority of samples N P, K, S and micronutrients are moderately sufficient to deficient. Based on the status of nutrients analyzed through soil testing, fertilizer recommendations must be made which helps in maintaining soil health which in turn improves availability of nutrients to crops for better growth and yield enhancement in sustained manner. Without soil testing, under or excess application of chemical fertilizers render agricultural soils towards degradation under long run and further lead to drastic reduction in the productivity of crops.

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