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Spatial Distribution and Mapping of DTPA Extractable Micronutrients in Sugarcane Growing Tracts of Prudential Sugar Factory Zone in Chittoor District, Andhra Pradesh, India

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A B S T R A C T

Two hundred and seventy (270) geo-referenced (GPS based) composite surface soil samples (0-15cm) were collected from 8 mandals of Prudential sugar factory zone, of Chittoor district, Andhra Pradesh. Soil samples were analyzed for exchangeable Ca, Mg and DTPA extractable micronutrients (Fe, Mn, Cu, Zn). The results revealed that exchangeable calcium and magnesium were ranged from 1 to 6.8 cmol (p+) kg^{-1} and 0.3 to 6.8 cmol (p+) kg^{-1} soil with a mean values of 3.43 cmol (p+) kg^{-1} soil and 3.44 cmol (p+) kg^{-1} soil respectively. The DTPA extractable micronutrients such as iron, manganese, zinc and copper were ranged from 0.11 to 34.27, 0.04 to 29.15, 0.01 to 10.22 and 0.01 to 2.67 mg kg^{-1}, respectively with a mean value of 6.30, 2.80, 1.32 and 0.79 mg kg^{-1} indicating deficient to sufficient in available micronutrients status. Thematic maps were prepared for each soil parameter using ArcGIS 9.3.1 package. The soil fertility maps provide the readymade source of information about soil fertility status.

Introduction

Soil fertility fluctuates throughout the growing season each year due to alteration in the quantity and availability of mineral nutrients by the addition of fertilizers, manure, compost, mulch and lime in addition to leaching. Hence, evaluation of fertility status of the soils of an area or a region is an important aspect in the context of sustainable agriculture (Singh and Mishra, 2012). Soil testing assess the current fertility status and provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximizing crop yields and to maintain the optimum fertility in soil year after year.

Sugarcane is the main sugar producing crop that contributes more than 75 per cent to the total sugar pool at the global level. India, being the world's second largest producer after Brazil, is producing nearly 15 and 25 percent of global sugar and sugarcane,

respectively. Indian sugar industry is playing a lead role in global sugar market contributing significantly to the socio-economic development of the nation. Area coverage, production and productivity of sugarcane in India are 5.0 million ha, 3.4 lakh million tones and 69.4 tonnes ha^{-1}, respectively. Area coverage, production and productivity of sugarcane in Andhra Pradesh are 1.22 million ha, 0.9 lakh million tonnes and 75.7 tonnes ha^{-1} (sugarcane.dac.gov.in/Statistics APY. pdf, 2015), respectively while sugarcane production in Chittoor district is to an extent of 26,000 ha with a productivity of 79.05 t ha^{-1}.

In agriculture, global positioning system (GPS) and geographic information system (GIS) technologies have been adopted for better management of land and other resources for sustainable crop production (Palaniswami *et al.,* 2011). Fertilizer is one of the costliest inputs in agriculture and the use of right amount of fertilizer is fundamental for farm profitability and environmental protection (Mahendra, 2010). The soil fertility maps for fertilizer recommendation with a support to calculate fertilizer doses based on soil test values interactively. Inventory of the available macro and micronutrient status of the soils help in demarcating areas where the application of particular nutrient is needed for profitable crop production (Sood *et al.,* 2009). However generation of soil fertility maps for various nutrients in sugarcane growing areas in Chittoor district of Andhra Pradesh is virtually lacking. Hence present investigation was carried out to know the nutrient status in soil along with fertility maps.

Materials and Methods

Prudential sugar factory zone is located in Chittoor district belonging to southern zone of Andhra Pradesh. Prudential sugar factory zone consists of eight mandals *viz.,* Nindra, Nagari,

Narayanavanam, K.V.B.Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur (Fig. 1). This area lies in between 13° 11′ 24″and 13^0 53′49.2″ North latitudes and 79^{0}11′ 49.2″ and 80^0 11′ 24″ East longitudes. Two hundred and seventy soil samples were collected at a depth of 0-20 cm sugarcane growing fields in about eight mandals of Prudential sugar factory zone by following random sampling technique during the month of November, 2017. The exact sample location was recorded by using hand held GPS. These soil samples were collected by adopting the procedure given by Jackson (1973). Exchangeable calcium and magnesium were extracted with neutral normal ammonium acetate and the content was determined by versenate titration method (Jackson, 1973). The available micronutrients in soil samples were extracted by using DTPA extractant of pH 7.3 (Lindsay and Norvell, 1978) and the extract was aspirated to atomic absorption spectrophotometer (VARIAN AA240FS).

The base map that was prepared by using Google earth image of the Prudential sugar factory zone, Chittoor district was used for preparation of thematic maps for various parameters such as, exchangeable calcium, magnesium and DTPA extractable micronutrients by adopting geostatical tool of krigging in *Arc*GIS 9.3.1 environment.

Results and Discussion

Exchangeable calcium (Ca)

The mean exchangeable calcium in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district *viz.,* Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur were 3.61, 3.88, 2.82, 3.31, 3.41, 3.28, 2.9 and 3.69 cmol (p+) kg^{-1} soil, respectively (Table 1). The exchangeable calcium in sugarcane growing soils was

ranged from 1 to 6.8 cmol (p+) kg^{-1} soil with a mean value of 3.43 cmol (p+) kg^{-1} soil. About 94.81 per cent area (5125 ha) was sufficient in available calcium as per the critical limit of 1.5 cmol (p+) kg^{-1} soil as suggested by Tandon (1989). This might be due to fact that soils might be formed from the basic parent materials rich in calcium. Similar findings were reported by Prasanna *et al.,* (2017) and Vinaykumar *et al.,* (2017).

Mapping of exchangeable calcium by GIS revealed that, about 5.19 per cent of study area was deficient and 94.81 per cent area was sufficient in the available calcium content. The coefficient of variation (CV) of 37.00 per cent for available calcium indicates that, it varied spatially in the Prudential sugar factory zone (Fig. 2).

Exchangeable magnesium (Mg)

The mean exchangeable magnesium in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district namely Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur were 3.58, 3.40, 3.46, 3.20, 3.42, 3.52, 3.25 and 3.50 cmol (p+) kg^{-1} soil, (Table 1) respectively. The exchangeable magnesium in the soils varied from 0.3 to 6.8 cmol (p+) kg^{-1} soil with a mean value of 3.44 cmol (p+) kg^{-1} soil. The results indicated that, about 97.41 per cent of study area (5266 ha) was sufficient in available magnesium as per the critical limit of 1.0 cmol (p+) kg^{-1} soil as suggested by Tandon (1991). Similar findings were also reported by Thangasamy (2002), Prasanna *et al.,* (2017) and Vinaykumar *et al.,* (2017).

Mapping of exchangeable magnesium by GIS revealed that, about 2.59 per cent of study area was deficient in the exchangeable magnesium. The CV of 35.60 per cent for available magnesium indicates that, it varied spatially in the study area (Fig. 3).

DEPA extractable micronutrients

DTPA extractable iron (Fe)

The range of DTPA extractable iron in sugarcane growing soils of Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur was varied from 0.11 to 29.29, 2.25 to 23.38, 2.14 to 17.79, 0.38 to 20.80, 0.30 to 16.42, 0.37 to 29.95, 1.02 to 34.27 and 1.69 to 25.56 mg kg^{-1}, respectively. The mean DTPA extractable iron in sugarcane growing soils of above mandals were 6.26, 6.65, 5.98, 6.70, 5.02, 6.17, 7.13 and 8.45 mg kg^{-1}, respectively. Mapping of available Fe by GIS revealed that, about 54.44 per cent area was deficient and 45.56 per cent area was sufficient as per the critical limit for available iron (4.0 mg kg^{-1} soil) as established by soil test based fertilizer application (Ahmed *et al.,* 2007). The coefficient of variation (CV) of 95.64 per cent for available Fe revealed that, it varied spatially in the Prudential sugar factory zone. The available iron in these soils was ranged from 0.11 to 34.27 mg kg^{-1} soil with a mean value of 6.30 mg kg^{-1} soil. The lower values of iron in these soils, might be due to various factors *viz.,* soils derived from parent materials originally containing low amounts of iron, soils with lighter textures, soils under intensive cultivation receiving high levels of high analysis NPK fertilizers *etc*. The high Fe in some soils could be attributed to the presence of high amount of ferro-magnesium minerals in these soils. Similar results in available iron were also reported by Leelavathi *et al.,* (2009) and Paramasivan *et al.,* (2016) (Fig. 6).

DTPA extractable Manganese (Mn)

The DTPA extractable manganese in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district *viz*., Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichatur,

Nagalapuram and Puttur ranged from 0.17 to 29.15, 0.25 to 13.90, 0.29 to 7.69, 0.04 to 11.57, 0.18 to 13.90, 0.09 to 7.99, 0.31 to 10.51 and 0.62 to 12.70 mg kg^{-1}, respectively. The mean available manganese in sugarcane grown soils of above mandals were 3.36, 2.16, 3.43, 3.46, 2.88, 2.13, 2.27 and 2.88 mg kg^{-1}, respectively. Mapping of DTPA extractable Mn by GIS revealed that, about 52.96 per cent area was deficient and 47.04 per cent area was sufficient as per the critical limit for available manganese (2.0 mg kg^{-1} soil) was established by (Ahmed *et al.,* 2007).

The CV value of 107.37 per cent for available Mn indicates that, it varied spatially in the Prudential sugar factory zone. DTPA extractable manganese of the soils under the study area ranged from 0.04 to 29.15 mg kg^{-1} with a mean value of 2.8 mg kg^{-1} soil. The wide variation in available manganese (0.04 to 29.15 mg kg^{-1}) among the soils studied could be ascribed to variation in manganese bearing minerals, clay, organic carbon, CEC and other associated elements (Prasad, 1994). These results were in accordance with the findings of Selvaraj and Naidu (2012) and Govardhan *et al.,* (2017) (Fig. 4).

DTPA extractable Zinc (Zn)

The DTPA extractable zinc in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district *viz.,* Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichattur, Nagalapuram, Puttur varied from 0.08 to 6.45, 0.44 to 10.22, 0.33 to 2.42, 0.08 to 4.10, 0.01 to 4.97, 0.08 to 6.22, 0.29 to 8.78 and 0.46 to 3.93 mg kg^{-1}, respectively. The mean available zinc in sugarcane growing soils of above mandals were 1.28, 1.80, 0.88, 1.21, 1.16, 1.20, 1.45 and 1.66 mg kg^{-1}, respectively.

Mapping of available zinc by *Arc*GIS revealed that, about 27.78 per cent area was deficient and 72.22 per cent area was sufficient as per

the critical limit for DTPA extractable zinc (0.65 mg kg^{-1} soil) as established by (Ahmed *et al.,* 2007). The CV of 92.88 per cent for available Zn indicates that, it varied spatially in the study area. The available zinc in the soils under the study area was ranged from 0.01 to 10.22 mg kg^{-1} soil with a mean value of 1.32 mg kg^{-1} soil. The relatively high available Zn may be attributed to variable intensity of pedogenic processes and complexing with organic matter which resulted in chelating of Zn. The occurrence of the zinc deficient in the soils of study area was due to the non-application of the zinc fertilizers by the farmers. These results were in agreement with findings of Verma *et al.,* (2016) and Govardhan *et al.,* (2017) (Fig. 7).

DTPA extractable Copper (Cu)

The DTPA extractable copper in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district *viz.,* Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur varied from 0.01 to 1.88, 0.25 to 1.71, 0.25 to 2.06, 0.02 to 1.75, 0.18 to 2.67, 0.02 to 1.58, 0.13 to 1.49 and 0.72 to 2.17 mg kg^{-1}, respectively. The mean DTPA extractable copper in sugarcane grown soils of above mandals were 0.72, 0.94, 0.78, 0.71, 0.83, 0.69, 0.61 and 1.30 mg kg^{-1}, respectively. Mapping of DTPA extractable copper by GIS revealed that, about 4.44 per cent study area was deficient and 95.56 per cent area was sufficient as per the critical limit for available copper (0.2 mg kg^{-1} soil) as established by soil test based fertilizer application (Ahmed *et al.,* 2007). The CV of 61.56 per cent for available Cu indicates that, it varied spatially in the Prudential sugar factory zone. The DTPA extractable copper in the factory zone ranged from 0.01 to 2.67 mg kg^{-1} with a mean value of 0.79 mg kg^{-1}. About 95.56 per cent of study area (5168 ha) was found to be sufficient (Fig. 5).

Table.1 Available Ca, Mg and DTPA extractable Fe, Mn, Zn and Cu in sugarcane growing soils
(0-20 cm depth) of various mandals in Prudential sugar factory zone of Chittoor district

S. No.	Mandal	Ca (cmol (p+) kg⁻¹)	Mg (cmol (p+) kg⁻¹)	Fe (mg kg⁻¹)	Mn (mg kg⁻¹)	Zn (mg kg⁻¹)	Cu (mg kg⁻¹)
1.	**Nindra**						
	Range	1.8-6.8	0.7-6.8	0.11-29.29	0.17-29.15	0.08-6.45	0.01-1.88
	Mean	3.61	0.10	3.58	3.36	1.28	0.72
2.	**Nagari**						
	Range	1.5-6.5	1.4-5.6	2.25-23.38	0.25-13.90	0.44-10.22	0.25-1.71
	Mean	3.88	3.40	6.65	2.16	1.80	0.94
3.	**Narayanavanam**						
	Range	1.9-3.8	1.5-4.4	2.14-17.79	0.29-7.69	0.03-2.42	0.25-2.06
	Mean	2.82	3.46	5.98	3.43	0.88	0.78
4.	**K.V.B. Puram**						
	Range	1.2-5.3	0.3-5.6	0.38-20.80	0.04-11.57	0.08-4.01	0.02-1.75
	Mean	3.31	3.20	6.70	3.46	1.21	0.71
5.	**Vijayapuram**						
	Range	1.2-6.5	0.7-6.1	0.3-16.42	0.18-13.90	0.01-4.97	0.18-2.67
	Mean	3.41	3.42	5.02	2.88	1.16	0.83
6.	**Pichatur**						
	Range	1.5-5.5	0.8-6.8	0.37-29.95	0.09-7.99	0.08-6.22	0.02-1.58
	Mean	3.28	3.52	6.18	2.14	1.21	0.69
7.	**Nagalapuram**						
	Range	1.0-5.0	1.2-5.5	1.02-34.27	0.31-10.51	0.29-8.78	0.13-1.49
	Mean	2.90	3.25	7.13	2.27	1.45	0.61
8.	**Puttur**						
	Range	1.5-6.2	0.9-5.7	1.69-25.56	0.62-12.70	0.46-3.93	0.72-2.17
	Mean	3.69	3.50	8.45	2.88	1.66	1.30
9.	**Overall range**	1.0-6.8	0.3-6.8	0.11-34.27	0.04-29.15	0.01-10.22	0.01-2.67
10.	**Overall mean**	3.43	3.44	6.30	2.80	1.32	0.79
11.	**C.V. (%)**	37.00	35.60	95.64	107.37	92.88	61.56
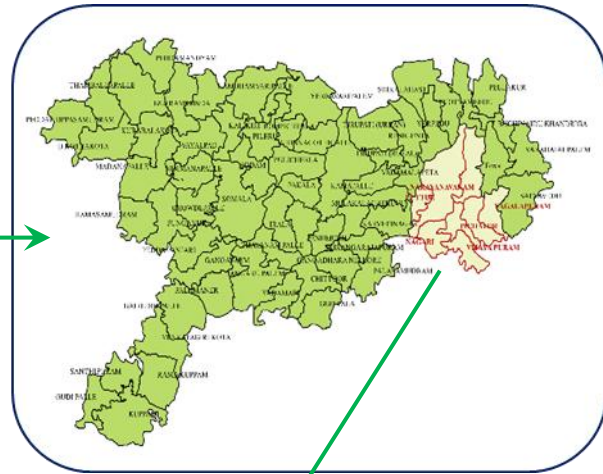
Fig.1 Location map of various mandals in Prudential sugar factory zone of Chittoor district in Andhra Pradesh
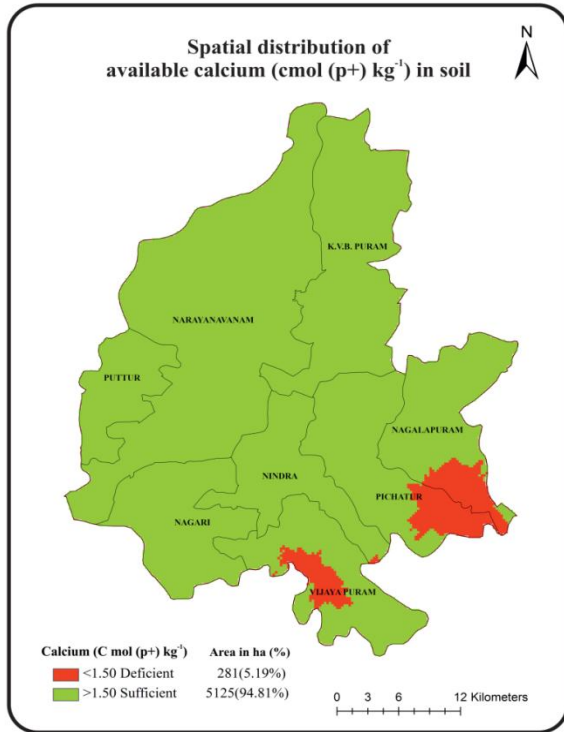
Fig.2 Status of calcium in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district in Andhra Pradesh
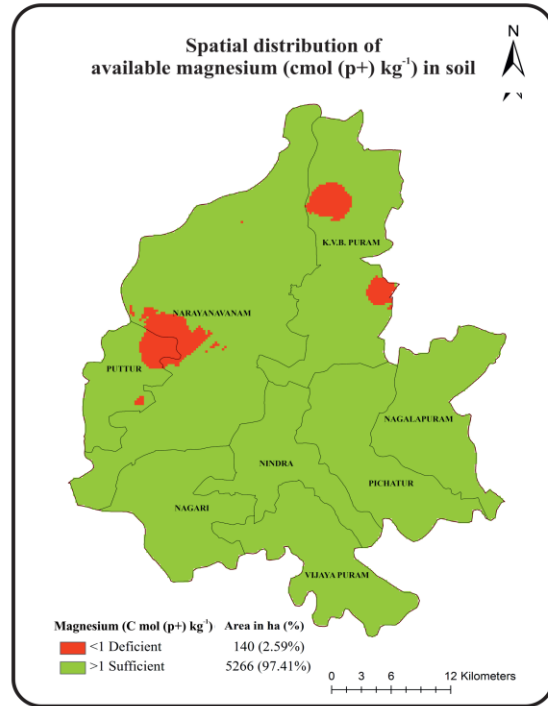

Fig.3 Status of magnesium in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district in Andhra Pradesh
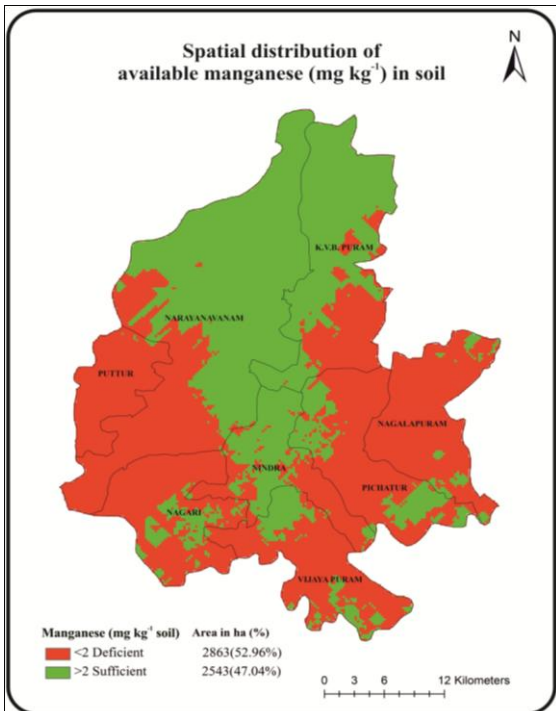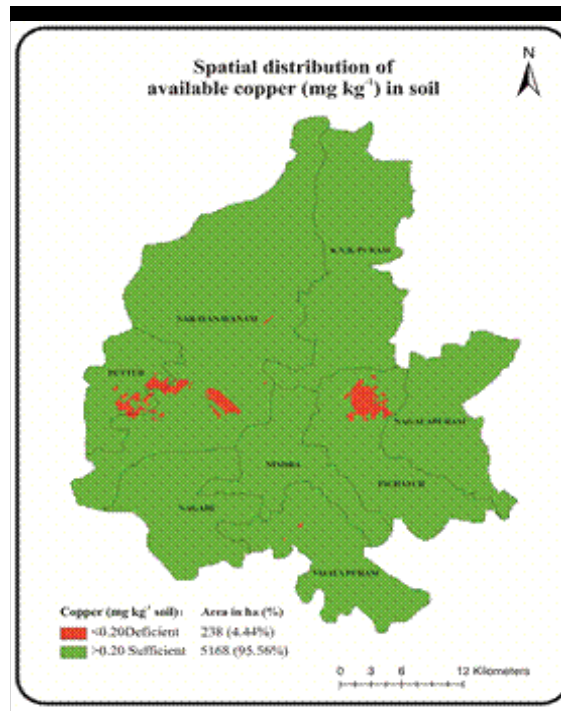

Fig.4 Status of Manganese in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district in Andhra Pradesh

Fig.5 Status of cuppere in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district in Andhra Pradesh
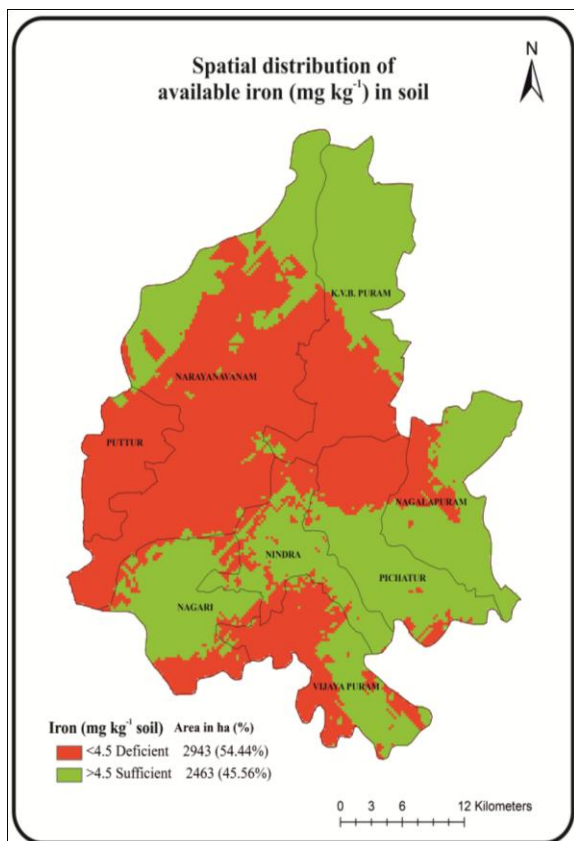
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Fig.6 Status of Iron in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district in Andhra Pradesh
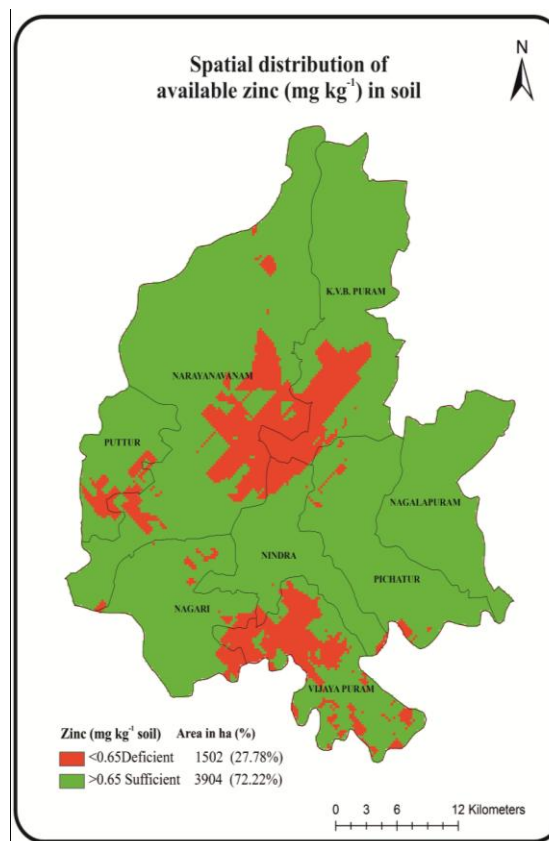

Fig.7 Status of Zinc in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district in Andhra Pradesh

The variation in available copper among these soils might be due to variation in copper bearing minerals in the soils. These findings are in accordance with the findings by Leelavathi *et al.,* (2009) and Ashokkumar and Prasad (2010).

From this study it can be concluded that most of the soils in prudential sugar factory zone are sufficient in exchangeable Ca, Mg and DTPA extractable Fe and Cu. Deficiency of DTPA extractable Mn and Zn was observed in considerable area. The use of GPS instrument and GIS package for collection of soil samples and preparation of soil fertility maps of sugarcane growing soils of Prudential sugar factory zone will help the local farming community in many ways. By collecting and analyzing the geo-referenced soil samples, the change in soil fertility status can be monitored and remedial measures can also be suggested to maintain soil health for sustainable crop production.

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