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SOIL SCIENCE

GIS based Spatial Variability Assessment in Flower Crops Grown Soils of Horticultural College and Research Institute, Periyakulam, Tamil Nadu

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ABSTRACT

Sixty five surface soil samples were collected in the flower crops grown soils of Horticultural College and Research Institute, Periyakulam, Tamil Nadu. The geo-coordinates were recorded for each sample using GPS. Field maps were digitized for its field number-wise boundary and other features. Soil samples were collected, processed and anlaysed for soil physico-chemical and soil fertility properties. Analytical results of flower-grown soil samples indicated that samples were acidic to alkaline in reaction, non-saline and slightly calcareous to non-calcareous in nature. Soil fertility groupings under percent category indicated the dominance of medium organic carbon, low available nitrogen, medium to high available phosphorus, high available potassium and low available sulphur categories. In the case of available micronutrients, the dominance of low DTPA-Fe, medium DTPA-Zn, high DTPA-Mn, medium DTPA-Cu and high HWS-B were observed. The nutrient index values of the samples indicated that low status for organic carbon and available N, medium for available P and K while very low for available sulphur. Regarding to micro nutrients, the order of nutrient index values were B>Mn>Cu>Fe>Zn. Nutrient index values found to indicate for very low DTPA-Fe, Zn and Cu while marginal for DTPA-Mn and HWS-B. Thematic maps generated on the individual soil parameters clearly indicated the spatial variability of individual parameters in the flower grown soils of Eastern farm of Horticultural College and Research Institute, Periyakulam. The low fertile areas have to be improved by the conjoint application of organic and /or inorganic sources for enhanced flower production and sustainable soil fertility.

HIGHLIGHTS

- Assessment of soil properties in flower grown soils.
- Nutrient Indexing of soils.
- Soil fertility mapping using GIS.

Keywords: Flower crops grown soils, GIS, nutrient status, spatial variability, thematic maps

Crop productivity in the semi-arid tropic region is low with an average of less than 1600 kg ha^{-1} (ICAR, 2011) due to poor water availability and soil fertility (Sahrawat and Wani 2013). The inadequacy of small scale information of soil nutrients found inadequate to effectively managing the individual farms and hence large scale spatial variability assessment using grid sampling method is a feasible option to identify critical nutrient deficiency zones (Vasu 2017). Detailed soil information is a prerequisite for planning, monitoring and development of management plan for optimum use of land, water and fertilizer aiming at high returns. Natural factors

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like soil and climate lead to the regional disparity in the productivity of crops. Sustained availability of nutrients and moisture in the root zone is essential to harvest good yield. Mono-cropping, run off, soil erosion, poor soil management etc., leads to loss of fertile soil and nutrient every year. Nutrient management strategies without replenishment of crop uptake in the soil ultimately lead to decline in natural fertility and crop yield.

Modern tools like Global Positioning System (GPS) and Geographic Information System (GIS) are highly useful in generating spatial variability maps of nutrients (Sharma 2004). Modern tools can be utilized for taking decisions for enhancing productivity and balanced nutrition of crops. GIS is a powerful tool for spatial analysis of natural resources and data base management and a versatile tool to automate soil data transformation into soil information (Kasthuri Thilagam and Sivasamy 2013). In the present study, an attempt has been made to evaluate the soil fertility status and their spatial variability in the flower grown soils of Eastern farm of Horticultural College and Research Institute, Periyakulam, Tamil Nadu to identify the potentialities and constraints of the farm soils.

MATERIALS AND METHODS

Collection of soil samples

Sixty five surface soil samples were collected from the fields of Eastern Farm of Horticultural College and Research Institute, Periyakulam, Tamil Nadu. The geo-coordinates were recorded for each sample using GPS (Fig. 1).

Analysis of soil samples

Collected soil samples were air-dried, sieved through a 2 mm sieve, labeled, and stored for analysis. Soil samples were sieved with a 0.5 mm sieve for the estimation of organic carbon. The soil samples were analyzed with standard procedures. Soil pH and EC were estimated as per Jackson, (1973). Organic carbon was estimated as per the procedure outlined by Walkley and Black (1934). Soil available nitrogen was estimated as per Subbiah and Asija (1956) and available phosphorus as per Olsen *et al.* (1954). Available potassium and sulphur were determined as per Stanford and English (1949) and Williams and Steinbergs (1959) respectively. Available Zn, Fe, Cu, and Mn were analyzed with respect to Lindsay and Norvell (1978) and available Boron as outlined by Berger and Truog (1944).

The analytical results of each soil sample was categorized into low, medium and high based on the critical limits as followed in Tamil Nadu (Table 1).

Table 1: Critical levels of nutrients for low, medium and high categories

Nutrient	Low	Medium	High
O.C. (g kg^{-1})	<5.0	5.0 - 7.5	>7.5
N (kg ha^{-1})	<280	280 - 450	>450
P (kg ha^{-1})	<11	11 - 22	>22
K (kg ha^{-1})	<118	118 - 280	>280
S (mg kg^{-1})	< 10	10-15	>15
Fe (mg kg^{-1})	< 3.7	3.7 --8.0	> 8.0
Mn (mg kg^{-1})	< 2	2 – 4	> 4
Zn (mg kg^{-1})	<1.2	1.2 – 1.8	> 1.8
Cu (mg kg^{-1})	<1.2	1.2 - 1.8	> 1.8
B (mg kg^{-1})	< 0.46	0.46 – 1.0	> 1.0

Using the number of samples in each category, the per cent sample category and Nutrient Index Values (NIV) were calculated using the formulae furnished below.

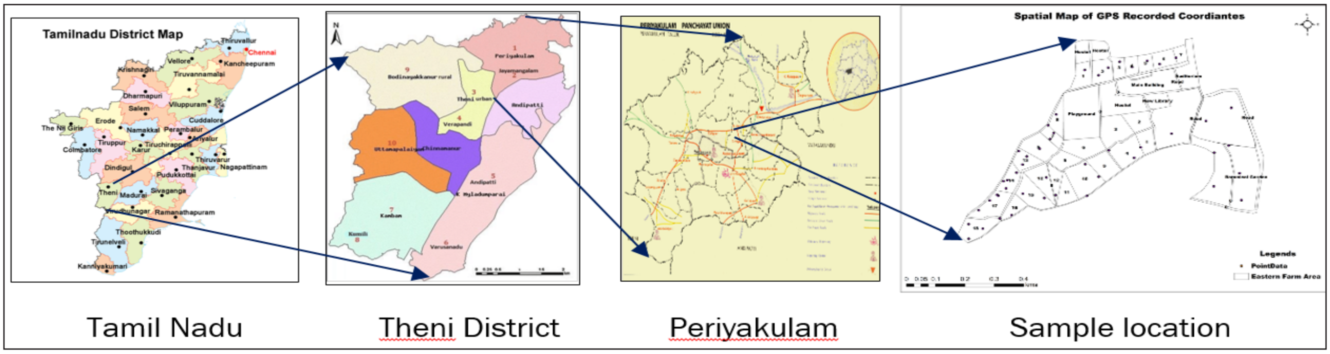

Fig. 1: Geocordiantes for the locations of soil sampling

Per cent sample category

Percent sample category =

$$\frac{\text{No. of samples in Low or Medium or High category}}{\text{Total number of samples}} \times 100$$

Nutrient index values and fertility rating

Nutrient index value was calculated from the proportion of soils under low, medium and high available nutrient categories, as represented by,

$$NIV = \frac{\left[(P_H \times 3) + (P_M \times 2) + (P_L \times 1)\right]}{100}$$

Where,

NIV = Nutrient Index Value

P_L, P_M and P_H are the percentage of soil samples falling in the category of low, medium and high nutrient status and given weightage of one, two and three respectively (Ramamoorthy and Bajaj, 1969).

The nutrient index values were rated into various categories *viz*., low (<1.67), medium (1.67-2.33), and high (>2.33) for OC and available N,P, and K. For available S and micronutrients, the ratings are very low (< 1.33), low (1.33-1.66), marginal (1.67-2.00) adequate (2.01-2.33), high (2.34-2.66) and very high (> 2.66).

Generation of thematic soil fertility maps

Database on soil analytical parameters was generated in Microsoft Excel and the thematic maps were created at the Department of Remote sensing and GIS, TNAU, Coimbatore by using Arc-GIS software. The thematic maps on physico-chemical properties and available nutrient status were generated by categorizing the fertility status such as 'Low', 'Medium' and 'High' by showing appropriate legend for soil fertility parameters by krigging.

RESULTS AND DISCUSSION

Soil Physico- chemical Properties

The overall data (65 Nos) indicated that pH of the soil varied from 5.09 to 8.33 with a mean value of 6.82. The electrical conductivity of the soil samples ranged from 0.01 to 0.21 dSm^{-1} with a mean value of 0.06 dSm^{-1} and soils were non saline. The organic carbon content of the soil samples ranged from 2.40 to 9.84 g kg^{-1} with a mean of 6.56 g kg^{-1}. The free $CaCO_3$ content in the soil samples ranged from non-calcareous to slightly calcareous in nature (3.95 to 5.65 %) with a mean value of 4.85% (Table 2).

Table 2: Range and mean values of various soil analytical parameters (n = 65)

Parameter	Unit	Range	Mean	SD	CV
pH		5.09 – 8.33	6.82	0.77	11.3
E.C	d Sm^{-1}	0.01 - 0.21	0.06	0.04	66.0
O.C	g kg^{-1}	2.40 – 9.84	6.56	1.89	28.7
Free $CaCO_3$	%	3.95 – 5.65	4.85	0.39	8.10
Available N	kg ha^{-1}	165 - 322	291	31.4	12.0
Available P	kg ha^{-1}	11.4 = 33.0	26.0	5.98	23.0
Available K	kg ha^{-1}	220 - 620	405	101.5	25.0
Available S	mg kg^{-1}	4.57 – 24.22	7.26	2.74	37.8
DTPA-Fe	mg kg^{-1}	0.69 - 16.65	6.53	5.00	76.5
DTPA-Zn	mg kg^{-1}	0.77 – 3.59	1.29	0.34	26.0
DTPA-Mn	mg kg^{-1}	2.01 – 11.96	6.85	3.30	48.1
DTPA-Cu	mg kg^{-1}	0.84 – 2.54	1.48	0.33	22.2
HWS-B	mg kg^{-1}	2.54 – 7.34	4.91	1.21	24.7

Available nutrient status

The available N, P and K status of the soils varied from 165 to 322; 11.4 to 33.0 and 220 to 620 kg ha^{-1} with a mean of 291, 26.0 and 405 kg ha^{-1} respectively. The available sulphur content varied from 4.57 to 24.22 mg kg^{-1} with a mean of 7.26 mg kg^{-1} (Table 2).

The DTPA extractable Fe, Zn, Mn, and Cu content ranged from 0.69 to 16.65; 0.77 to 3.59; 2.01 to 11.96; 0.84 to 2.54 mg kg^{-1} with a mean of 6.53, 1.29, 6.85 and 1.48 mg kg^{-1} respectively. The hot water soluble boron content of the soils ranged from 2.54 to 7.34 mg kg^{-1} with a mean of 4.91 mg kg^{-1}.

Fertility grouping of soil samples

Number of samples in each fertility category were worked out and the results are furnished in Table 3. Among the 65 soil samples, 17 are acidic, 32 are neutral and 16 are alkaline in reaction. Soil EC values of all the samples found to be in non-saline category. Organic carbon content in soil samples revealed that, 13 samples under low, 30 under medium and 22 were high category. With respect to available nitrogen, 46 samples fell under the low and 19 under medium status. In the case of available phosphorus, 20 and 45 samples were coming under the category of medium and high status, respectively. Among the soil samples, 11 and 54 samples were belonging to the category of medium and high available potassium status. Available sulphur found to record 60 samples under low, 4 samples under medium and 1 sample under high category. With respect to DTPA micronutrients, 29, 15, 21; 28, 36, 1; 0, 19, 46; 9, 47, 9 nos of samples are grouped under low, medium and high category for DTPA Fe, Zn, Mn and Cu respectively. In the case of HWS-B, all the 65 samples fell under the category of high status.

Table 3: Number samples under each category of fertility groups

Parameters	Low	Medium	High
pH	Acidic 17	Neutral 32	Alkaline 16
E.C	Non saline -65	Saline-0	
O.C	13	30	22
Available N	46	19	0.0
Available P	0	20	45
Available K	0	11	54
Available S	60	4	1
DTPA-Fe	29	15	21
DTPA-Zn	28	36	1
DTPA-Mn	0	19	46
DTPA-Cu	9	47	9
HWS-B	0	0	65

Per cent samples for each fertility group

Percent category samples for soil physic-chemical properties and available nutrients was worked out and the results are given in Table 4.

Table 4: Percent category of samples for available nutrients

Parameters	Per cent category		
	Low	Medium	High
pH	Acidic 26.2	Neutral 49.2	Alkaline 24.6
E.C	Non saline -100	Saline-0	
O.C	20.0	46.2	33.8
Available N	70.8	29.2	0.0
Available P	0.0	30.8	69.2
Available K	0.0	16.9	83.1
Available S	92.3	6.2	1.5
DTPA-Fe	44.6	23.1	32.3
DTPA-Zn	43.1	55.4	1.5
DTPA-Mn	0.0	29.2	70.8
DTPA-Cu	13.8	72.3	13.8
HWS-B	0.0	0.0	100.0

Soil pH values indicated that out of total samples, 26.2 per cent were acidic, 49.2 per cent were neutral and 24.6 per cent were alkaline. All the soil samples were categorized under non saline. Among the 65 soil samples, 20.0, 70.8 and 92.3 per cent of samples are grouped under the low status for O.C, available N and S respectively. In the case of micronutrients, 44.6, 43.1 and 13.8 per cent of samples were grouped under low status for available Fe, Zn and Cu respectively.

Among the 65 soil samples, 46.2, 29.2, 30.8, 16.9 and 6.2 per cent of samples are with medium status for O.C, available N, P, K, and S respectively. Among the micronutrients, 23.1, 55.4, 29.2, and 72.3 cents of samples were classified under medium status for available Fe, Zn, Mn, and Cu respectively.

High category found to be with 33.8, 69.2, 83.1 and 1.5 per cent of samples in O.C, available P, K and S respectively. Micronutrients viz., Fe, Zn, Mn, Cu and B recorded 32.3, 1.5, 70.8, 13.8, and 100 percent of samples under high category.

Nutrient index values

Nutrient index values were worked out and the values are furnished in Table 5.

Table 5: Nutrient index value and fertility status

Parameters	Nutrient index value	Fertility status
O.C	1.39	Low
Available N	0.84	Low
Available P	1.75	Medium
Available K	1.84	Medium
Available S	0.71	Very low
DTPA-Fe	1.22	Very low
DTPA-Zn	1.03	Very low
DTPA-Mn	1.76	Marginal
DTPA-Cu	1.30	Very low
HWS-B	1.95	Marginal

Among the major nutrients, nitrogen registered the lowest nutrient index value of 0.84 followed by phosphorus (1.75) and potassium (1.84). Among the micronutrients, the order of nutrient index values was B>Mn>Cu>Fe>Zn. Nutrient index values for organic carbon and available N were low while for available P and K, the nutrient index values were medium. Nutrient index values for available sulphur found to be very low. With respect to micronutrients, DTPA-Fe, Zn and Cu were classified under very low while DTPA-Mn and HWS-B were marginal. Similar results were

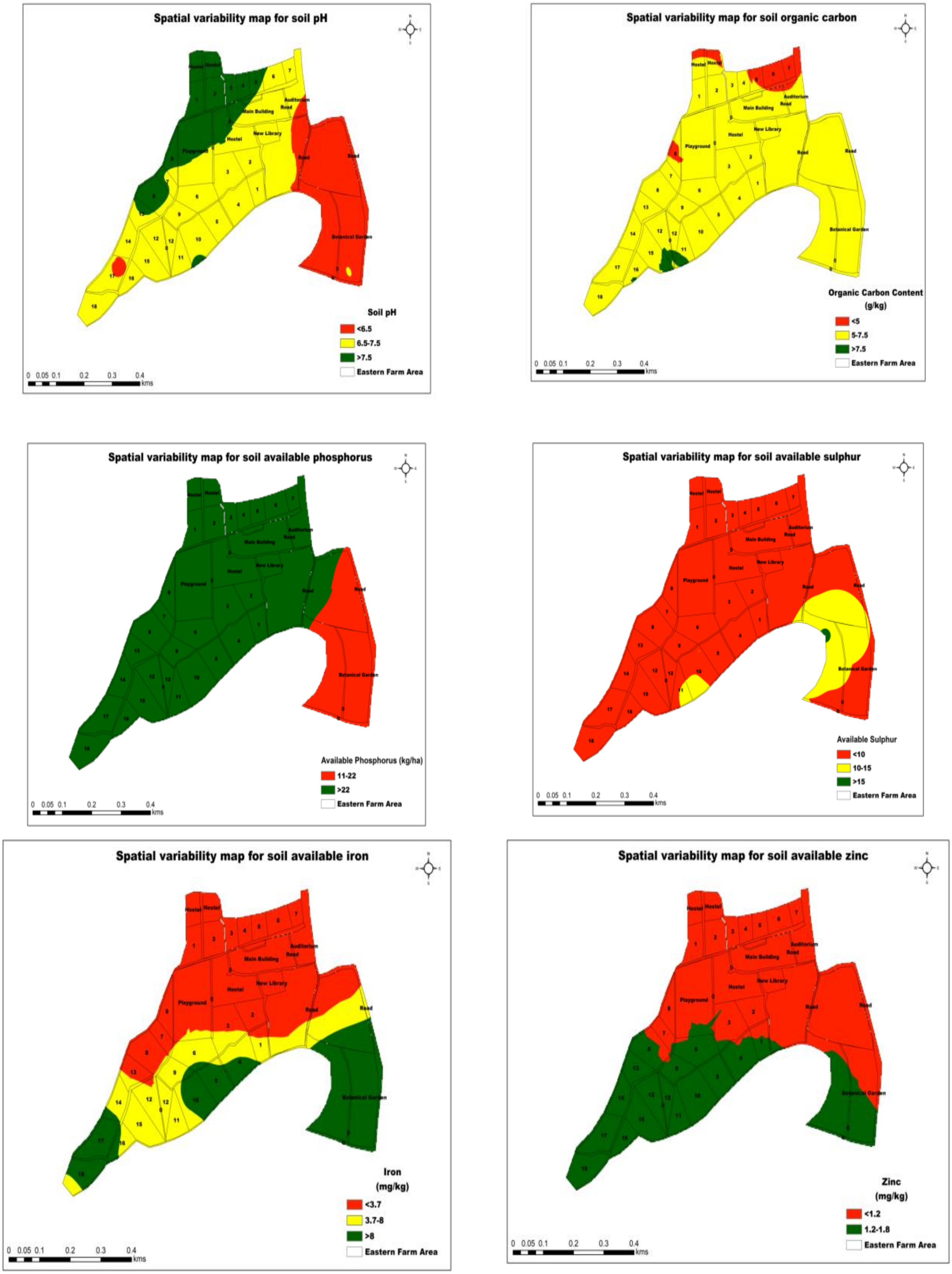

Fig. 2: Spatial variability maps for soil pH, O.C, available-P, S and Fe

reported by Sellamuthu *et al*. (2015), Theresa *et al*. (2019) and Muthumanickam (2020) for assessing the nutrient index values in Tiruchirapalli District, rice ecosystem of Anaimalai Block and vegetable grown soils of Horticultural College and Research Institute, Periyakulam respectively.

Thematic soil fertility maps

Thematic maps were generated for soil pH, EC, organic carbon and available nutrient status by showing appropriate legend for the respective parameters (Fig. 2). Thematic maps generated clearly depicted the spatial variability of soil fertility parameters. Similar thematic maps were created in Veeranam Command Area, Tamil Nadu by Arunkumar and Paramasivan, (2015); mapping Soil Fertility and its Spatial Variability in Tiruchirapalli District, Tamil Nadu Using GIS by Sellamuthu *et al*. (2015) and for vegetable grown soils of Horticultural College and Research Institute, Periyakulam by Muthumanickam (2020).

CONCLUSION

Soils of flower-grown soils of Eastern farm of Horticultural College and Research Institute, Periyakulam were acidic to alkaline in reaction, non saline and slightly calcareous to non calcareous in nature. Soil fertility groupings with per cent sample in each category revealed the dominance of medium in organic carbon, low in available nitrogen, medium to high in available phosphorus, high in available potassium and low in available sulphur. With respect to soil available micronutrients, dominance of low category in DTPA-Fe, medium in DTPA-Zn, high in DTPA- Mn, medium in DTPA-Cu and high in HWS-B were observed. GIS found to be an essential tool in converting the numerical values of soil parameters into visual images for better understanding of soil properties, soil constraints and to generate site specific management strategies for sustaining soil fertility. Application of organic manures, green or green leaf manures or any other natural organic sources is essential for improving the productivity of soil. Identified deficient nutrients in soils have to be reinstated through chemical fertilizers and/or natural means. Soil test based fertilizer recommendations along with micronutrients is advocated for enhanced crop production and sustained soil fertility.

REFERENCES

Arunkumar, V. and Paramasivan, M. 2015. Spatial variability and geostatistics application for mapping of soil properties and nutrients in intensively cultivated village of Veeranam Command Area, Tamil Nadu. *An Asian J. of Soil Sci*., **10** (2): 299-305.

Berger, K.C. and Troug, E. 1944. Boron test and determination for soils and plants. *Soil Sci*., **57**: 25 – 26.

ICAR, 2011. Vision 2030. . http://www.icar.org.in/files/ICAR-Vision-2030.pdf.

Jackson, M.L. 1973. Soil chemical analysis. Prentice hall of India Pvt Ltd., New Delhi, pp. 496.

Kasthuri Thilagam, V. and Sivasamy, R. 2013. Role of remote sensing and GIS in land resource inventory-a review. *Agri. Rev*., **34**(3): 223-229.

Lindsay, N.L. and Norvell, W.A. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Am. J*., **42**: 421-428.

Muthumanickam, D. 2020. Spatial variability mapping of available nutrient status in vegetable grown soils using GIS Techniques. *Int. J. Curr. Microbiol. App. Sci*., **9**(5): 3227-3236.

Olsen, S.R., Cole C.V., Watanabe, P.S. and Dean. L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S.D.A. *Circ*., 939.

Ramamoorthy, B. and Bajaj, J.C. 1969. Available N, P and K status of Indian soils. *Fertilizer News*, **14**: 24-26.

Sahrawat, K.L. and Wani, S.P. 2013. Soil Testing as a Tool for On-Farm Fertility Management: Experience from the Semi-arid Zone of India. *Communications in Soil Sci. and Plant Analysis*, **44**(6), 1011–1032.

Sellamuthu, K.M., Santhi, R., Sivagnanam, S., Radhika, K., Sekar, J., Pradip Dey and Subba Rao, A. 2015. Mapping soil fertility and its spatial variability in Tiruchirapalli district, Tamil Nadu using GIS. *Madras Agric. J*., **102**(10-12): 317-324.

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.

Stanford, S. and L. English. 1949. Use of Flame photometer in rapid soil test for K and Ca. *Agron. J*., **41**: 446-447.

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

Theresa, K., Shanmugasundaram, R. and Kennedy, J.S. 2019. Assessment of spatial variability of soil nutrient status in rice ecosystem using Nutrient Index in Anaimalai Block, Coimbatore. *Int. J. Curr. Microbiol. App. Sci.,* **8**(8): 2169-2184.

Duraisamy Vasu, Singha, S.K., Nisha Sahua, Pramod Tiwarya, Chandrana, P., Duraisami, V.P., Ramamurthy, V., Lalitha, M. and Kalaiselvi. B. 2017. Assessment of spatial variability of soil properties using geospatial techniques for farm level nutrient management. *Soil and Tillage Res*., **69**: 25-34.

Walkley, A. and Black, I.A. 1934. An examination of soil organic carbon by chromic acid titration method. *Soil Sci*., **37**: 29.

Williams, C.H. and Steinbergs, H. 1959. Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. *Australian J. Agric. Res*., **10**: 340-352.