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Nutrient Status of Sugarcane Growing Soils of Nizamabad District of Telangana State

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Authors' contributions

This work was carried out in collaboration among all authors. Authors JK and TPR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KPCR and DVL managed the analyses of the study. Authors FS and JR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Sugarcane is a commercial crop predominantly grown in Nizamabad district. Investigating the fertility status of sugarcane growing soil is required to underpin future land use planning. A field soil survey was carried out in major sugar cane growing soils (5 mandals/taluk) of Nizamabad district of Telangana state. A total number of 94 samples were collected from 0-15 cm (surface soil) and 15-30

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cm (subsurface soil) depths using global positioning system (GPS) co-ordinates. Collected soil samples were chemically analyzed for the important soil attributes *viz.,* pH, electrical conductivity (EC), organic carbon (OC), nitrogen (N), phosphorus (P), potassium (K), sulphur (S), iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) using standard analytical procedures. Correlation analysis was performed to study the relationship between the different soil properties. The soil reaction (pH) showed wide variation at surface and subsurface depths showing that soils are slightly acidic to strongly alkaline in nature. Organic carbon content varied from low to high (0.25 to 1.41% and 0.22 to 0.75% at 0-15 and 15-30 cm depths respectively). Whereas available N content were low to high (136 to 310 kg ha^{-1} and 23 to 166 kg ha^{-1} at 0-15 cm and 15-30 cm depths respectively), medium to high in available P (12.05 to 103.6 kg ha^{-1} and 3.6 to 27.90 kg ha^{-1} at 0-15 cm and 15-30 cm depths respectively), high in available K (242 to 715 kg ha^{-1} and 108 to 466 kg ha^{-1} at 0-15 cm and 15-30 cm depths respectively). Further, the soils are deficient to sufficient in available S and Zn, Fe, Mn and Cu were sufficient. Nitrogen was positively correlated with the organic carbon ($r=0.883$, $p<0.05$) at surface soil and negatively related at subsurface soil. All the major nutrients *viz.,* N, P, and K correlated positively with OC (r=0.883*, 0.768, and 0.267 respectively) at surface soil. Conclusively, the results of the study area showed in all the sugarcane growing mandals of Nizamabad district necessitating the need for refinement of fertilizer scheduling to sugarcane crop yield and productivity.

Keywords: Sugarcane; soil fertility; soil attributes; surface and subsurface depth; nutrient recommendation.

1. INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is an important cash crop in India, which is grown in 49.54 lakh hectares with a production of 313.7 million tonnes and productivity of 63.3 tonnes ha^{-1} (Annual Report, 2017-18) [1]. In Telangana region, sugarcane grown in an area of 0.35 lakh hectares with a production of 27.93 lakh tonnes and productivity of 79.80 tonnes ha^{-1} (Directorate of Economics and Statistics, 2018) [2]. Nizamabad district of Telangana comprises of about 18,000 acres ofsugarcane with an average production of sugarcane is 5.76 lakh tonnes with average cane productivity of 80 tonnes per hectare.

Nutrient level is decreasing continuously in Indian soils due to extensive agriculture while meeting the food demand of escalating population growth. Since sugarcane is a long duration crop, inter cropping is also recommended in this crop. The soil under sugarcane cultivation exhausted very soon as the nutrient uptake is very high in this crop. As a result, the soils under continuous sugarcane cultivation show deficiencies of plant nutrients such as N, P, K and S. Most of the cane growers use heavy doses of chemical fertilizers which resulted in decreased recycling of crop residues, losses of crop nutrient due to leaching, erosion and large scale shifts towards organic free materials in the fertilizer product. All these factors in a given area are prone to nutrient deficiencies in the soil which is likely to be exhausted in nutrient level in a shorter period. Soil health and nutrient management along with climatic factors play major role for sugarcane yield as the crop remains in the field for 12-18 months and an average crop of sugarcane removes 208, 53, 280, 30, 3.4, 1.2, 0.6 and 0.2 kg N, P, K, S, Fe, Mn, Zn, and Cu, respectively from the soil to yield about 100 tonnes of cane per hectare [3].

Inventory of the physico-chemical properties, available macro and micronutrients status of the soils helps in demarcating the areas where the application of particular nutrient is needed for profitable crop production [4]. Also, it is already well known that the properties of a soil are the basic attribute that influence directly on the soil response to any specified use [5]. Though sporadic information is available on characterization and classification of soils in Nizamabad and Kamareddydistricts, detailed and systematic investigation on the properties of soils, specifically in sugarcane growing soils is meagre. Hence, the present study was taken up in the major sugarcane growing soil series of Nizamabad district with an objective to understand and update the knowledge on the potentials and limitations of these soils in enhancing the productivity of sugarcane.

2. MATERIALS AND METHODS

2.1 Study Area and Sample Collection

The soil survey was carried out in six sugarcane growing mandals*viz*., Madnoor (20 samples), Banswada (14 samples), Bikanoor (18 samples), Machareddy (12 samples), Bodhan (30 samples) representing all the major sugarcane growing soils of the Nizamabad district (Location map is presented in Fig. 1). The sampling distance between two villages was approximately 2 to 4 kms; while for mandal to mandal it was 15 kms. Soil samples were collected from 16 villages of five mandals/taluk, at two depths (0-15 and 15-30 cm), samples were drawn before the commencement of spring season planting in the year 2016. Eight primary surface and sub-surface soil samples were collected randomly in a zig-zag way covering an area of 0.5 ha from a sampling site to make a composite sample (500 g) by using the quarter technique. The composite soil samples were packed and labelled properly in polythene bags and brought to the laboratory for further analysis.

2.2 Laboratory Analysis

All the soil samples were air dried, grounded and passed through 2 mm sieve for chemical analysis. Soil pH and electrical conductivity (EC) were determined by pH and conductivity meter using 1:2.5 soil water suspensions [6]. The representative soil samples were analysed for organic carbon [7], available nitrogen by $KMnO_4$ oxidation method [8], available P [Neutral and alkaline soil pH by Olsen *et al.* 1954 [9] (sodium bi-carbonate extractant) and acidic soil pH by Bray and Kurtz, 1945 [10] (ammonium fluoride extractant)], available K by neutral normal ammonium acetate extractant method [6] and DTPA extractable Fe, Mn, Zn & Cu (Lindsay and Narvell, 1978) [11] were determined on an Atomic Absorption Spectrophotometer. The soil analysis was done separately for surface and sub-surface soil samples.

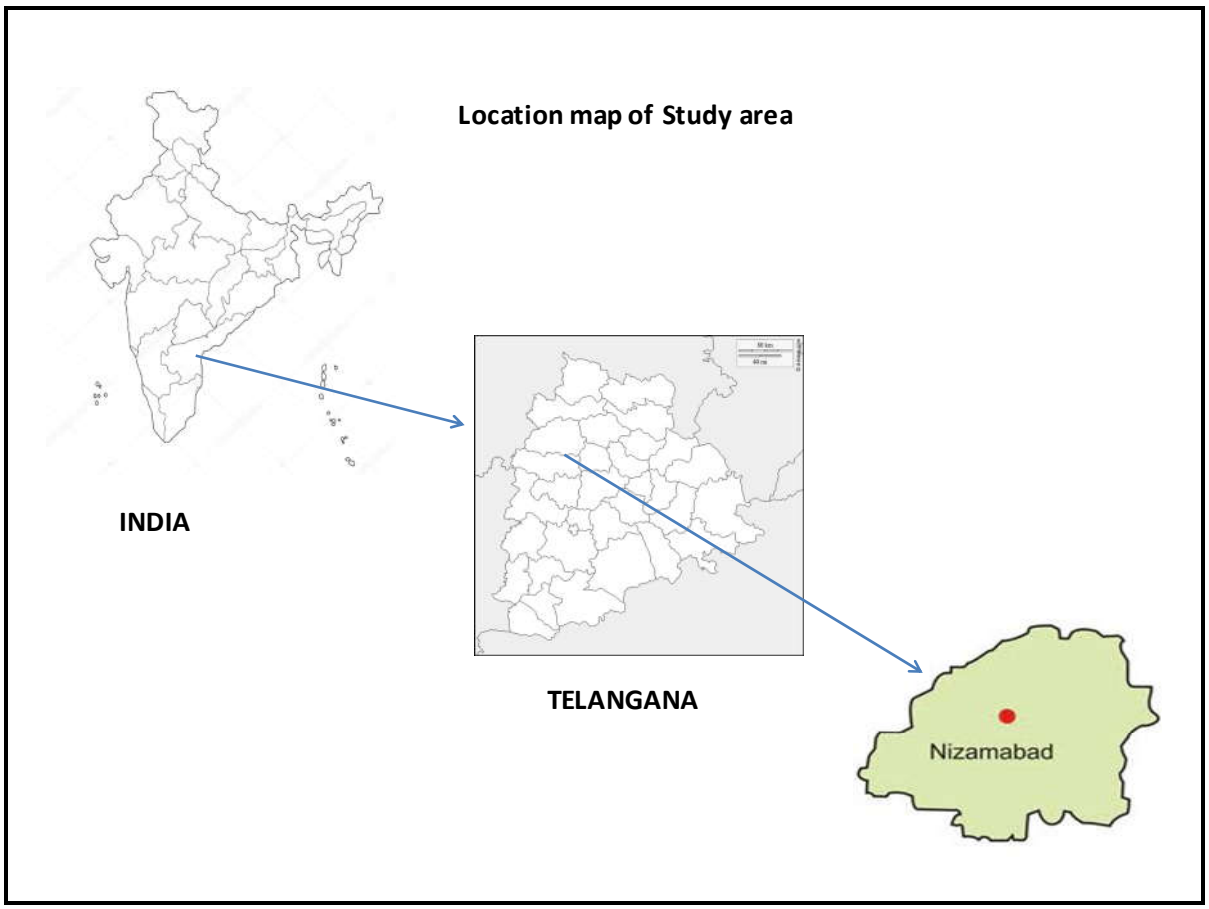

Fig. 1. Location map of the study area

2.3 Statistical Analysis

The descriptive analysis was performed in MS Excel 2007 after enabling the Add-Ins, analysis Tool. The correlation study was carried out in SPSS 17.0 version statistical package.

3. RESULTS

Detailed soil characteristics sugarcane growing soils of five mandals of Nizamabad district studied in surface and subsurface depths (0-15 and 15-30 cm respectively) have been presented in (Tables 1 and 2). We observed a wide variation in soil chemical properties *viz.,* pH, EC, N, P, K, S, OC, Fe, Cu, Mn, and Zn in two soil depths.

3.1 Soil Reaction (pH) and Electrical Conductivity (EC):

Soil reaction (pH) of the surface soil samples ranged from slightly acidic to slightly alkaline (5.88 to 8.82). Whereas sub surface soil samples recorded pretty higher pH values; however, it ranged from slightly acidic to strongly alkaline (5.82 to 9.12) than surface soils (Tables 1 and 2). The observations on soil pH of surface soils revealed that 3.2% samples were slightly acidic (6.0-6.5), 7.5% neutral (6.6-7.3), 63.8% slightly alkaline (7.4-8.4) and 25.5% strongly alkaline (8.5-9.0). Correlation study (Tables 3 and 4) showed that soil pH was negatively related with Fe and Mn (r= -0.151 and -0.748 at surface and r= -0.207 and -0.487 at subsurface soil for Fe and Mn respectively). Electrical conductivity (EC) of surface soil ranged from 0.09 to 0.98dSm^{-1} whereas in subsurface soil it ranged from 0.11 to 0.94 dSm^{-1} indicating that these soils were non saline in nature. However, the average maximum EC value of 0.93 dSm^{-1} observed at subsurface soil was 111.36% higher than value observed at surface soil (0.44 dSm^{-1}).

3.2 Organic Carbon

Status of organic carbon (%) showed wide variation of surface and subsurface soils. The values found to vary from low to high 0.25 to 1.41% in surface soil, whereas in subsurface soil it was low to medium ranging from 0.22 to 0.75% (Table 2). About 59.57 and 79.80 percent of the soils from surface and sub-surface soils, respectively were found to have low organic carbon status (<0.5%). A significantly positive relationship was observed between OC and N (r=0.883, p<0.05) at surface soil but negatively related at subsurface soil (r=-0.066).

3.3 Soil Available Macronutrients

The available nitrogen content of the surface and subsurface soils samples varied from 136 to 310 kg ha^{-1} in surface soils where as in sub-surface soils it is varied from 23 to 166 kg ha^{-1} in (Table 1) the sugarcane growing areas of Nizamabad District. On an average 91.50% of the surface soils and 100 percent of sub-surface soils were found to have low status of available nitrogen. The available phosphorus content of surface and sub-surface soil samples exhibited extreme variation between 12.05 and 103.6 kg ha^{-1} and while in subsurface soils it is varied from 3.6 to 27.90 kg ha^{-1}(Table 1). About 23.4 per cent of surface soils and 100 percent of sub-surface soils were found to be low in available phosphorus status (>24 kg ha^{-1}). The available potassium content of soil samples ranged from 242 to 715 kg ha^{-1} where as in sub-surface soils is varied from 108 to 466 kg ha^{-1}(Table 1) About 100% and 40% of soils from surface and sub-surface soils respectively recorded high status of available potassium (> 300 kg ha^{-1}). Most of the soils were high in availability of K. The average available sulphur content varied from 5.7 to 63.64 ppm in surface soils and 3.89 to 52.89 ppm in sub-surface soils. Considering 10 ppm as critical limit for available sulphur, 34.04% and 70.21% of soils from surface and sub-surface soils, respectively registered low available sulphur content. All the nutrients like N, P, and K in (Table 4) correlated positively with OC (r=0.883*, 0.768, and 0.267 respectively) at surface soil indicated the importance of OC in enhancing the macronutrients. Overall the availability of major nutrients was found lower in the sub-surface soils as compared to the surface soils.

3.4 Soil Available Micronutrients

The available Fe, Cu, Mn and Zn contents of surface soils is varied from 6.75 to 82.32, 2.64 to 11.37, 6.72 to 48.75 and 0.2 to 3.02 ppm in (Table 4) respectively. Whereas the available Fe, Cu, Mn and Zn contents of sub-surface soils is 2.4 to 14.64, 0.6 to 6.99, 1.74 to21.9 and 0.10 to 1.04 ppm, respectively. About 72.34% and 93.62% of surface and sub-surface soils, respectively. The DTPA-extractable Cu, Fe and Mn micronutrients in sub-surface soil were well above the critical limits. Interestingly, we found a strong positive relationship of Cu with soil pH (r=0.987, p<0.01) at surface soil indicating that increase in soil pH, the availability of Cu nutrient increases.

Table 1. Characterization of sugarcane growing soils of Nizamabad District

	Surface soil						Subsurface soil					
			kg ha^{-1}						kg ha^{-1}			
	pH	EC (dsm^{-1})	N	P_2O_5	K_2O	S	pH	EC (dsm^{-1})	N	P_2O_5	K_2O	S
Madnoor Mandal (3 villages, No. of samples 20)												
Range	7.62-8.62	0.091-0.985	164-288	15.25-103.5	651-715	7.95-23.7	7.95-18.73	0.134-0.725	28-112	5.1-23.6	168-466	4.59-14.56
Mean	8.12	0.44	224.00	58.01	566.40	13.79	8.32	0.38	68.20	10.23	343.15	9.63
S.D	0.29	0.26	39.79	26.80	61.97	4.46	0.29	0.18	24.67	4.12	68.34	3.00
C.V (%)	3.52	57.80	17.76	46.20	10.94	32.38	3.54	47.10	36.17	40.31	19.92	31.17
Banswada Mandal (3 villages, No. of samples 14)												
Range	7.25-8.56	0.152-0.822	154-285	16.97-95.69	282-581	6.85-24.7	6.99-8.57	0.18-0.796	28-95	6.5-15.7	116-354	3.89-16.89
Mean	8.09	0.39	214.79	52.24	398.71	12.87	8.17	0.36	62.86	10.44	226.00	9.42
S.D	0.35	0.19	41.32	25.71	85.75	5.24	0.39	0.19	21.78	3.68	76.86	3.73
C.V (%)	4.33	48.12	19.24	49.22	21.51	40.67	4.72	52.43	34.65	35.24	34.01	39.58
Bikanur Mandal (4 villages, No. of samples 18)												
Range	6.26-8.73	0.129-0.554	136-308	21.4-103.6	242-563	6.7-17.68	6.35-8.75	0.128-0.556	40-166	4.2-24.6	112-372	4.39-12.59
Mean	7.85	0.31	225.72	53.39	403.33	9.74	8.08	0.25	73.33	11.55	218.50	7.92
S.D	0.82	0.15	45.53	22.79	77.84	3.86	0.59	0.12	31.04	5.52	61.08	2.67
C.V (%)	10.44	48.17	20.17	42.69	19.30	39.62	7.30	46.58	42.33	47.77	27.96	33.64
Machareddy Mandal (3 villages, No. of samples 12)												
Range	5.88-8.82	0.128-0.428	139-256	13.28-62.48	263-486	5.7-63.64	5.82-9.12	0.153-0.623	41-158	3.6-22.8	108-232	52.89
Mean	7.83	0.44	188.83	37.63	349.42	20.10	7.89	0.93	70.75	10.60	167.67	14.10
S.D	0.81	0.41	47.05	16.39	70.20	16.53	0.84	1.72	37.16	5.10	46.36	13.04
C.V (%)	10.39	94.04	24.92	43.57	20.09	82.21	10.63	186.30	52.52	48.14	27.65	92.50
BodhanMandal (4 villages, No. of samples 30)												
Range	7.3-8.61	0.11-0.969	154-310	12.05-95.69	281-706	6.3-126.7	7.74-8.72	0.112-0.94	23-106	4.8-27.9	137-418	5.28-46.21
Mean	8.19	0.30	203.90	50.69	505.83	22.01	8.29	0.28	57.47	10.48	275.97	12.08
S.D	0.31	0.16	45.33	22.90	106.81	28.73	0.25	0.17	24.14	5.08	91.71	9.41
C.V (%)	3.82	53.66	22.23	45.18	21.11	130.52	3.07	59.58	42.01	48.50	33.23	77.94

SD-Standard Deviation; CV- Co-efficient of variation; EC-Electrical conductivity; N-Nitrogen; P_2O_5-Phosphorus; K_2O-Potassium; S-Sulphur

Table 2. Characterization of sugarcane growing soils of Nizamabad District

	Surface soil					Subsurface soil				
		mg kg^{-1} / ppm					mg kg^{-1} / ppm			
	OC (%)	**Fe**	**Cu**	**Mn**	**Zn**	**OC (%)**	**Fe**	**Cu**	**Mn**	**Zn**
Madnoor Mandal (3 villages, No. of samples 20)										
Range	0.25-1.05	6.75-36.6	4.89-11.37	6.72-26.82	0.5-2.88	0.22-0.56	3.06-14.55	1.62-5.79	2.67-7.86	0.36-1.04
Mean	0.56	12.50	6.25	13.71	1.59	0.42	6.67	2.72	5.50	0.70
S.D	0.22	6.52	1.75	6.30	0.68	0.11	2.71	1.19	1.41	0.29
C.V (%)	39.88	52.13	27.94	45.97	42.75	25.64	40.60	43.91	25.63	41.48
Banswada Mandal (3 villages, No. of samples 14)										
Range	0.43-0.88	7.98-82.32	4.44-8.97	8.7-36.6	0.58-3.02	0.31-0.62	3.66-14.64	1.38-3.9	4.47-9.69	0.36-0.78
Mean	0.55	33.12	5.70	26.94	1.44	0.45	7.14	2.46	7.12	0.51
S.D	0.12	22.57	1.56	8.66	0.83	0.10	3.02	0.71	1.59	0.12
C.V (%)	22.10	68.14	27.40	32.15	57.54	23.25	42.32	28.95	22.31	23.08
Bikanur Mandal (4 villages, No. of samples 18)										
Range	0.33-1.11	7.92-19.79	2.88-7.17	15.36-48.75	0.22-1.12	0.27-0.66	2.4-7.71	0.6-4.53	1.74-18.6	0.10-0.74
Mean	0.54	13.92	4.33	29.80	0.61	0.41	4.39	1.78	9.43	0.41
S.D	0.18	3.34	1.16	11.36	0.24	0.10	1.42	0.93	4.54	0.36
C.V (%)	33.23	24.01	26.76	38.13	40.30	24.04	32.34	52.68	48.08	87.77
Machareddy Mandal (3 villages, No. of samples 12)										
Range	0.27-0.82	8.67-60.27	2.64-5.55	17.01-45.42	0.34-1.74	0.22-0.49	3.3-11.22	0.81-3.84	1.8-19.02	0.24-0.86
Mean	0.46	27.78	3.81	26.98	0.82	0.37	7.27	1.85	7.84	0.43
S.D	0.13	18.70	1.02	7.79	0.51	0.07	2.56	0.86	4.44	0.21
C.V (%)	28.03	67.30	26.84	28.86	62.05	20.13	35.30	46.74	56.66	49.74
BodhanMandal (4 villages, No. of samples 30)										
Range	0.25-1.41	7.65-44.97	4.59-9.15	9.75-38.07	0.2-2.84	0.22-0.75	3.06-9.51	0.66-6.99	2.88-21.9	0.14-0.88
Mean	0.46	16.15	6.91	18.28	1.24	0.38	5.28	2.21	8.09	0.47
S.D	0.23	7.86	1.13	7.64	0.78	0.14	1.74	1.26	5.01	0.22
C.V (%)	50.60	48.64	16.40	41.79	62.99	35.42	32.97	56.97	61.93	47.32

SD-Standard Deviation; CV- Co-efficient of variation; OC-Organic carbon; Fe-Iron; Cu-Copper; Mn-Manganese; Zn-Zinc

Table 3. Relationship between important soil properties at surface soil depth

	pH	EC	N	P	K	S	OC	Fe	Cu	Mn	Zn
pH	1	-.144	.205	.567	.761	.253	.115	-.151	.987**	-.748	.857
EC		1	-.231	-.252	-.036	.024	.176	.358	-.247	-.202	.354
N			1	.920*	.455	-.840	.883*	-.503	.263	-.145	.219
P				1	.721	-.583	.768	-.539	.618	-.457	.514
K					1	.061	.267	-.687	.819	-.935*	.677
S						1	-.899*	.123	.240	-.328	.079
OC							1	-.133	.102	-.051	.359
Fe								1	-.295	.513	.060
Cu									1	-.774	.789
Mn										1	-.739
Zn											1

***. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed)*

Table 4. Relationship between important soil properties at sub-surface soil depth

	pH	EC	N	P	K	S	OC	Fe	Cu	Mn	Zn
pH	1	-.762	-.593	-.416	.921*	-.413	.389	-.207	.775	-.487	.674
EC		1	.340	-.220	-.569	.783	-.519	.648	-.326	-.090	-.194
N			1	.573	-.327	-.227	-.033	-.066	-.443	.198	-.114
P				1	-.457	-.433	-.080	-.738	-.773	.855	-.663
K					1	-.349	.283	-.104	.798	-.651	.853
S						1	-.766	.460	-.230	-.052	-.224
OC							1	.161	.574	-.350	.415
Fe								1	.430	-.681	.376
Cu									1	-.899*	.909*
Mn										1	-.929*
Zn											1

***. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed)*

4. DISCUSSIONS

Our results showed that soil pH was increased with the soil depth. Such trend was in strong agreement with the results reported by Ramprasad *et al.* [12] and Rakesh *et al.,*[13]. The mild to strong alkalinity could be due to accumulation of exchangeable sodium and calcium carbonate. Similar results were observed by Surekha *et.al.*, [14] in vertisols of Andhra Pradesh. With the increase of pH, the availability of Fe and Mn was decreased which probably might be due to alkaline nature of soils [15]. The electrical conductivity (EC) of majority of the soils were normal. The modest EC values of the soil samples could be ascribed to leaching of salts to lower horizon as frequent copious irrigations are very common in sugarcane cultivation. Ramprasad *et.al.,*[12] also reported non-saline EC values in chevellamandal of Telangana State.The organic carbon content of surface horizons was relatively higher than sub-surface horizons due to incorporation of organic materials to the surface horizons. Prevalence of medium and low status of organic carbon content in the major sugarcane growing soils of Nizamabad district may be due to mono culture of sugarcane and exhaustive cropping systems followed in the region on the other hand, higher content of organic carbon in certain areas may be attributed to the difference in soil properties, crop management practices and recycling of farm biomass [16]. Soil Nitrogen was increased with the OC content revealed from the positive correlation study was in supportive with the results found by (Rakesh *et al.,* 2020) [13] in AlfisolsandEntisols of West Bengal.Low status of nitrogen in soils may be attributed to intensive cropping as well as to high N requirement of the sugarcane crop. Further, high analyses fertilizers for N supplementation causes increased N loss through various mechanisms like NH_3 volatilization, nitrification, succeeding de-nitrification, leaching, runoff that finally renders the soil poor in N. These findings are related with those of Dhale and Prasad [17]. Higher

availability of P in most of the soils may be attributed to adequate application of phosphatic fertilizers to the sugarcane and other crops of the cropping system in these districts resulting in build-up of P in these soils. Similar results were reported by Shukla.S. S *et al.,* (1995) [18] and Venkatakrishnan and Ravichandran [19]. The high availability of K may be attributed to the medium and high prevalence of K rich minerals in these soils [20],[21] and [22]. Bhanu and Sindhu [23] also observed that the soils of Punjab are medium to high in available K. The DTPA-extractable micronutrients Zn, Fe, Cu and Mn in sub-surface soils were recorded to be lower compared to that of surface soils. Poor status of zinc in soils may be attributed to low organic carbon content and high soil pH [15]. In soil where available phosphorous content is high there are much chances of zinc deficiency and it is extremely important to use requisite amount of phosphatic fertilizers [24]. Zinc is one of the most important components of recommended package in most of these soils. Specifically, soil Cu showed a strong positive relationship with soil pH. Similar relationship also observed by (Kumar and Haroon 2013) [25].

5. CONCLUSION

Soil fertility analysis of sugarcane growing soils in 5 mandals of nizamabad district revealed that the soils are low to medium in available N, medium to high in available P, high in available K, deficient to sufficient in available S and Zn, sufficient in available Cu, Mn and Fe in the surface soil. The key fertility constraints observed in this investigated area is, soils are low in organic carbon, N, S and Zn content. To realise the full potential, these soils should be properly managed, supplemented with organic manures and inorganic fertilisers. Better N and Zn management is most important to sustain the soil fertility and productivity levels. The area under marginally suitable for cultivation may be converted to moderately suitable and highly suitable for cultivation of sugarcane, if proper nutrient management practices are followed in these soils.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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