Madras Agric. J., 103 (7-9): 219-222, September 2016
https://doi.org/10.29321/MAJ.10.001023

Mapping of Available Nutrient Status of Thirunavalur Village, Villupuram district, Tamil Nadu using Geographic Information System

V. Arunkumar, S.G. Patil* and M. Paramasivan
Department of Soil Science and Agricultural Chemistry,
Agricultural College and Research Institute,
*Department of Social Sciences, Agricultural College and Research Institute,
Tamil Nadu Agricultural University, Killikulam 628 252, Tamil Nadu.

A study was conducted to assess the available nutrient status by using Geographic Information System (GIS) in Thirunavalur Village, Villupuram district, Tamil Nadu. One hundred and eleven samples from 0-20 cm depth at 300 x 300 m grid were collected from the study area and GPS coordinates were recorded using GPS Map 76CSx instrument. The soil samples were analysed for their fertility status and mapped by using GIS. The pH of the soil samples was neutral to strongly alkaline. The organic carbon content was low to medium. Available nitrogen was low, phosphorus was low to medium, available potassium was medium to high and sulphur was low. Regarding available micronutrients zinc, copper and manganese were deficient in these soils and iron was deficient to moderate.

Key words: Geographic Information System, Nutrient mapping, Soil fertility status

The tremendously growing population in the country is an acute problem that demands maximum possible output of food, fibre and fuel from each unit of cultivated land area. The soil fertility undergoes change due to cropping, manure and fertilizer application. The practice of intensive cropping with hybrid varieties for boosting food production has led to decline in productivity of soils of India. Maintenance of native soil fertility is one of the preconditions of improving the crop yield levels. Multinutrient deficiency in soils has become wide spread in recent years resulting in low crop yields, more so with the introduction of high yielding crop varieties coupled with the use of high analysis fertilizer and increased cropping intensity.

Soil properties vary spatially and temporally from a field to a larger region scale and are influenced by geology, topography, climate as well as soil use (Quine and Zhang, 2002). In addition, variability can occur as a result of land use and management strategies (Wang et al., 2009). Hence, a comprehensive understanding of distribution of soil properties at field scale is important for refining agricultural management practices and assessing the effects of agriculture on environmental quality (Cambardella *et al.*, 1994). Spatial variability map of soil properties (pH, organic carbon, nitrogen and potassium) will make it possible to reduce fertilizer use, costs and environmental risks (Lopez-Granados *et al*., 2002). Therefore, spatial information of nutrients status should be characterized when making fertilizer recommendation. The recent technologies like Global positioning system (GPS), Geographical information system (GIS) facilitate soil fertility mapping and provide quantitative support for decision and policy making to improve agricultural approaches towards balanced nutrition. GPS and GIS helps in collecting a systematic set of georeferenced samples and generating spatial data about the distribution of nutrients (Sharma, 2004). Foreseeing the importance of soil fertility map, a study was carried to assess the fertility status and nutrient mapping of soils to identify the extent of soils deficient in nutrients for site specific recommendations. The information regarding the status of available nutrient mapping of soils is essential in planning soil fertility management on village basis.

Materials and Methods

Thirunavalur village of Villupuram district, Tamil Nadu is located between 11° 44'39''N and 11° 46'49''N Latitude; 79° 22'53''E and 79° 25'07''E Longitude (Fig.1). The annual rainfall of the region is 1070 mm. The mean maximum and minimum temperatures are 38°C and 21°C, respectively. The soils are clay loam in texture belonging to Vertic Haplustepts. The majority soils of the village have been affected by presence of soluble salts. Hence, a mono-cropping pattern of paddy cultivation is common in the region.

To map the spatial distribution of nutrients, surface soil samples (0-20 cm) at a 300 x 300 m grid were collected during May 2013. Exact geographical locations of the soil samples were recorded using GPS Map 76CSx instrument. The samples were air dried and ground to pass through

*Corresponding author email: varrun1974@gmail.com

2 mm sieve. Processed soil samples were analyzed for various physico-chemical properties such as pH, EC, organic carbon, calcium carbonate, available N, P, K and DTPA extractable Zn, Fe, Cu and Mn using standard procedures (Jackson, 1973 and Lindsay and Norwell, 1978). The fertility ratings for available nutrients are presented in Table 1.

Table 1. Soil fertility ratings for available nutrients

Property/Nutrient	Fertility rating major nutrients		
	Low	Medium	High
Organic carbon (g kg^{-1})	<5	5-7.5	>7.5
Nitrogen (kg ha^{-1})	<280	280 – 450	>450
Phosphorus (kg ha^{-1})	<11	11-22	>22
Potassium (kg ha^{-1})	<118	118-280	>280
Sulphur (mg kg^{-1})	<10	10-15	>15
Micronutrient	Deficient	Moderate	Sufficient
Zinc (mg kg^{-1})	< 1.2	1.2 -1.8	> 1.8
Iron (mg kg^{-1})	< 3.7	3.7 - 8.0	> 8.0
Copper (mg kg^{-1})	< 1.2	1.2 - 1.8	> 1.8
Manganese (mg kg^{-1})	< 2.0	2.0 - 4.0	> 4.0

A database file consisting of data for X and Y coordinates in respect of sampling site location was created in Microsoft excel. A shape file (vector data) showing the outline of Thirunavalur village was created in Arc GIS 9.1. A shape file (point data) showing the sampling locations was created in Arc GIS 9.1. The database file was joined to the point data. Geostatistics was used to estimate and map soils in unsampled areas .Ordinary kriging, which is an exact interpolator was used to estimate values of soil chemical properties for unsampled locations. Kriging was performed using Geostatistical analyst that are interfaced with Arc GIS 9.1. The thematic maps on available nutrient status were generated by categorizing the fertility status as 'low', 'medium' and 'high' by showing appropriate legend for OC and available N, P, K and S; 'Deficient', 'Moderate' and 'Sufficient' for available micronutrients by kriging.

Results and Discussion

The thematic maps depicting the soil fertility status of Thirunavalur village were generated using sampling point data and by kriging. The soil fertility maps pertaining to 12 chemical parameters are depicted in Fig. 2. The pH of surface soil ranged from 7.01 to 9.56 with a mean of 8.22 with soluble salts ranging from 0.17 to 1.65 dS m^{-1} (Table 2). The available nitrogen content varied from 134.4 to 280 kg ha^{-1}. The available phosphorus ranged from 8.1 to 19.4 kg ha^{-1} and that of available potassium ranged from 204 to 552 kg ha^{-1} in the study area. The major portion of the study area was low in organic carbon and remaining area was medium in organic carbon (Table 2 and Fig. 2.) The lower organic carbon content in these soils may be attributed to the lack of addition of crop residues and organic manures. Intensive cropping is one of the reasons for low organic carbon content.

Table 2. Range and mean values of available macro and micronutrients in soil of Thirunavalur village

	pH	EC dS m^{-1}	OC g kg^{-1}	$CaCO_3$ %	N	P	K	S	Zn	Fe	Cu	Mn
					kg ha^{-1}				mg kg^{-1}			
Range	7.01- 9.56	0.17 -1.65	2.6 -7.0	0.64- 3.89	134.4- 280.0	8.1 - 19.4	204- 552	4.1- 9.8	0.11- 0.91	1.24- 3.82	0.02- 0.09	0.01- 0.09
Mean	8.22	0.59	6.1	1.56	207.21	13.55	348.90	6.19	0.38	2.59	0.05	0.04
SD	0.43	0.23	0.17	0.72	34.55	2.98	103.66	1.46	0.19	0.65	0.01	0.01

Table 3. Correlation coefficients (r) between micronutrients and soil properties of Thirunavalur village

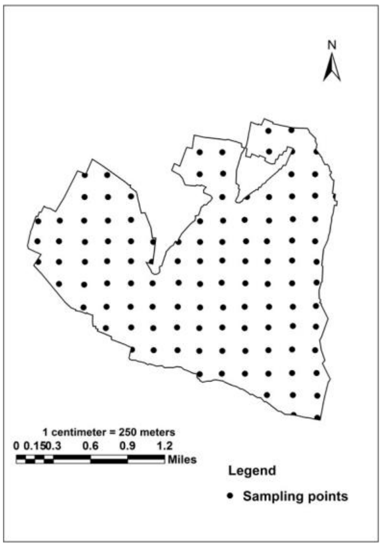
	Zn	Fe	Cu	Mn
pH	-0.147	-0.363**	-0.127	-0.166
EC	0.005	-0.108	0.075	0.008
OC	0.038	0.197*	0.083	0.097
CaCO3	-0.315**	-0.389**	-0.039	-0.085

**- Correlation is significant at the 0.01 level

* - Correlation is significant at the 0.05 level.

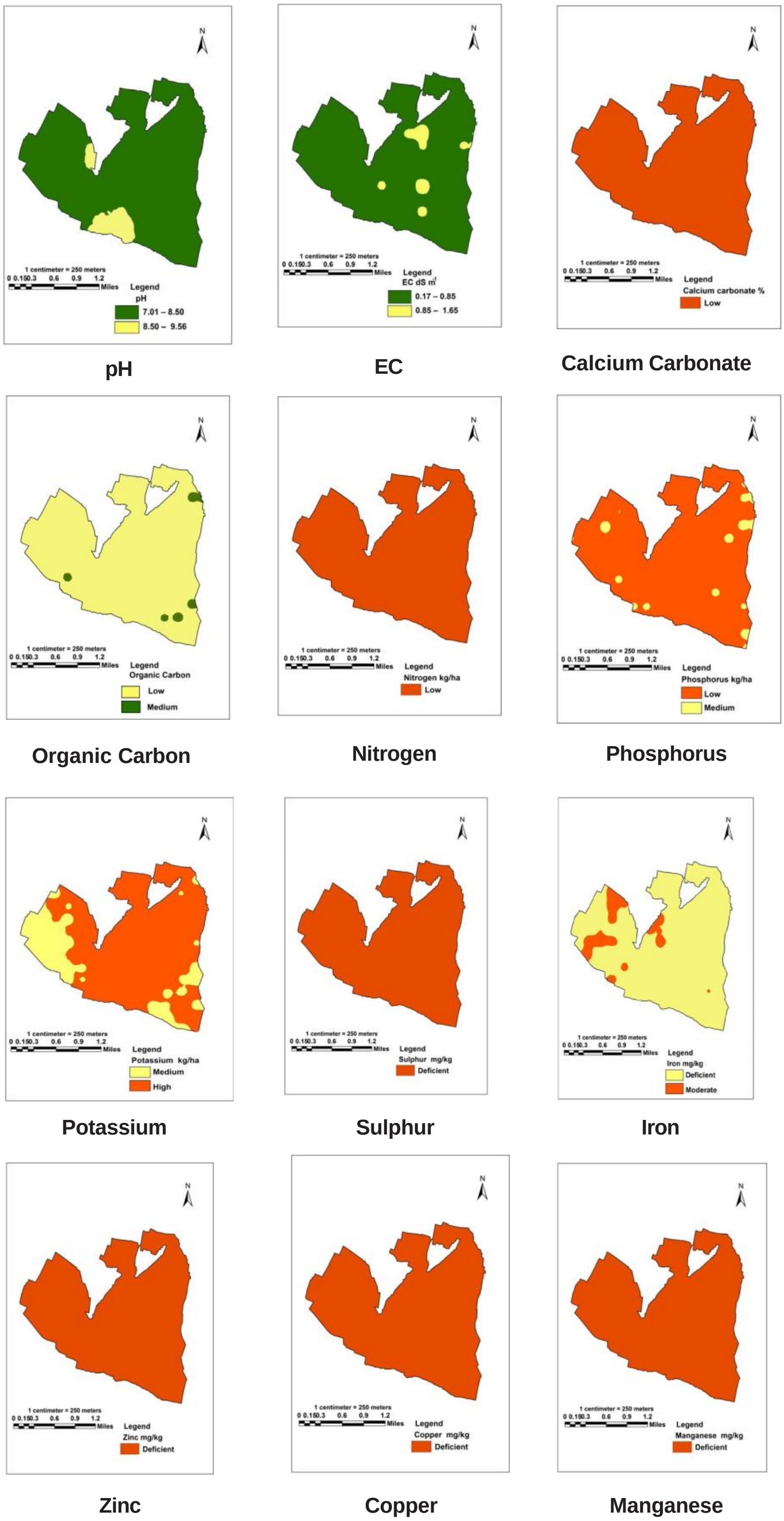
The available nitrogen was low in the study area (Table 2 and Fig.2.). The variation in N content may be related to soil management, varied application of FYM and fertilizer to previous crops. This might be due to low organic matter content in these areas due to low rainfall and high temperature which facilitate degradation and removal of organic matter leading to nitrogen deficiency. Similar nitrogen status was reported by Basavaraju *et al.* (2005), Thangasamy *et al.* (2005) and Shankaraiah *et al.* (2006) in non-saline clay to sandy loam and calcareous soils.

Fig. 1. Sampling locations in Thirunavalur village



The available phosphorus was low in major part of the study area (Table 2 and Fig.2.). Low phosphorus availability in these soils is related to their high pH, calcareousness and low organic matter content.

Fig.2. Soil fertility maps of Thirunavalur village



Ravikumar *et al.* (2007a) and Patil *et al.* (2011) reported that available phosphorus was low due to high calcium carbonate content. The available potassium was medium to high in the study area (Table 2 and Fig. 2.). Ravikumar *et al.* (2007a) reported that available phosphorus was medium to high due to increase in pH and CEC, which increases the number of sites for K adsorption. The available sulphur content in entire portion of the study area was in low category (Table 2). Low level of available sulphur is due to lack of sulphur addition and continuous removal of S by crops.

The available zinc status ranged from 0.11 to 0.91 mg kg^{-1} and the whole village was deficient in Zinc (Table 2). The content of Zn decreases with increase in pH and $CaCO_3$ content as reported by Satyavathi and Suryanarayana Reddy (2004). Since, most of the soils are alkaline and dominated by $CaCO_3$, Zn may be precipitated as hydroxides and carbonates, as a result, their solubility and mobility may be decreased and reduce the availability. The available Zn was positively correlated with organic carbon (r = 0.038) and electrical conductivity (r = 0.005) but negatively correlated with pH (r= - 0.147), and $CaCO_3$ (r = - 0.315).

The available iron status ranged from 1.24 to 3.82 mg kg^{-1}. The major portion of the study area was deficient in available iron status (Table 2). Low Fe content may be due to precipitation of Fe by $CaCO_3$ and decrease its availability. The available iron was positively correlated with organic carbon (r = 0.197) but negatively correlated with pH (r= - 0.363), electrical conductivity (r = - 0.108**) and $CaCO_3$ (r = - 0.389). Low Fe content in agriculture soils was due to continuous crop removal and neglecting the inclusion of Fe dose in the fertilizer recommendations (Somasundaram *et al.,* 2009).

The entire area of the village was deficient in available copper and ranged from 0.02 to 0.09 mg kg^{-1}. The available Cu was positively correlated with organic carbon (r = 0.083) and electrical conductivity (r = 0.075) but negatively correlated with pH (r = - 0.127) and $CaCO_3$ (r = - 0.039). Similar relation was also observed by Chaudhari *et al.* (2012).

The available manganese was deficient in the entire study area and it ranged from 0.01 to 0.09 mg kg^{-1}. The available manganese was positively correlated with organic carbon (r=0.097) and electrical conductivity (r = 0.008), but negatively correlated with pH (r = - 0.166) and $CaCO_3$ (r= - 0.085). Similar relation was also observed by Chaudhari *et al.* (2012).

From the study, it has been concluded that soils of Thirunavalur village, Villupuram district, Tamil Nadu were low in available N and available Sulphur. Soil organic carbon, available phosphorus and available iron were low to medium and available potassium was medium to high. Regarding available micronutrients zinc, copper and manganese were deficient. Soil organic carbon, available nitrogen, phosphorus, sulphur, zinc, copper and manganese are the important soil fertility constraints in the village indicating their immediate attention for sustained crop production. The deficient micronutrient may be replenished to avoid the crops suffering from their deficiency and for optimum utilization of other nutrients.

References

Basavaraju, D., Naidu, M.V.S, Ramavatharam, N, Venkaiah, K, Rama Rao, G. and Reddy, S.K. 2005. Characterisation, classification and evaluation of soils in Chandragiri Mandal of Chitoor district, Andhrapradesh. *Agropedology*, **15**: 55-62.

Cambardella, C.A., Moorman, R.B, Novak, J.M, Parkin, T.B, Karlen, D.L, Turco, T.E. and Konopka, A.E. 1994. Field scale variability of soil properties in Central Iowa soils. *Soil Sci. Soc. Am. J.,* **58:** 1501-1511.

Chaudhari, P.R., Ahire, D.V. and Ahire,V.D. 2012. Correlation between physico-chemical properties and available nutrients in sandy loam soils of Haridwar. *J.Che. Bio. Phy. Sci.,* **2(3)**: 1493-1500.

Jackson, M. L. 1973. Soil chemical analysis. Oxford IBH publishing co., Bombay.

Lopez Granados, F., Jurado Exposito, M, Atenciano, S, Gracia Ferrer, A,. De La Orden, M.S. and Gracia Toreres, L. 2002. Spatial variability of agricultural soil parameters in South Spain. *Plant and Soil*, **246**: 97-105.

Lindsay, W.C. and Norwell, W.A. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Am. Proc.,* **42(3)**: 421-428.

Patil, S.S., Patil,V.C. and Al-Gaadi, K.A. 2011. Spatial variability in fertility status of surface soils. *World Applied Sci. J.,* **14(7)**: 1020-1024.

Ravikumar, M.A., Patil, P.L. and Dasog,G.S. 2007a . Mapping of nutrient status of 48A distributory of Malapraba Right Bank Command of Karnataka by GIS technique. “Major Nutrients”. *Karnataka J.Agric. Sci*., **20(4)**: 735-737.

Quine, T.A. and Zhang, Y. 2002. An investigation of spatial variation in soil erosion, soil properties and crop production within an agricultural field in Devon U.K. J. *Soil and Water Conserv.,* **57**: 50-60.

Satyavathi, P.L.A. and Suryanarayana Reddy, M. 2004. Distribution of DTPA extractable micronutrients in soils of Telengana, Andhrapradesh. *Agropedology*, **14(1)**: 32-37.

Shankaraiah, M., Sreemannarayana, B. and Srinivasaraju, A. 2006. Studies on the status and distribution of sulphur in black soils (Vertisols) of Karimnagar district, Andhrapradesh. *Indian J. Dryland Agric. Res Dev.,* **21(1)**: 74-79.

Sharma, P.K. 2004. Emerging technologies of remote sensing and GIS for the development of spatial data structure. J. *Indian Soc. Soil Sci.,* **52 (4)**: 384-406.

Somasundaram, J., Singh, R.K, Prandiyal, A.K. and Prasad, S.N. 2009. Micronutrient status of soils under different land use systems in chambal ravines. *J. Indian Soc. Soil Sci.,* **57(3)**: 307-312.

Thangasamy, A., Naidu, M.V.S, Ramavatharam, N. and Raghava Reddy, C. 2005. Characterisation, classification and evaluation of soil resources in Sivagiri micro-watershed of Chitoor district, Andhrapradesh for sustainable land use planning. *J. Indian Soc. Soil Sci., **53**: 11-21.*

Wang, Y., Xhang, X. and Huang, C. 2009.Spatial variability of soil total nitrogen and soil total phosphorus under different land uses in a small watershed on the loess plateau, China. *Geoderma,* **150(2)**: 141-149.

Received after revision: August 30, 2016 ; Accepted: September 30, 2016