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GIS AND GPS-BASED MAPPING OF SOIL PROPERTIES IN SUGARCANE GROWING AREAS OF SNJ SUGAR FACTORY ZONE, ANDHRA PRADESH

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ABSTRACT

A survey work was conducted to assess the soil fertility status of sugarcane growing soils of SNJ sugar factory zone, Andhra Pradesh. Two hundred seventeen (217) soil samples were collected at a depth of 0-15 cm from nine mandals (Palasamudram, Veduru Kuppam, Penumuru, Rompicherla, Pileru, Pulicherla, Chinnagottigallu, Erravaripalem and Chandragiri) and analyzed for physico-chemical and chemical properties. Geo reference coordinates (Latitude and Longitude) also noted at sampling sites. The results revealed that 38% of soils were neutral in reaction (pH 6.5-7.0), 10% were slightly acidic and 33% of soils were slightly alkaline in reaction. All soils had non saline nature. 80% of soils were low in organic carbon (OC) content and 20% of soils had medium in OC content. Available nitrogen in 93% of collected soils was low (< 280 kg ha^{-1}). Available phosphorus in these sugarcane growing soils ranged from 26 to 114 kg ha^{-1} with a mean of 57.07 kg ha^{-1}. Available potassium levels varied between 197 and 521 kg ha^{-1} (medium to high) with a mean of 347 kg ha^{-1}. The soils have available sulphur ranged from 2.6 to 15.6 mg kg^{-1}. 74% of soils were showed deficient in available sulphur. Digital soil maps for pH, EC, OC, available nitrogen, phosphorus, potassium and sulphur prepared by using GIS approach. Soil nutrient index for OC, available nitrogen, phosphorus, potassium and sulphur was 1, 1, 2, 2.31 and 1, respectively.

Key words: Sugarcane soils, Soil properties, Fertility maps, Nutrient index, GIS approach and Andhra Pradesh.

INTRODUCTION

Sugarcane is one of the important commercial crops grown in India and plays a vital role in the agricultural as well as industrial economy. It is a multipurpose crop that provides sugar, fiber, bio fuel and manure apart from many by products. In India, sugarcane is grown under diverse agro climatic conditions with an area of about 48.51 lakh hectares with an annual production of 397.65 million tones and mean productivity of 81.98 t ha^{-1}. India is one of the largest producers of sugarcane and has a neck to neck race with Brazil for first position. In Andhra Pradesh, it is cultivated in an area of 0.55 lakh hectares with production and productivity of 4.29 million tones and 78.08 t ha^{-1}, respectively (Co-operative sugar, 2021), sugarcane – sugarcane followed by 3 to 4 rations is the prominent cropping system in Andhra Pradesh. The physic-chemical and chemical properties of soils their interaction with one another and variation in nutrient supplying capacity is a natural phenomenon. Therefore, different management practices are required for sustaining crop productivity at various locations. In this part, fertility status or nutrient status of various soils is very important. Kumar *et al.* (2017) reported that generally soil differs in their morphological, physical, mineralogical and biological

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characteristics.

Sugarcane needs large quantity of nutrients and it removes about 1.2 kg nitrogen, 0.22 kg phosphorus and 2.8 kg potassium for each ton of cane production. Hence its productivity per unit area and time heavily rests on inherent soil nutrient status and their availability. To ensure optimum agricultural production, it is imperative to know nutrients status of sugarcane growing soils and their management to achieve sustainable production.

The geographical information system (GIS) techniques have great demand in agriculture for future site specific management of nutrients in different locations/ villages (Sharma., 2004: Vivekananda *et al.*, 2017). Developing accurate application maps for different nutrients is critical in implementing precision farming technology (Jena *et al.*, 2021). Farmers hardly have any knowledge about available nutrients especially micronutrients and its importance in sugarcane production. Hence, the present study focuses on assessment of soil properties (soil nutrient status) and their extent of deficiency in sugarcane growing soils of SNJ sugar factory zone, Andhra Pradesh.

MATERIALS AND METHODS

To know the status of soil properties, 217 soil samples were collected from surface soil up to a depth of 15 cm from sugarcane growing areas of nine mandals *viz.*, Palasamudram, Vedurukuppam, Penumuru, Rompicerla, Pileru, Pulicherla, Chinnagotigallu, Erravaripalem, Chandragiri in SNJ sugar Factory zone, Andhra Pradesh, India. The GPS coordinates (Latitude and Longitude) were recorded at each sampling site. The collected soil samples were air dried, grounded sieved and analyzed for soil physico-chemical and chemical properties. The soil pH and EC were measured in 1:2.5 soil:water ratio (W/V) suspension using pH meter and EC meter, respectively (Jackson, 1975). Soil organic carbon content in 0.5 mm sieved soil samples was estimated by Walkley and Black (1934) rapid titration method and expressed the result in per cent. Available nitrogen was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956). The available phosphorus was extracted with the 0.5 *M* $NaHCO_3$ (pH:8.5) extract ant and determined by using ascorbic acid as reducing agent (Olsen *et al.*, 1954) and the available potassium in the soils was extracted by employing neutral normal ammonium acetate and determined by aspirating the extract into the flame photometer (Jackson, 1975). Available sulphur was determined by extracting with 0.15 per cent calcium chloride followed by development of turbidity with barium chloride (Hesse, 1971). Soil nutrient index was calculated by using the following formulae as described by Motsara *et al.*, (1982) to express area wise soil fertility status.

$$\text{Nutrient Index (N1)} = \frac{N_l + 2\,N_m + 3\,N_h}{N_l + N_m + N_h}$$

Rating chart of nutrient index is given as follows:

NI	Rate
<1.67	Low
1.67 to 2.33	Medium
>2.33	High

where Nl, Nm, Nh are the numbers of soil samples falling in the category of low, medium and high nutrient status and are given weightages of 1, 2 and 3, respectively.

The descriptive statistics like maximum, minimum, mean and coefficient of variation (CV) for various soil properties were computed using SPSS-2.0 soft ware. The digital soil maps for various parameters have been prepared by using GIS technology.

RESULTS AND DISCUSSION

Data pertaining to range, mean and CV of various soil properties was presented in Table 1. Most of the farmers in study area applied complex fertilizers led to imbalanced application of fertilizers causes deficiency or excess of nutrients. It has been shown detrimental effect on plant growth.

Soil pH

The pH of surface soils of SNJ Sugar Factory Zone in Andhra Pradesh ranged from 6.24 to 8.20 with a mean of 7.36. The lowest pH was noticed in chandragiri mandal (6.24) and highest pH was observed in Penumuru mandal (8.20) (Table 1). The soil reaction values in sugarcane growing soils of various mandals in SNJ sugar factory zone of Andhra Pradesh *viz.*, Palasamudram, Vedurukuppam, Penumuru, Rompicerla, Pileru, Pulicherla, Chinnagotigallu, Erravaripalem, Chandragiri varied from 6.39 to 8.34, 6.34 to 8.24, 6.55 to 8.2, 7.2 to 7.56, 6.28 to 7.13, 7.12 to 8.02, 6.42 to 8.04, 7.12 to 7.53 and 6.24 to 8.01, respectively (Table 1). Mapping of soil reaction (pH) by GIS

Table 1. Physico chemical and chemical properties in sugarcane growing soils in SNJ sugar factory zone, Andhra Pradesh.

	pH	EC (dS m^{-1})	OC (%)	Avail. N (kg ha^{-1})	Avail. P_2O_5 (kg ha^{-1})	Avail. K_2O (kg ha^{-1})	Avail. S (mg kg^{-1})
Mandal: Palasamudram							
Min	6.39	0.337	0.26	113	28	197	4.9
Max	8.34	2.025	0.54	300	114	452	12.4
Mean	7.46	1.19	0.39	208.29	56.45	299.09	8.87
Mandal: Vedurukuppam							
Min	6.34	0.762	0.26	75	27	230	3.5
Max	8.24	2.51	0.58	263	78	521	15.6
Mean	7.42	1.59	0.45	180.10	49.15	322.69	8.96
Mandal: Penumuru							
Min	6.55	0.265	0.38	138	26	248	3.6
Max	8.2	2.358	0.62	300	82	457	10.7
Mean	7.45	1.38	0.49	203.90	51.57	294.21	7.24
Mandal: Rompicherla							
Min	7.2	0.472	0.46	175	40	357	4.5
Max	7.56	1.62	0.61	313	82	502	9.1
Mean	7.41	1.09	0.54	237.88	60.50	404.00	6.80
Mandal: Pileru							
Min	6.28	0.58	0.26	75	28	259	3.6
Max	7.13	1.001	0.56	225	97	510	9.2
Mean	6.68	0.84	0.45	166.93	51.67	385.67	6.23
Mandal: Pulicherla							
Min	7.12	0.53	0.32	100	26	264	2.6
Max	8.02	2.64	0.57	238	109	512	7.4
Mean	7.67	1.55	0.46	184.04	54.40	402.40	5.39
Mandal:Chinnagottigallu							
Min	6.42	0.44	0.24	100	47	256	4.4
Max	8.04	1.952	0.56	263	103	458	12.8
Mean	7.46	0.70	0.37	189.19	63.89	354.11	8.39
Mandal: Erravaripalem							
Min	7.12	0.623	0.42	225	54	378	6.9
Max	7.53	0.965	0.55	288	92	482	12.4
Mean	7.3	0.8	0.5	254.6	77.0	437.3	9.2
Mandal: Chandragiri							
Min	6.24	0.259	0.28	150	42	265	4.6
Max	8.01	1.048	0.61	263	102	502	12
Mean	7.024	0.58235	0.45	211.588	69.4	372.4	9.34
Overall							
Min	6.24	0.825	0.24	70	26	197	2.6
Max	8.2	2.640	0.62	313	114	521	15.6
Mean	7.36	1.160	0.45	198	57.07	347	7.89
CV (%)	13.28	40.18	36.50	49.11	61.24	38.90	61.82

technique resulted in three soil reaction classes *viz*., slightly acidic, neutral, slightly alkaline. Major proportion of the SNJ sugar factory zone was neutral (38%) followed by slightly alkaline (33%) and slightly acidic (10%). The CV (13.28%) of soil pH indicates that it did not vary spatially in the SNJ sugar factory zone. The variation in soil pH might be attributed to the variation in nature of parent materials and degree of weathering. The higher pH values could be ascribed to the comparatively less leaching of bases in sandy clay loams than that in other coarse textured soils (Kavitha *et al*., 2020).

Electrical conductivity (EC)

All the soil samples in SNJ sugar factory zone were non salinine nature. The soils in Palasamudram, Vedurukuppam, Penumuru, Rompicerla, Pileru, Pulicherla, Chinnagotigallu, Erravaripalem,

Chandragiri mandals of SNJ sugar factory zone of Andhra Pradesh registered the mean EC of 1.19, 1.59, 1.38, 1.09, 0.84, 1.55, 0.70, 0.80 and 0.5 dS m^{-1}, respectively.

The CV (40.18%) of EC values indicated that presence of salts in SNJ sugar factory zone varied spatially. The EC ranged from 0.825 dS m^{-1} to 2.640 ds m^{-1} with a mean of 1.16 dS m^{-1} indicating the presence of very low amount of soluble salts. All the soils under the study area were non-saline in nature as the EC of soils was far below 4 dS m^{-1}. The low EC in the sugarcane growing soils was due to excess leaching of soluble salts and free drainage conditions which favoured the removal of salts by percolating and drainage water. All the soil samples in the present study have favourable EC for crop growth. Similar findings were reported by Verma *et al.*, (2016) in sugarcane growing soils of Ahmednagar district in Maharashtra.

Organic carbon (OC)

Organic carbon content of surface soils varied from 0.24% to 0.62% with a mean of 0.45%. Among the samples 80% of samples showed low OC content and remaining % of soil samples had medium OC content. Low OC content in most of the soils might be due to the fact that the farmers cannot apply manures or organic sources of nutrient at required level. These results were in conformation with the findings of Kavitha *et al.*, (2019). The CV value of 36.50 per cent indicates that, organic carbon in the soils varied spatially in SNJ sugar factory zone. The lower organic carbon content was observed in 80% of soils in this factory zone, might be due to the prevalence of favourable climatic conditions where the decomposition of organic matter occurs at a faster rate coupled with low vegetative cover thereby leaving less organic carbon in the soils. These findings were in good agreement with the findings of Somasekharbabu *et al.* (2016).

Available nitrogen

Most of the sugarcane growing soils in SNJ sugar factory zone of Andhra Pradesh had low in available nitrogen and ranged from 70 kg ha^{-1} to 313 kg ha^{-1} with a mean value of 198 kg ha^{-1}. Mapping of soil available nitrogen by GIS revealed that, about 93 per cent area was low and 7 per cent area was medium in available nitrogen. The CV value of 49.11 per cent indicates that, available nitrogen in soils varied spatially. This might be due to low organic matter content. Further, it may also be due to rapid oxidation and lesser accumulation of organic matter releasing more NO_3-N which could have been lost by leaching. The low nitrogen in sugarcane growing soils in their study area was reported by Ashok kumar and Prasad (2010) in Ahmednagar district of Maharashtra. The low available nitrogen status of these soils also may be attributed to the application of complex fertilizers, thus may not meet the nitrogen requirement to sugarcane. Due to nitrogen deficiency in soils, the cane yield in sugarcane also decreased. Hence, it is necessary to aware the farmers with respect to balanced fertilizer application.

Available phosphorus

Available phosphorus in soils of SNJ sugar factory zone ranged from 26 to 114 kg ha^{-1} with a mean of 57.47 kg ha^{-1}. The soil in Penumuru mandal recorded low available phosphorus (26 kg ha^{-1}) where as soils in Palasamudram mandal having high available phosphorus content (114 kg ha^{-1}). In this factory zone, 59% of soils had been showed medium and 41% of soils showed high in available phosphorus. The high available phosphorus might be due to continuous application of phosphotic fertilizers in huge quality in the form of DAP, SSP apart from complex fertilizers.

Mapping of available P_2O_5 by GIS revealed that, about 59 per cent and 41 per cent of study area was found to be medium and high in phosphorus status, respectively. The CV of 61.24 per cent for available P_2O_5 in the SNJ sugar factory zone indicates that, it varied spatially. Similar type of results was noticed by Kavitha *et al.*, (2019).

Available potassium

Regarding available potassium in surface soil samples, 49% of samples ranged between 197 kg hg^{-1} and 340 kg ha^{-1}. Among all samples, 51% of samples found to be higher in range (>340 kg ha^{-1}).

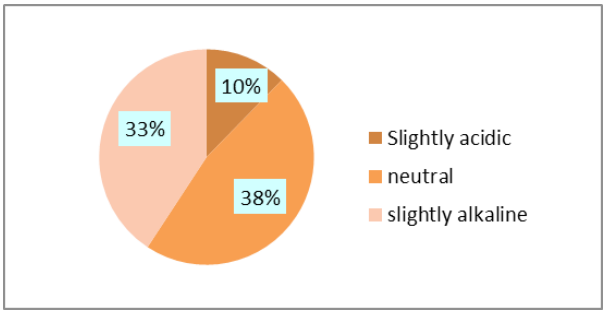
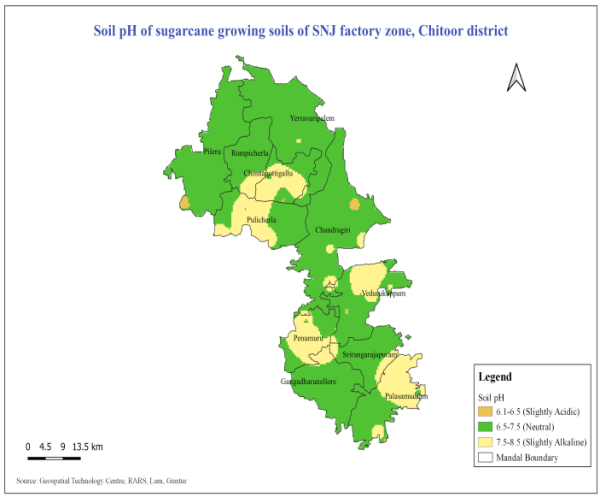
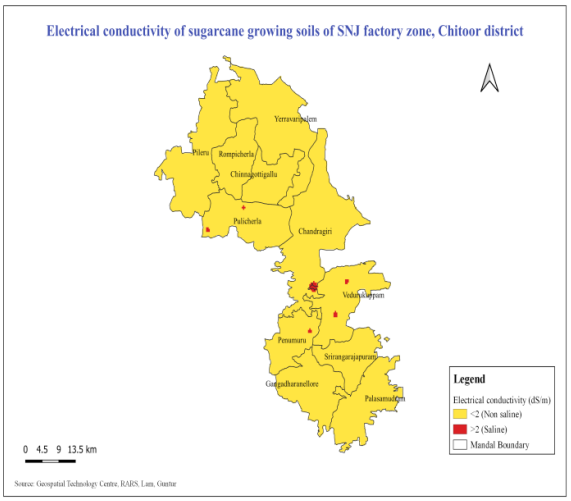
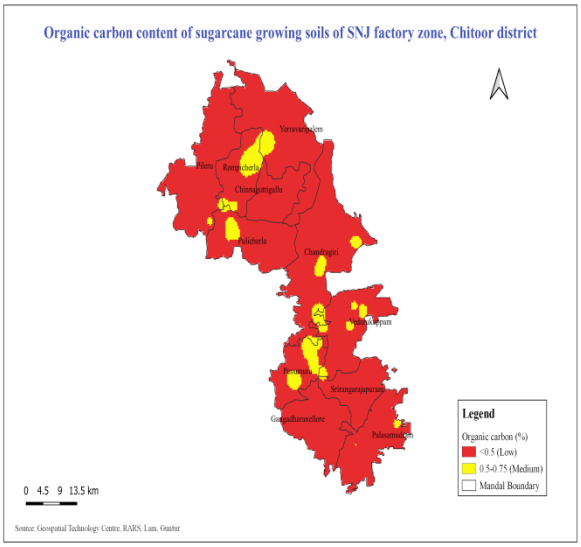
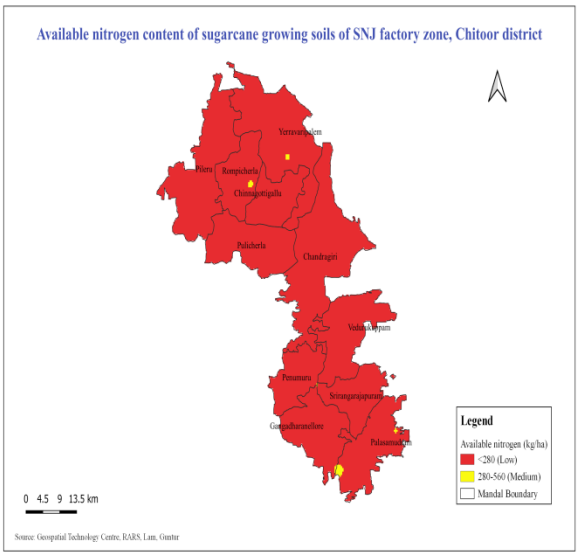


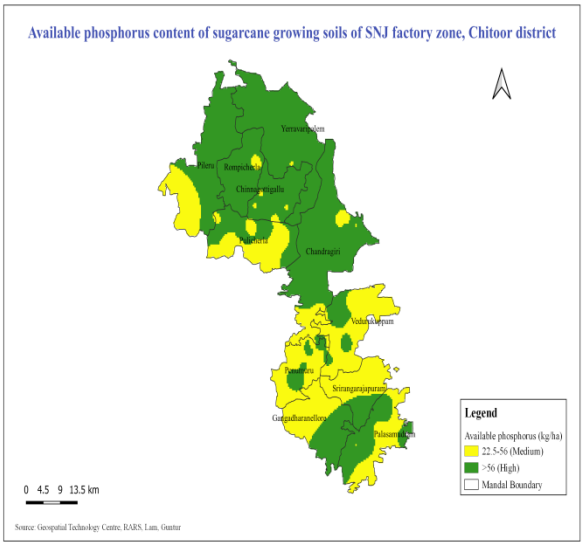
Fig. 1. Soil reaction in sugarcane growing soils of SNJ sugar factory zone.

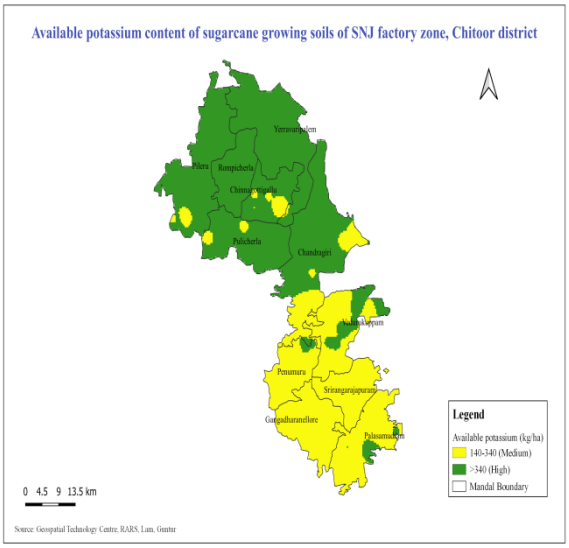

Soil pH of sugarcane growing soils of SNJ factory zone, Chitoor district
Yerravaripalem
Pileru
Rompicherla
Chinnagottigallu
Pulicherla
Chandragiri
Vedurukuppam
Penumuru
Srirangarajapuram
Gurrandharanellore
Palasamudram
Legend
Soil pH
6.1-6.5 (Slightly Acidic)
6.5-7.5 (Neutral)
7.5-8.5 (Slightly Alkaline)
Mandal Boundary
0 4.5 9 13.5 km
Source: Geospatial Technology Centre, RARS, Lam, Guntur


Electrical conductivity of sugarcane growing soils of SNJ factory zone, Chitoor district
Yerravaripalem
Pileru
Rompicherla
Chinnagottigallu
Pulicherla
Chandragiri
Vedurukuppam
Penumuru
Srirangarajapuram
Gurrandharanellore
Palasamudram
Legend
Electrical conductivity (dS/m)
<2 (Non saline)
>2 (Saline)
Mandal Boundary
0 4.5 9 13.5 km
Source: Geospatial Technology Centre, RARS, Lam, Guntur


Organic carbon content of sugarcane growing soils of SNJ factory zone, Chitoor district
Yerravaripalem
Pileru
Rompicherla
Chinnagottigallu
Pulicherla
Chandragiri
Vedurukuppam
Penumuru
Srirangarajapuram
Gurrandharanellore
Palasamudram
Legend
Organic carbon (%)
<0.5 (Low)
0.5-0.75 (Medium)
Mandal Boundary
0 4.5 9 13.5 km
Source: Geospatial Technology Centre, RARS, Lam, Guntur


Available nitrogen content of sugarcane growing soils of SNJ factory zone, Chitoor district
Yerravaripalem
Pileru
Rompicherla
Chinnagottigallu
Pulicherla
Chandragiri
Vedurukuppam
Penumuru
Srirangarajapuram
Gurrandharanellore
Palasamudram
Legend
Available nitrogen (kg/ha)
<280 (Low)
280-560 (Medium)
Mandal Boundary
0 4.5 9 13.5 km
Source: Geospatial Technology Centre, RARS, Lam, Guntur


Available phosphorus content of sugarcane growing soils of SNJ factory zone, Chitoor district
Yerravaripalem
Pileru
Rompicherla
Chinnagottigallu
Pulicherla
Chandragiri
Vedurukuppam
Penumuru
Srirangarajapuram
Gurrandharanellore
Palasamudram
Legend
Available phosphorus (kg/ha)
22.5-56 (Medium)
>56 (High)
Mandal Boundary
0 4.5 9 13.5 km
Source: Geospatial Technology Centre, RARS, Lam, Guntur


Available potassium content of sugarcane growing soils of SNJ factory zone, Chitoor district
Yerravaripalem
Pileru
Rompicherla
Chinnagottigallu
Pulicherla
Chandragiri
Vedurukuppam
Penumuru
Srirangarajapuram
Gurrandharanellore
Palasamudram
Legend
Available potassium (kg/ha)
140-340 (Medium)
>340 (High)
Mandal Boundary
0 4.5 9 13.5 km
Source: Geospatial Technology Centre, RARS, Lam, Guntur

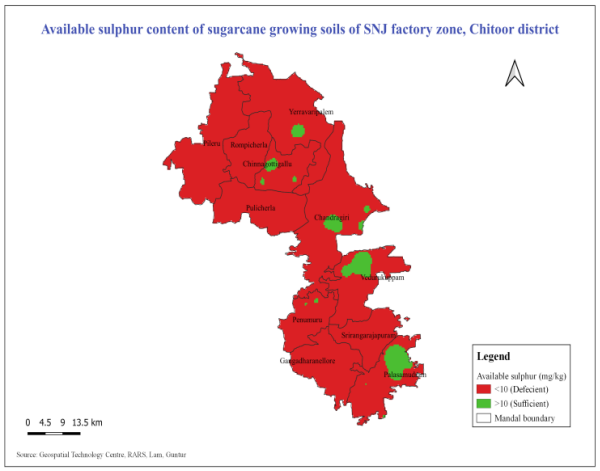


Fig. 2. Soil fertility maps of sugarcane growing soils of SNJ sugar factory zone, A.P.

The overall available potassium in this SNJ sugar factory zone was ranged from 197 kg lit to 521 kg ha^{-1} with a mean of 347 kg ha^{-1}. The potassium was supplied in adequate quantities through fertilizers. Hence all the soils bagged medium to high available potassium content. Digital map for available potassium was prepared by using GIS approach (Fig.1) the results were in confirmation with Sireesha *et al.* (2021).

Available sulphur

The soils in SNJ sugar factory zone, Andhra Pradesh having available sulphur ranged from 2.6 to 15.6 mg kg^{-1} with a mean of 7.89 mg kg^{-1}. Considering 10.00 mg sulphur kg^{-1} soil (Tandon, 1991) as the critical limit for normal plant growth, it may be inferred that about 74% of soils showed deficiency in available sulphur. The soils in Pulicherla mandal recorded lowest available sulphur (2.6 mg kg^{1}) and soils in Vedurukuppam mandal showed high available sulphur content (15.6 mg kg^{-1}). The mean available sulphur in sugarcane growing soils of various mandals in SNJ sugar factory zone of Andhra Pradesh *viz*., Palasamudram, Vedurukuppam, Penumuru, Rompicerla, Pileru, Pulicherla, Chinnagotigallu, Erravaripalem, Chandragiri mandals was 8.87, 8.96, 7.24, 6.86, 6.23, 5.39, 8.39, 9.20 and 9.34 mg kg^{-1}, respectively.

Table 2. Soil Nutrient Index for sugarcane growing areas in SNJ sugar factory zone, Chittoor district, Andhra Pradesh.

S. No.	Nutrient	Nutrient Index	Rating
1	Organic carbon	1	Low
2	Available nitrogen	1	Low
3	Available phosphorus	2	Medium
4	Available potassium	2.31	Medium
5	Available sulphur	1	Low

By using GIS approach fertility map for available S was prepared. The map showed that, about 74 per cent study area was deficient and 26 per cent area was sufficient in the available sulphur. These results were in confirmation with those reported by Vijayakumar and Haroon (2013). The CV of 61.82 per cent for available sulphur indicates that, in the SNJ sugar factory zone available sulphur varied spatially.

Soil Nutrient Index

The nutrient Index for OC, available nitrogen, phosphorus, potassium and sulphur in sugarcane growing areas of SNJ sugar factory zone was 1, 1, 2, 2.31,1 which indicated that the soils were low in organic carbon, available nitrogen, medium in available phosphorus, and potassium, low in available sulphur.

CONCLUSION

This study reveals that sugarcane growing soils of SNJ Sugar Factory zone, Chittoor district, Andhra Pradesh were slightly acidic to slightly alkaline in reaction, non-saline nature and low to medium in organic carbon content. Most of the soils (93%) were low in available nitrogen. Available phosphorus and potassium were medium to high. Available sulphur was deficient in 74% of samples. The data on soil nutrient index indicated that sugarcane growing soils registered low in organic carbon content, available nitrogen and available sulphur. The available phosphorus and potassium were medium in range. Hence, these results indicates that there is need to adopt soil test based balanced nutrient management to rectify the deficiency of nutrients in soil for improving soil health and enhanced sugarcane production, productivity and profitability in a sustainable manner.

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