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Fertility Mapping of Available Micronutrients Status in the Soils of Dharmapuri District, Tamil Nadu, Using GIS and GPS Techniques

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A soil resource inventory was conducted at village level in all the blocks of Dharmapuri district, Tamil Nadu to assess the micronutrients status in the soils and to prepare fertility maps depicting the extent of soil micronutrient deficiency/sufficiency using GIS and GPS techniques. Soil samples were collected at Panchayat village wise along with geo coordinates and analysed for available micronutrients such as Zn, Fe, Cu, Mn and B by adopting standard procedures. Based on the nutrient status, the soils were grouped as deficient or sufficient using the critical limits. Per cent deficiency of micronutrients in each block was worked out and the thematic maps showing status of different available micronutrients were generated at block level. The results indicated that, Zn deficiency is most prevalent in the soils of all the blocks in Dharmapuri to an extent of 67.4 per cent, followed by Cu (7.8 %) and B (6.8 %), where as the other micronutrients were in sufficient level.

Key words: Dharmapuri district, Soil resource survey, Micronutrients status, Thematic maps

Soil is the precious natural resource for crop production, which supplies essential nutrients for plant growth and development. Soil survey and testing are the proven practical methods for evaluating the soil fertility status and to prescribe balanced fertilizer management strategies to improve crop productivity and to sustain the soil health. Micronutrient deficiencies in soils drastically affect the growth, metabolism and reproductive processes in plants, animal and human beings. Particularly, Zinc deficiency in soils and plants is a global micronutrient disorder reported widely in many countries (> 30 per cent) (Arvind Kumar Shukla *et.al*.,2015).

Generally, quantity and distribution of micro nutrients in soils depends upon the parent materials, organic matter, pH, mineralogy, soil forming processes, drainage, vegetation, anthropogenic and natural processes (Baligar *et al*., 1988). Micronutrient status of Tamil Nadu is generally poor as a result of intensive cropping without proper substitution of deficient nutrients and lesser recycling of organic manures. Spatial variability analysis of nutrients is one of the key factor for precision agricultural management and helps in rational of soil resources management to ensure sustainability of agricultural productivity. The soil nutrient concentrations reported as index values, can be used to predict soil fertility levels which provides a common scale for judging nutrient supply and balance in soil (Hardy *et al*., 2008). The Global Positioning System (GPS) has wide adaptability in Agriculture for preparing thematic maps to describe various land uses, land cover, soil fertility etc (Nahak Truptimayee *et al*.,2016). A soil resource inventory was made in Dharmapuri district, Tamil Nadu, India for assessing the micronutrients availability in soils using GPS geo coordinates to prepare the fertility maps at block level.

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Material and Methods

Dharmapuri district in Tamil Nadu comes under North West Agro Climate Zone, geographically located in latitudes between 11o47' and 12o33' N and longitudes between 77o 02' and 78o40' E. It has a total geographical area of 497.77 km² (3.46% of Tamil Nadu) bounded on the north by Krishnagiri district, on the east by Tiruvannamalai district and Viluppuram districts, on the south by Salem district, and on the west by Karnataka's Chamarajanagar district. The economy is mainly agrarian in nature and receives an annual rainfall of 896 mm. About 70 per cent of the workforce is dependent on agriculture and allied activities. Granites, quartz/silica, apatite, sand, vermiculite china clay and corundum iron are the common minerals present in the soils. The district is one among most backward and drought prone area in the state. The district has eight Taluks, 8 blocks and 252 villages.

A ground truth survey and geo referenced soil samples collection was carried out to delineate and map the spatial distribution of soil available micronutrients status. Totally 1008 surface samples at 0 -15 cm depth, were collected at 4 samples per panchayat village along with GPS coordinates from eight blocks covering entire district of Dharmapuri. The collected soil samples were analyzed for various physicochemical properties by adopting standard procedures and DTPA extractable micronutrients as outlined by Lindsay and Norwell,1978. Based on the below critical limits the soil samples were

grouped at block level as deficient (Low), moderate (Moderate) and sufficient (High) (Table 1). The extent of micronutrient deficiency in each block was computed and expressed in per cent and the thematic maps for different available micronutrients status were generated by using Arc GIS.

Results and Discussion

The present study was conducted with an objective of assessing the soil physico chemical properties, available micronutrients status, fertility ratings and to prepare the thematic maps of Dharmapuri district of North Western zone of Tamil Nadu.

Table 1. Range and mean values of soil properties in different blocks of Dharmapuri district

Name of the block	No.of samples	Soil properties			
		pH		EC (dS m-1)	
		Range	Mean	Range	Mean
Dharmapuri	108	7.11 – 8.85	8.21	0.04 – 0.82	0.37
Pennagaram	140	6.02 – 8.62	7.62	0.02 – 0.84	0.21
Morapur	180	6.39 – 8.99	7.74	0.05 – 0.97	0.42
Karimangalam	116	5.51 – 7.91	7.19	0.04 – 0.90	0.30
Palakodu	132	6.58 – 8.35	7.55	0.04 – 0.75	0.23
Harur	132	5.73 – 8.24	7.28	0.01 – 0.85	0.14
Pappireddipatty	72	6.73 – 8.91	8.07	0.01 – 0.85	0.19
Nallampalli	128	5.88 – 8.52	7.45	0.01 – 0.61	0.07
Overall	1008	5.51 – 8.99	7.64	0.01 – 0.97	0.24

Soil physico - chemical properties of Dharmapuri district

The overall soil reaction (pH) of Dharmapuri district ranged from 5.51 to 8.99 with a mean of 7.64, indicating that the soils are slightly acidic to alkaline in nature (Table1). The highest alkaline soil pH value of 8.99 was noticed in Morapur block and the lowest value of 5.51 was noticed in Karimangalam block. The acidic range of soil pH was noticed in some villages of Karimangalam, Harur and Nallampalli blocks. The electrical conductivity (EC) of the soils varied from 0.01 to 0.97 dSm^{-1} with a mean of 0.24 dSm^{-1}. The highest mean EC value of 0.42 dSm^{-1} was registered in Morapur and Dharmapuri (0.37 dSm^{-1} blocks. Most of the samples were reported to contain low salt status with a mean EC of < 0.28 dSm^{-1}. The low salt status of the soils may be due to leaching of salts to lower horizons due to coarser texture of soil. Similar results was also reported by Awanish Kumar *et.al*. (2014) in the soils of Kabeerdham district of Chhattishgarh.

Table 2. Range and mean values of soil available micronutrients status (mg kg^{-1}) in different blocks of Dharmapuri district

Name of the block	DTPA –Fe		DTPA –Mn		DTPA -Zn		DTPA -Cu		HWS B	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Dharmapuri	4.03 - 48.8	20.07	2.49 - 4.81	18.3	0.32 - 6.22	1.23	0.36 - 6.94	1.91	0.29 - 4.10	1.62
Pennagaram	4.26 - 80.9	24.57	6.53 -57.1	30.4	0.19 - 6.93	1.69	1.63 - 14.3	7.73	0.09 - 4.53	1.49
Morapur	3.35 - 66.1	21.65	5.37 - 27.8	20.7	0.28 - 7.68	1.5	0.01 - 8.15	2.48	0.36 - 4.18	1.76
Karimangalam	3.99 - 78.0	25.54	13.9 - 43.8	35.7	0.21 - 8.61	1.45	0.92 - 6.58	3.05	0.14 - 4.20	1.38
Palakodu	5.15 - 133	38.15	17.9 -43.7	36.6	0.16-13.5 13.513.54	1.84	1.03 - 8.30	3.73	1.85 - 4.20	3.13
Harur	3.80 - 47.4	15.65	1.96 - 26.6	9.09	0.13 - 2.05	0.5	0.25 - 4.09	1.71	1.60 - 4.79	2.64
Pappireddipatty	1.84-17.8	5.53	1.44-6.91	2.71	0.21-3.94	0.75	1.19-3.92	2.38	0.06 - 4.1	2.05
Nallampalli	0.34 - 45.9	14.4	0.17 -35.7	11.8	0.03 -7.83	0.59	0.34 - 45.9	2.05	0.35 - 4.79	1.58
Overall	0.34 –133.4	20.7	0.17 – 57.1	20.7	0.03 - 13.5	1.19	0.01 - 14.3	3.13	0.06 - 4.79	1.96

Micronutrients availability

Soil available micronutrients status mg kg^{-1} in different blocks of Dharmapuri district is furnished in Table 2.The available Fe content in the soils of Dharmapuri district ranged from 0.34 to 133.4 mg kg^{-1} with a mean of 20.7 mg kg^{-1} . The highest DTPA-Fe was observed in the soils of Palakodu block (38.2 mg kg^{-1}) followed by Karimangalam (25.5 mg kg^{-1}) and Pennagaram (24.6 mg kg^{-1})

blocks while the lowest available Fe was registered in the soils of Pappireddipatty (5.53 mg kg^{-1}) block. The Fe sufficiency in soils might be ascribed to non calcareousness to slightly calcareous nature of the soils of region and coarse texture of the soils, which was in accordance with the findings of Katyal and Rattan (2003). Lowest available Fe was registered in the soils of Pappireddipatty block might be due calcareous nature of the soil. Similar findings were reported by Karpagam and Grish Chander (2015) in the soils of Virudhunagar district.

Table 3. Per cent sample micronutrients deficiencies in the soils of different blocks of Dharmapuri district

Name of the Block	Sample size	DTPA - Fe			DTPA - Mn			DTPA – Zn			DTPA - Cu			HWSB		
		D	M	H	D	M	H	D	M	H	D	M	H	D	M	H
Dharmapuri	108	0	14.0	86.0	0	4.60	95.4	68.5	14.8	16.7	54.6	4.60	40.7	11.1	3.70	85.2
Pennagaram	140	0	9.3	90.7	0	0	100	42.0	25.0	32.9	0	0.70	99.3	11.4	6.40	82.0
Morapur	180	0.01	13.9	85.6	0	0	100	51.6	23.3	25.0	8.30	29.4	62.2	4.40	0.60	95.0
Karimangalam	116	0	6.90	93.1	0	0	100	60.3	18.1	21.6	1.70	6.90	91.0	18.1	9.50	72.4
Palakodu	132	0	4.50	95.5	0	0	100	41.7	18.9	39.4	0.01	3.80	95.0	0	0	100
Harur	132	0	18.2	81.8	0.80	9.10	90.2	91.7	5.30	2.30	30.3	26.5	43.2	0	0	100
Pappireddipatty	72	37.5	43.1	19.4	27.8	61.1	11.1	90.3	4.20	5.60	1.40	18.0	80.0	5.60	2.80	91.7
Nallampalli	128	0.80	21.9	77.3	1.60	3.90	94.5	93.0	2.30	4.70	13.0	29.7	57.0	7.80	3.90	88.3
Overall	1008	4.80	16.5	78.7	3.80	9.80	86.4	67.4	14.0	18.5	7.80	16.4	75.4	6.80	3.30	89.1

The DTPA-Mn content in the soils of Dharmapuri district ranged from 0.17 to 57.1 mg kg^{-1} with a mean of 20.7 mg kg^{-1} . The highest Mn availability was recorded in Palakodu (36.6 mg kg^{-1}) followed by Karimangalam (35.7 mg kg^{-1}) and Pennagaram (30.4 mg kg^{-1}) blocks. The lowest mean DTPA-Mn was observed in the soils of Pappireddipatty block (2.71 mg kg^{-1}). Higher Fe and Mn content in the soils of Dharmapuri district may be due the occurrence of Fe- Mn rich rocks containing minerals such as granites, quartz/silica, apatite, vermiculite china clay and corundum iron. Higher Mn status in the surface soils may also be attributed to the lower oxidation and acidic nature of soils. Similar findings were reported by Sharma and Chaudhary (2007).

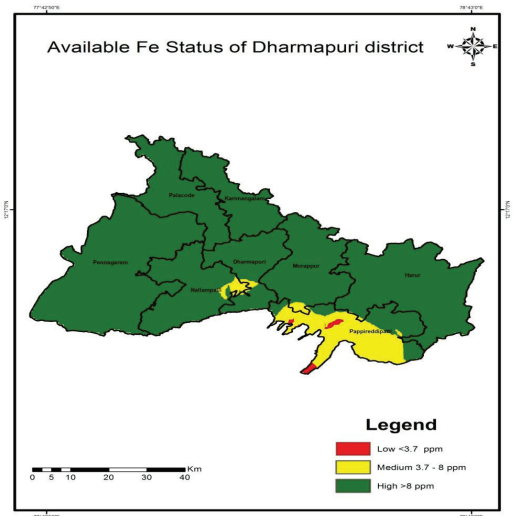

Figure 1. Spatial variability map of available iron in the soils of Dharmapuri district

The DTPA-extractable Zn status of the soils ranged from 0.03 to 13.5 mg kg^{-1} with a mean of 1.19 mg kg^{-1}. The available Zn status was the highest in Palakodu block (1.84 mg kg^{-1}) followed by Pennagaram (1.69 mg kg^{-1}) and Karimangalam blocks (1.45 mg kg^{-1}). The lowest mean available Zn content was observed in the soils of Harur (0.50 mg kg^{-1}) which might be apparently due to continuous cropping especially with vegetable based cropping system with intensive application of major nutrient fertilizers without adequate supply of micronutrients and organic manures. Increasing cropping intensity in marginal lands and lower use of micronutrients in district has enhanced the magnitude of zinc deficiency (Singh *et al.,* 2009).

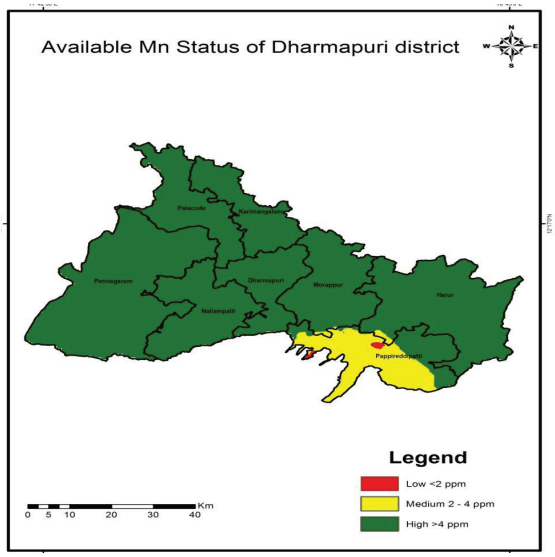

Figure 2. Spatial variability map of available manganese in the soils of Dharmapuri district

The DTPA-extractable Cu status of the soils of Dharmapuri district ranged from 0.01 to 14.3 mg kg^{-1} with a mean of 3.13 mg kg^{-1}. The highest available Cu status was recorded in the soils of Pennagaram block (7.73 mg kg^{-1}) followed by Palakodu (3.73 mg kg^{-1}) and Karimangalam (3.05 mg kg^{-1}) blocks. The lowest mean available Cu content was observed in the soils of Harur block (1.71 mg kg^{-1}).

The HWS-B content in the soils ranged from 0.06 to 4.79 mg kg^{-1} with a mean of 1.96 mg kg^{-1} (Table 2).

The highest available boron content was registered in the soils of Palakodu (3.13 mg kg^{-1}) followed by Harur (2.64 mg kg^{-1}) and Pappireddipatty (2.05 mg kg^{-1}) while the lowest B status (1.38 mg kg^{-1}) was

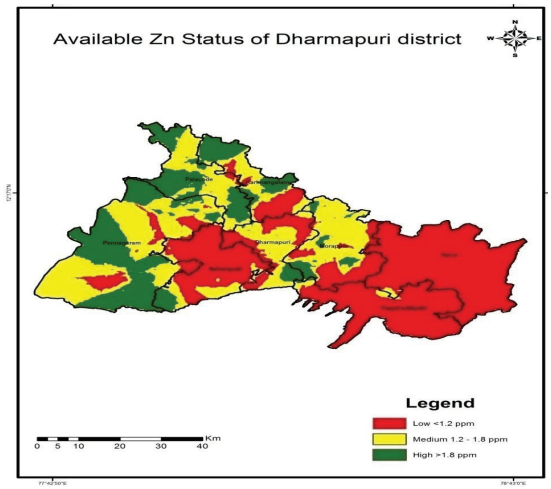

Figure 3. Spatial variability map of available zinc in the soils of Dharmapuri district

noticed in the soils of Karimangalam block. Higher B availability in soils may be due to inherent B content of the soils and favourable soil reaction which was in line with the findings of Datta and Munna Rao (1993) and Adeboye (2011).

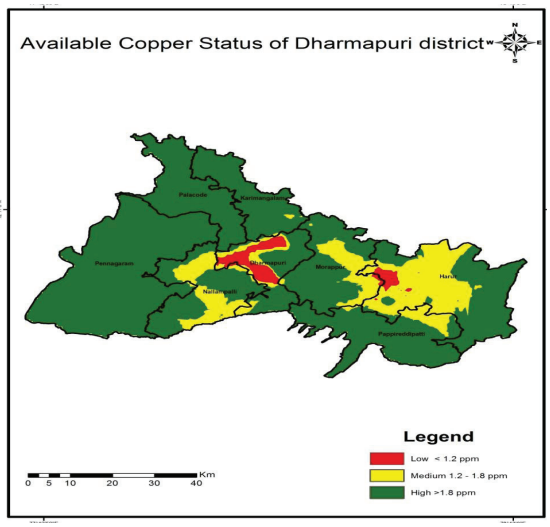

Figure 4. Spatial variability map of available copper in the soils of Dharmapuri district

Extent of micronutrients deficiency

Based on the micronutrient availability, the soils of different blocks of Dharmapuri district is grouped in to deficient (low), moderate (medium), and sufficient (high) categories using the respective critical limit and per cent of each category in Dharmapuri district is depicted in Table 3.

Analysis of surface soil samples collected from various blocks of Dharmapuri district revealed that, more than 75 per cent of the soils were sufficient, 4.80 per cent were deficient and 16.5 per cent samples were moderate in DTPA Fe status. Among the eight blocks, the soils of Pappireddipatty showed higher Fe deficiency (37.5 %) and highest Fe sufficiency was observed in the soils of Palakodu block (95.5 %).

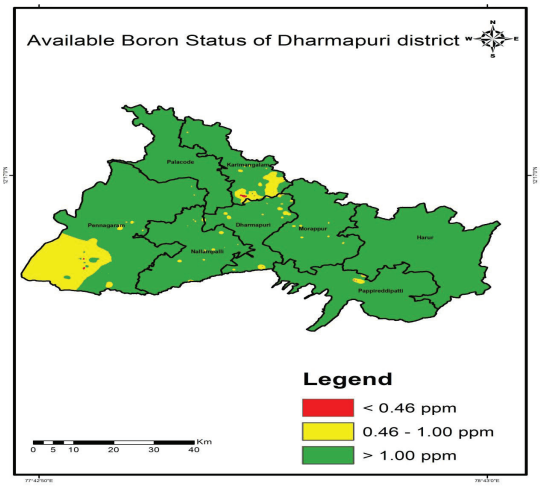

Figure 5. Spatial variability map of available boron in the soils of Dharmapuri district

The DTPA-extractable Mn content in the soils of various blocks revealed that about 86.4 per cent of the soils in Dharmapuri district were having higher DTPA-Mn status. All the samples from Pennagaram, Morapur, Karimangalam and Palakodu blocks were found to be high in Mn status (100 %). Overall mean values of the blocks showed, only 3.8 per cent of the samples were deficient in Mn status. Soil samples from Pappireddipatty had higher percentage of Mn deficiency (27.8 %) as well as moderate Mn status (61.1%). High Fe and Mn in the soils might be due to inherent parent materials like gneiss and granitic rocks which was in accordance with the results of Nahak Truptimayee *et al*., (2016).

The DTPA-extractable Zn status in the soils showed, 67.4, 14.0 and 18.5 per cent deficiency of low, medium and higher category, respectively. Among the 8 blocks, the extent of Zn deficiency was the highest in Nallampalli (93.0 %) block followed by Harur and Pappireddipatty. In medium category, higher percentage of samples was found in Pennagaram block (25.0 %) followed by Morapur (23.3 %) blocks. The soil samples collected from Palakodu (39.4 %) and Pennagaram (32.9 %) blocks had higher Zn status and sufficient for better crop productivity.

The Cu deficiency in the soil samples of Dharmapuri district were found to be low predominantly (7.8 per cent), while 16.4 and 75.4 per cent of samples were found to be medium and high category, respectively. The highest percentage of samples with high Cu content was observed in Pennagaram (99.3 %) followed by Palakodu (95.0 %) and Karimangalam blocks (91.0 %). The highest percentage of medium category samples was noticed in the soils of Nallampalli (29.7 %) and Morapur (29.4 %) blocks.

Most of the soil samples tested in Dharmapuri district had higher HWS-B (89.1 per cent), and few samples alone were found to be medium (3.3 %) and low (6.80 %) in B category, respectively. All samples in Palakodu and Harur are having higher B status and all samples of Karimangalam block are in medium (100 %) category.

Mapping of micronutrients status

The spatial variability maps for available micro nutrients *viz*, Fe, Mn, Zn, Cu and B were prepared by constructing linear directional semivariogram in spatial dependent models by plotting the semi-variance, which is a function of log between neighbouring observations. Inverse distance weighted model was fitted to semivarogram in order to create continuous surface for the estimated soil properties by using model fitting interface. Based on the percentage of nugget, spatial dependence classes were categorized in to spatial variability map as low, medium and high nutrient status (Fig.1 to 5).

The fertility status of DTPA-Fe and Mn at block level in the district revealed that, almost all the soils in various blocks were sufficient in both the elements. However the soils of Pappireddypatty had marginal Fe and Mn status (Fig.1 and 2). Similar attempt was made and reported by Prabhavati *et.al.*, (2015) for the Agro-climatic zones of Belaum district, Karnataka. The Zn status (Fig.3) in the soils varied widely from marginal to highly deficient in all the blocks of the district except few blocks like Pennagaram and Palakodu. The soils of Harur and Dharmapuri and Nallampalli blocks had medium copper availability where as (Fig.4). portions of Karimangalam, Pennagaram and Dharmapuri blocks were with low HWS - B and all the other blocks of Dharmapuri district were having higher B status (Fig.5).

Conclusion

Micronutrients are required in small quantities for the plant but found to be most important in the plant system to increase the yield. Crop growth and yield, particularly quality gets affected, if any of the essential micronutrient is deficient in the soil. In recent times, micronutrient deficiencies become deficient invariably in all the soils under intensive cropping system of majority of the agriculturally progressive states of India. From the soil resource inventory made in Dharmapuri district for the micronutrients assessment, it was concluded that, Zn deficiency is predominant in the soils (67.4 %) followed by Cu (7.8 %) and B (6.8 %). Rests of the elements (Fe and Mn) were sufficient in status. The soil micronutrient status will be highly useful for planning and organizing soil fertility improvement programmes. Fertility maps will be helpful to plan for balanced nutrient management to get more yield and net returns by avoiding the yield loss due to nutritional deficiency especially with reference to micronutrients.

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