Assessment of Soil Physico-Chemical Properties and Macronutrients Status in Theni District of Tamil Nadu using GIS Techniques

R.K. Kaleeswari*, A. Kayalvizhi and S. Krishnakumar

Department of Soil Science and Agricultural Chemistry,
Tamil Nadu Agricultural University, Coimbatore - 641 003

Delineation of available macronutrients was carried out by randomly collecting geo referenced surface (0-0.15m) soil samples representing different soil units as per the soil map prepared on 1:50,000 scale from 598 sites in Theni district, Tamil Nadu using Global Positioning System (GPS). The soil samples were analysed for available macronutrients. The available N status ranged from 129 to 322 kg ha$_{-1}$ while the available P and K status varied from 7.34 to 65 kg ha$_{-1}$ and 122 to 697 kg ha$_{-1}$ respectively. Analytical results and the GPS data were used for the preparation of thematic map showing spatial distribution of macronutrients status block wise in the district. Locations of soil sampling sites of Theni district were marked on base map on 1:50,000 scale prepared from State Revenue Maps and digitized using Arc-info GIS. The delineation study clearly indicated that the available N was found to be low in 73.71 percent of soils of Theni district while phosphorus is in medium status. Nearly 70 per cent of the surface soil of Theni district was high in available K status.

Key words: Available Nitrogen, Phosphorus, Potassium, GPS, GIS, Thematic maps.

Higher yields at balanced fertilization indicate better use efficiency of the natural resource, land and energy, in form of fertilizers and transport. It also protects the environment by better utilization of applied nutrients. Balanced fertilization, which takes care on all nutrients according to site and crop-specific needs to assist the farmer to comply with the demand from the consumer.

With the invent of modern technologies like Global Positioning System (GPS) and Geographical Information System (GIS), there is a need to develop spatial data of soil nutrient status. Introduction of scientific tools and techniques like Remote Sensing, GPS and GIS are essential for holistic analysis of whole gamut of resources and quick retrieval of the data (Sharma, 2004). This will also help in monitoring changes in soil nutrient status over a period of time. It can be revisited with help of GPS, which is otherwise not possible in the random sampling. In the past studies, soil test was the only criteria to delineate the different regions, and sampling was done by random method and scant attention was paid to collect the geo-referenced samples.

GPS provides real time, continuous, available economic and very precise positioning technique and useful for the establishment of geodetic control survey i.e. location of precise control points, geodynamic surveys, monitoring mars movements and Geo-physical and cadastral surveys (Guo *et al.*,

*Corresponding author email: kaleeswari@tnau.ac.in

2002). The GPS can be effectively used in conducting survey for updating the existing base maps and mapping the extent of spread of deficiency of nutrients in soil (Sood *et al.*, 2004). Keeping these in view, the present study was conducted during the year 2010-2011 to diagnose macronutrient related constraints to productivity by assessing macronutrient status and their spatial variability in soils.

Study Area

Theni District is an inland district, is situated in between latitude 9°30' and 10°30' and longitude 77°00' and 78°30' with an area of 3,24,230 ha. It is encompassed on the west by Kerala State, on the east by Madurai District, on the north by Dindigul District and on the south partly by Kerala and Virudhunagar. The soils of Theni are highly heterogeneous in nature. The major soil types in this district are forest and hills soil type (51.3 %) and red soil (30.5 %).

Materials and Methods

Collection of Soil Samples

Totally 598 geo-referenced surface soil samples covering the entire villages in eight blocks of Theni district were collected randomly at 0-15 cm depth by adopting the standard procedures of soil sample collection. The GPS data (Latitude °N and Longitude °E) were collected from each sampling site distributed over the entire Theni district by using Garmin GPS 76CS model (Fig.1). The collected soil

samples were dried, ground, sieved (2 mm sieve) and analysed for available N by alkaline $KMnO_4$ method (Subbiah and Asija, 1956), available P at 660 nm on the UV Spectrophotometer by Olsen method (Olsen *et al.*, 1954), Bray I method (Bray and Kurtz, 1945) and available K was estimated by flame-photometry (Jackson, 1973).

Locations of soil sampling sites of Theni district were marked on base map on 1:50,000 scale prepared from State Revenue Maps and digitized using Arc-info GIS (9.2). Each soil sample was categorized into low, medium and high categories based on the ratings of available macronutrients.

Generation of Map

Theni district map (1:50,000) were vectorised by using Raster to Vector software (R_2V) and then exported into Arc-GIS software. Database on soil available macronutrients status of the study area were developed using Microsoft Excel package. The database was exported to Arc GIS software and the thematic maps on available macronutrients status were generated.

Results and Discussion

The pH of the soils of Theni district varied from 5.20 to 8.40 with mean of 7.38 (Table 1). The highest

Table 1. Range and mean values of soil physico-chemical properties and available macro nutrients status of Theni district

Soil properties	Lowest	Highest	Mean	Mode
pH	5.20	8.40	7.38	7.69
EC dS m-1	0.10	0.97	0.34	0.27
Available N kg ha-1	129	322	250	278
Available P kg ha-1	7.3	65.0	23.7	19.3
Available K kg ha-1	122	697	402	328

Total number of samples = 598

mean soil pH of 7.73 was registered in Uthamapalayam block and the lowest value of 7.01 was noticed in Periyakulam block (Table 2). The

electrical conductivity of the surface soils of Theni district varied from 0.10 to 0.97 dSm-1 with mean value of 0.34 dS m-1. The soils of all the blocks in Theni district were free from salinity and the highest mean electrical conductivity of 0.43dSm-1 was noticed in Cumbum block, the lowest value of 0.24 dSm-1 was recorded in the K. Myladumparai block (Table 2).

Available macronutrients

The available nitrogen status in the surface soil samples of Theni district ranged from 129 to 322 kg ha-1 with mean value of 250 kg ha-1 (Table 1). Nearly 81 per cent of the surface soils of Chinnamanur block of Theni district were low in available N status (Table 3). The low content of organic carbon in soils resulted in low N status. This result corroborate with the findings of Pradeep *et al.* (2006); Susan John *et al.* (2009) and Ajitkumar Kushwaga *et al.* (2009). The predominance of low status of available N in this district indicates that need based application of N fertilizers is required. In Theni district, the highest mean value for available N was registered in K.Myladumparai block (273 kg ha-1) while the lowest mean available N value was recorded in Bodinayakanur block (226 kg ha-1) (Table 2). However nearly 34 per cent of the surface soil of K.Myladumparai block in Theni district was medium in the available N status (Table 3). The soils in this block are under intensive cultivation of vegetables in irrigated conditions. The medium status of available N in K.Myladumparai block could be due to the continuous crop residue additions to the soil (Table 4). The present results corroborate with the findings of Ramamoorthy *et al.* (2004).

The available phosphorus status of the soils of Theni district ranged from 7.3 to 65.0 kg ha-1 with the mean value of 23.7 kg ha-1 (Table 1) and about 59 per cent of the surface samples were under medium category. The neutral pH (mean pH value: 7.38) would have enhanced the P availability and

Table 2. Range and mean values of soil physico-chemical properties and available macronutrients status for different blocks of Theni district

Block name	pH	EC (d S m-1)	Available Macronutrients (Kg ha-1)		
			N	P	K
Andipatti	5.90-8.10	0.10-0.88	140-308	8.39-55.10	149-678
	(7.38)	(0.36)	(250)	(21.4)	(387)
Bodinayakanur	5.80-8.14	0.10-0.84	129-300	7.35-63.50	168-667
	(7.59)	(0.36)	(226)	(22.8)	(360)
Cinnamanur	5.20-8.00	0.11-0.82	148-305	9.45-65.00	263-683
	(7.21)	(0.32)	(230)	(25.0)	(446)
Cumbum	6.15-8.08	0.12-0.82	171-308	7.34-47.25	122-690
	(7.61)	(0.43)	(234)	(22.5)	(431)
K.Myladumparai	5.23-8.40	0.10-0.97	238-308	8.39-60.50	168-697
	(7.40)	(0.24)	(273)	(22.6)	(367)
Periyakulam	5.30-7.92	0.12-0.76	210-314	11.60-65.00	173-679
	(7.01)	(0.39)	(261)	(26.9)	(374)
Theni	5.30-8.10	0.12-0.78	193-322	9.45-60.00	257-673
	(7.14)	(0.34)	(262)	(27.8)	(433)
Uthamapalayam	5.35-8.40	0.10-0.77	196-308	8.39-65.00	229-627
	(7.73)	(0.27)	(263)	(21.0)	(415)

the results corroborate with the findings of Pujar *et al.* (2010) and Mahesh Kumar *et al.* (2009). The highest mean value of 27.8 kg ha$_{-1}$ was registered in Theni block while in the Uthamapalayam block the mean value for available P was the lowest (21.0 kg ha$_{-1}$).

Table 3. Percentage sample category of available macronutrients status in different blocks of Theni district

Block name	Percentage sample category								
	Available N			Available P			Available K		
	L o w	Medium	High	L o w	Medium	High	L o w	Medium	High
Andipatti	71.31	28.69	0.00	8.20	56.56	35.25	0.00	26.23	73.77
Bodinayakanur	70.42	29.58	0.00	9.86	56.34	33.80	0.00	33.80	66.20
Cinnamanur	80.56	19.44	0.00	6.94	54.17	38.89	0.00	15.28	84.72
Cumbum	77.78	22.22	0.00	13.89	55.56	30.56	0.00	27.78	72.22
K.Myladumparai	66.20	33.80	0.00	12.68	61.97	25.35	0.00	39.44	60.56
Periyakulam	74.70	25.30	0.00	0.00	65.06	34.94	0.00	36.14	63.86
Theni	69.05	30.95	0.00	2.38	58.33	39.29	0.00	30.95	69.05
Uthamapalayam	79.66	20.34	0.00	13.56	67.80	18.64	0.00	28.81	71.19
Overall district	73.71	26.29	0.00	8.44	59.47	32.09	0.00	29.80	70.20

Nearly 39 per cent of the surface samples in Theni block registered high status of P (Table 3). More than 19.4 per cent of total cropped area in Theni block was under pulse cultivation and the higher and continuous application of P fertilizers would have resulted in high P status in this block.

Table 4. Cropping pattern of Theni district

Block	Theni	Periyakulam	Andipatti	K.Myladumparai	Uthamapalayam	Cumbum	Chinnamanur	Bodinayakanur	District
Paddy	2145	1936	1009	572	1959	3916	2890	1322	15855
	(18.3%)	(10.7%)	(6.3%)	(3.6%)	(19.4%)	(23.0%)	(25.6%)	(7.0%)	(13.3%)
Total cereals	6660	3829	7646	2201	3907	4869	5581	5525	40475
	(56.8%)	(21.1%)	(47.8%)	(13.9%)	(38.7%)	(28.6%)	(49.5%)	(29.4%)	(33.8%)
Red gram	100	19	504	1034	60	568	604	142	3050
	(0.8%)	(0.1%)	(3.2%)	(6.5%)	(0.6%)	(3.3%)	(5.4%)	(0.8%)	(2.5%)
Total pulses	2269	645	1030	1974	338	1751	929	1145	10145
	(19.4%)	(3.5%)	(6.4%)	(12.4%)	(3.3%)	(10.3%)	(8.2%)	(6.1%)	(8.5%)
Groundnut	27	184	902	109	780	98	224	77	2418
	(0.2%)	(1.0%)	(5.6%)	(0.7%)	(7.7%)	(0.6%)	(2.0%)	(0.4%)	(2.0%)
Coconut	1139	3249	579	1423	2134	3739	1359	1772	15488
	(9.7%)	(17.9%)	(3.6%)	(9.0%)	(21.1%)	(21.9%)	(12.1%)	(9.4%)	(12.9%)
Total oilseeds	2009	2918	1557	1542	2944	4150	1589	1936	18766
	(17.1%)	(16.1%)	(9.7%)	(9.7%)	(29.2%)	(24.4%)	(14.1%)	(10.3%)	(15.7%)
Cotton	508	383	1086	630	9	26	22	471	3153
	(4.3%)	(2.1%)	(6.8%)	(4.0%)	(0.1%)	(0.2%)	(0.2%)	(2.5%)	(2.6%)
Sugarcane	1436	2203	659	786	289	262	345	1537	7558
	(12.25%)	(12.1%)	(4.1%)	(5.0%)	(2.9%)	(1.5%)	(3.1%)	(8.2%)	(6.3%)
Total vegetables	638	317	1402	11177	939	345	532	372	5353
	(5.44%)	(1.7%)	(8.8%)	(70.4%)	(9.3%)	(7.0%)	(4.7%)	(2.0%)	(4.5%)
Total cropped area	11723	18154	15985	15875	10095	17040	11269	18794	119637

This result was in confirmation with the findings of Sen *et al.* (2007).

The available K status of the surface soils of Theni district ranged from 122 kg ha$_{-1}$ to 697 kg ha$_{-1}$ with the mean value of 402 kg ha$_{-1}$ (Table 1). The lowest mean value for available K status of 360 kg ha$_{-1}$ was recorded in the Bodinayakanur block of Theni district (Table 2). Nearly 30 per cent of the surface soils in the study area of Theni district were medium in available K status (Table 3).This result was in confirmation with the findings of Rakesh Kumar *et al.* (2009) and Anil Sharma (2009). The highest mean value of available K (447 kg ha$_{-1}$) was observed in Chinnamanur block. Nearly 70 per cent of the surface soils of Theni district were high in available K status. The high status of available K in surface soils of Theni district could be due to the addition of plant residue, manure and fertilizers for intensive cropping system. This finding was in line with the results reported by Arora and Chahal (2003) for Punjab soils.

Thematic maps

In Theni district constituting eight blocks, the low status of available N was a serious problem. Major portion of the study area in Theni district registered low status of available N while the medium status of available N occupied very small area. The spatial distribution of available P in the study area indicated that major portion of the study area in Theni district had medium status of available P while the high status of available P occupied a negligible area. Spatially, major portion of the study area in this district had high status of available K while the remaining

Fig.1. Soil sampling points (Latitude °N and Longitude °E) of Theni district
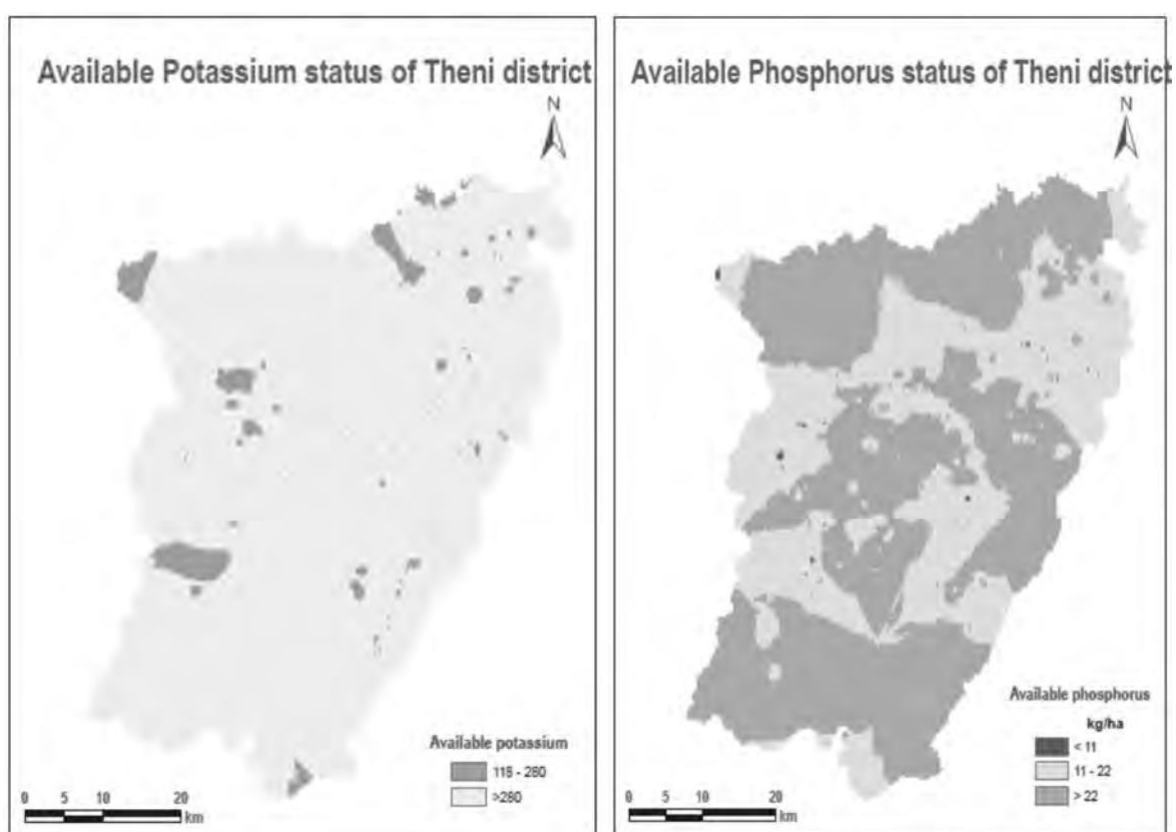

Fig.2. Map showing available macronutrients status of Theni district in Tamil Nadu

portion of the study areas registered medium status of available K (Fig.2).

From the above investigation it is very clear that the soils of Theni district are predominantly low in available nitrogen, medium to high in available phosphorus and high in available K and required to be applied in specific situations as per the need.

The areas suffering from low status of available N and P can be alleviated through periodical application of organic manures along with inorganic fertilizers based on soil testing, selection of suitable cropping programme and adopting improved package of practices which in turn would sustain crop productivity and soil health.

References

Ajitkumar Kushwaha., Surendra singh and Singh, R.N. 2009. Available nutrients and response of lentil to boron application in rainfed upland soils of Ranchi. *J. Indian Soc. Soil Sci.,* **57:** 219-222.

Anil Sharma., Jalali, V.K., Sharma, V. and Sharma, K.L.2009. Distribution of available potassium in soils of rainfed areas responding different agro climatic zones of Jammu and Kashmir. *Indian J. Dryland Agric.Res.Dev.* **24:** 39-44.

Arora, S. and Chahal, D.S. 2003. Distribution of available potassium in benchmark soils of Punjab in relation to soil characteristics.*J. Potassium. Res.* **19:** 41-44.

Bray, R.H. and Kurtz, L.T.1945. Determination of total organic and available forms of phosphorus in soils. *Soil Sci.,* **59:** 39-45.

Guo, F., Shengue ., Ji, Y. and Hu, G.2002. Methods for improving the accuracy and reliability of of vehicle borne GPS Intelligence navigation system.http://www.gisdevelopment.net/application /utility / transport/ utilitytr 0022.htm.

Jackson, M.L.1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Mahesh Kumar., Singh, S.K. and Sharma, B.K.2009. Characterization, classification and evaluation of soil of Churu district, Rajasthan. *J. Indian Soc. Soil Sci.,* **57:** 253-261.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A.1954. Estimation of available phosphorus by extraction with sodium carbonate, *USDA. Circ.,* **939:**19

Pradeep, R., Dasog, G.S. and Kuligod, V.S. 2006. Nutrient status of some groundnut growing soils of upper Krishna Command area, Karnataka. *Karnataka J. Agric. Sci.,* **19:**131-133.

Pujar, A.S., Yadawe, M.S., Pujeri, U.S., Pujari, K.G. and Hiremath, S.C.2010. Assessment of soil fertility of grape field at Bijapur district, Karnataka, India. *J. Chem.,* **7:** 1304-1307.

Rakesh Kumar, Sarkar, A.K., Singh, K.P., Agarwal, B.K. and Karmakar, S.2009. Appraisal of available nutrients status in Santhal Paraganas region of Jharkhand. *J. Indian Soc. Soil Sci.,* **57:** 366-369.

Ramamoorthy, K., Christopher Lourduraj, A., Alagudurai, S. and Kandasamy, O.S.2004. Effect of crop residue management of early season legumes on the succeeding rainfed finger millet. *Madras Agric. J.,* **91:** 180-183.

Sen, P., Majumdar, K. and Sulewski, G.2007. Spatial variability in available nutrient status in an intensively cultivated village. *Better Crops.,* **91:** 10-11.

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

Sood, Anil., Setia, R.K., Bansal, R.L., Sharma P.K. and Nayyar, V.K.2004. Spatial distribution of micronutrients in soils of Amristar district using frontier technologies. Proc. of 7 th Punjab Science Congress held at Guru Nanak Dev. University, Amristar, 7-9 February, 2004.pp 29-30.

Subbiah, B.V. and Asija, G.L.1956. Rapid procedure for estimation of available nitrogen in soils. *Curr. Sci.,* **25:** 259-260.

Susan John, K., Ravindran, C.S. and Manikantan Nair, M. 2009. Macronutrient status of cassava growing soils of Kerala. *J. Root Crops.* **35:** 41-49.