A-5929
[1-5]

RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume Issue : ()

Geo Statistical Tool for Soil Fertility Assessment in Pulses Growing Area of Melur Block, Madurai District, Tamil Nadu

P. Ramamoorthy[1], P. Christy Nirmala Mary[2], P. Saravanapandian[1], A. Gurusamy[3], K. Kumutha[4] 10.18805/IJARe.A-5929

ABSTRACT

Background: Soil fertility is a significant natural property which decides the health and quality of land resources. Pulse productivity diminishes nowadays under rain fed condition due to improper nutrient management practices. Hence the present study was carried out to assess the soil fertility status under major pulses growing area by using advanced geo statistical tool with ArcGIS.

Methods: Soil survey was taken in 14 revenue villages in Melur block, Madurai district. Soil samples were collected and analysed for its nutrient properties. The Parker's Nutrient Index and soil fertility maps were prepared by using ArcGIS.

Result: Pulses growing soils were mostly neutral in pH and soluble salt content was low. The organic carbon and available nitrogen content was low to medium. The available phosphorus and potassium status were medium to high. Hence proper nutrient management practices are to be needed for augment pulse production in such area.

Key words: ArcGIS, Parker's index, Pulses, Soil fertility.

INTRODUCTION

Pulses occupy an inimitable position in Indian farming as protein supplement and restoration of soil fertility (Jeevitha *et al.* 2019). Pulses are grown under poor fertile soil under imbalanced nutrient application (Hosamani *et al.,* 2017). India, China, Canada, Brazil and Myanmar are the top five countries accounting for 50% of global pulses production.

India area under pulses cultivation were 27.98 m ha, production of 23.02 m t and productivity of 823 kg ha^{-1}. In Tamil Nadu area of 0.82 m ha, under production 0.6 m t and productivity of 735 kg ha^{-1} (India stat, 2020). India consumes 30% of global pulses production. China and Brazil was a distant second in consumption, with a 6% share each. (Anonymous, 2010).

The static production of pulses in India coupled with an explosion of population has led to steep fall in per capita availability of pulses from 70 gram per day in 1960-61 to less than 40 gram per day during present decade (Pushpa, 2007) as against FAO/WHO's recommendation of 80 gram per day. The crisis of shortage of pulses has aggravated the problem of malnutrition. Thus, there is an imperative need to increase the production of pulses to meet the requirement. Soil fertility assessment in pulse growing area can be done with the help of Geo Graphical Information (GIS) system with advanced geostatistical tools called Kriging for preparation of thematic maps (Burgess and Webster, 1980). Proper nutrient management practices can be effectively made with thematic maps based on deficient of nutrients.

MATERIALS AND METHODS

Study area

The study area of Melur block, Madurai District is having an area of 3057 ha is located between 10° 03′ 36″ N latitude, 78° 33′ 58″ E longitude and elevation with 101 m above MSL. The length of growing period (LGP) is >120 days (Ramamurthy *et al.*, 2009). The climate is semi-arid with a mean annual average rainfall of 857.63 mm.

[1]Department of Soils and Environment, Agricultural College and Research Institute, TNAU, Madurai-625 104, Tamil Nadu, India.
[2]Department of Crop Management, Agriculture College and Research Institute, Kudumiyanmalai-622 104, Tamil Nadu, India.
[3]Dry Land Agricultural Research Station, Chettinad, TNAU, Sivagangai-630 102, Tamil Nadu, India.
[4]Department of Agricultural Microbiology, Agricultural College and Research Institute, TNAU, Madurai-625104, Tamil Nadu, India.

Corresponding Author: P. Ramamoorthy, Department of Soils and Environment, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India. Email: ramagri95@gmail.com

How to cite this article: Ramamoorthy, P., Mary, P.C.N., Saravanapandian, P., Gurusamy, A. and Kumutha, K. (2022). Geo Statistical Tool for Soil Fertility Assessment in Pulses Growing Area of Melur Block, Madurai District, Tamil Nadu. Indian Journal of Agricultural Research. DOI: 10.18805/IJARe.A-5929.

Submitted: 07-10-2021 **Accepted:** 07-03-2022 **Online:** 11-04-2022

Soil sampling and analysis

A detailed soil survey of the study area was carried out based on grid map using ArcGIS software. Soil samples, 280 nos. were collected with soil auger from 0-20 cm depth in 14 revenue villages. Each revenue villages 20 soil samples collected. The sample locations (latitude and longitude) were recorded with GPS. The collected soil samples were processed and stored for further soil analysis. The stored samples were analyzed for pH, electrical conductivity, organic carbon, available nitrogen, P_2O_5 and K_2O. The soil reaction (pH) and electrical conductivity was determined by

Jackson (1973).The organic carbon was determined by Walkley and Black (1934) method. Available nitrogen was determined by modified alkaline permanganate method as described by Sharawat and Burford (1982). The available phosphorous was determined by spectrophotometer (Olsen *et al.,* 1954). Available potassium was determined by Flame Photometer with neutral ammonium acetate as an extractant by Hanway and Heidel (1952) method.

Nutrient availability index (NAI) determination

Nutrient Index was introduced by Parker *et al.,* (1951) and modified by Pathak (2010); Kumar *et al.,* (2013) and RaviKumar *et al.,* (2007). Nutrient Index can be calculated by using the following formula:

Nutrient index =

$$\frac{\{(1 \times A) + (2 \times B) + (3 \times C)\}}{TNS}$$

Where,

A = Number of samples in low category.
B = Number of samples in medium category.
C = Number of samples in high category.
TNS = Total number of samples.

Spatial analysis by ArcGIS

The location of sampling sites was fed into GIS environment and digitized using ArcGIS-10 software; they are validated for digitization errors, polygonized and finally transformed in to thematic map (Burgess and Webster, 1980).

RESULTS AND DISCUSSION

Soil fertility status of study area

The results on physico-chemical properties of soil samples are presented in Table 1 and 2. The data on Nutrient Index status and correlation data are presented in the Table 3 and 4.

Soil reaction (soil pH)

The data revealed that the pH of soils varied from slightly acidic to neutral (6.8 to 7.90) with a mean of 7.38. About 2.15**%** soils of pulses grown in acidic condition and 97 per cent of the area were neutral in nature (Table 1). The high pH values are possibly due to the presence of soluble salt and exchangeable sodium along with bicarbonate ions, which precipitates calcium and magnesium during evaporation (Singh *et al.,* 2016 and Denis *et al.,* 2016). The variation in soil pH of acid to neutral could be attributed to leaching of bases, rainfall, continuous decaying of organic matter and parent material (acid rich ingenious rocks and granite gneiss) *etc.* as reported by Kumar and Paliyal (2018) and Thakur *et al.,* (2021). According to Brady and Weil (2005), the alkalinity problem in soils is due to indigenous calcareous parent material with low organic matter content. Therefore, in such areas, fertilization, organic manures along with legumes as crop rotation with minimum/no-tillage practices play an important role to sustain soil fertility (Sainju *et al*., 2008).

Electrical conductivity

The electrical conductivity (EC) is the measure of soluble salts of soil and is affected by cropping sequence, irrigation, land use and application of fertilizers, manure and compost (Singh *et al*., 2016). High value of electrical conductivity represents higher degree of salinity. Excessive amount of dissolved salts in soil solutions causes hindrance in normal nutrient uptake process either by imbalance of ions uptake, antagonistic effect between nutrients or excessive osmotic potentials of soil solution or a combination of the three effects (Rahman *et al*., 2010). The results presented in Table 1 indicate that salinity hazard does not presently exist in the study area. The mean value of EC is 0.4 dS/m with a range varying from 0.17 to 1.97 dSm^{-1}. According to Roy and Landey (1962), low EC of soils is indicated that conditions are not favourable for accumulation of salts.

Organic carbon

Organic matter has a vital role in agricultural soils. It supplies plant nutrients, improves soil structure, water infiltration and retention, feeds soil micro flora and fauna, retention of

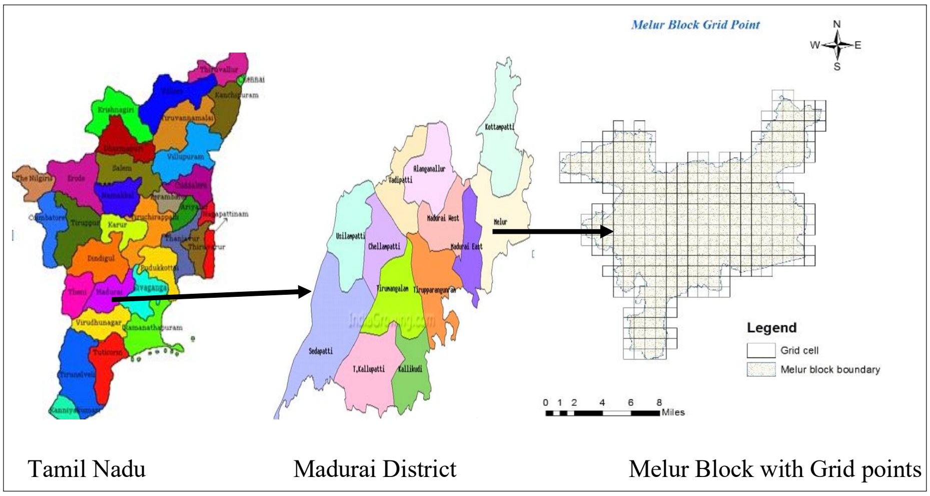

Fig 1: Study area with grid points of soil samplings.

Table 1: Per cent distribution of electrochemical properties and organic carbon status in melur block soils.

Revenue village	pH				Electrical conductivity (dS m^{-1})				Organic carbon (g/kg)			
	Mean	Acid (<6.0)	Neutral (6.0-8.5)	Alkaline (>8.5)	Mean (<1)	Safe (1-2)	Critical	>2	Mean	Low (<5)	Medium (5-7.5)	High (>7.5)
Surakundu	7.55	9.1	90.9	0.0	0.48	100.0	0.0	0.0	6.3	0.0	90.90	9.90
Therkkutheru	7.56	0.0	100.0	0.0	0.41	100.0	0.0	0.0	4.5	70.0	30.0	0.0
Kidaripatti	6.83	0.0	100.0	0.0	0.43	100.0	0.0	0.0	4.0	91.66	0.0	8.33
Melur	7.94	0.0	100.0	0.0	0.15	100.0	0.0	0.0	4.3	100.0	0.0	0.0
Kilaiyur	7.92	0.0	100.0	0.0	0.14	100.0	0.0	0.0	3.4	100.0	0.0	0.0
Thiruvathavur	7.50	0.0	100.0	0.0	0.35	100.0	0.0	0.0	5.0	66.66	16.66	16.68
Uranganpatti	7.09	12.5	87.5	0.0	0.17	100.0	0.0	0.0	4.6	75.0	12.5	12.5
Manikkampatti	7.60	0.0	100.0	0.0	1.9	100.0	0.0	0.0	3.6	80.0	20.0	0.0
Kottakudi	6.80	0.0	100.0	0.0	0.20	100.0	0.0	0.0	4.0	90.0	10.0	0.0
Veppadappu	7.14	0.0	100.0	0.0	0.30	100.0	0.0	0.0	3.5	90.0	10.0	0.0
Poonjuthi	7.60	0.0	100.0	0.0	0.17	100.0	0.0	0.0	4.8	90.0	10.0	0.0
Arittapatti	7.20	0.0	100.0	0.0	0.36	100.0	0.0	0.0	3.9	90.0	9.90	0.0
Ambalakaranpatti	7.30	0.0	100.0	0.0	0.34	100.0	0.0	0.0	4.4	88.88	11.11	0.0
Vellalapatti	7.40	8.5	89.4	2.1	0.3	97.9	0.0	2.1	5.0	53.31	40.42	40.25
Mean	7.38	2.15	97.0	0.15	0.40	99.8	0	0.2	4.4	77.7	18.62	18.62

Table 2: Per cent distribution of available nitrogen, phosphorus and potassium status in melur block soils.

Revenue village	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})				Potassium (kg ha^{-1})			
	Mean	Low (<280)	Medium (280-480)	Mean	Low (<11)	Medium (11-22)	High (>22)	Mean	Low (<118)	Medium (118-280)	High (>280)
Surakundu	317	9.1	90.9	36	0.0	36.4	63.6	392	0.0	27.2	72.7
Therkkutheru	253	70.0	30.0	24	0.0	70.0	30.0	263	0.0	55.0	45.0
Kidaripatti	209	91.7	8.3	18	0.0	91.7	8.3	450	0.0	0.0	100.0
Melur	200	100.0	0.0	30	0.0	0.0	100.0	252	0.0	75.0	25.0
Kilaiyur	193	100.0	0.0	29	0.0	33.3	66.7	389	0.0	0.0	100.0
Thiruvathavur	269	66.7	33.3	35	0.0	16.7	83.3	261	0.0	60.0	40.0
Uranganpatti	235	75.0	25.0	17	0.0	100.0	0.0	361	0.0	50.0	50.0
Manikkampatti	208	80.0	20.0	19	0.0	70.0	30.0	354	0.0	20.0	80.0
Kottakudi	215	90.0	10.0	28	0.0	30.0	70.0	356	0.0	20.0	80.0
Veppadappu	217	90.0	10.0	34	0.0	50.0	50.0	307	0.0	40.0	60.0
Poonjuthi	261	100.0	0.0	52	0.0	10.0	90.0	288	0.0	40.0	60.0
Arittapatti	222	100.0	0.0	73	0.0	0.0	100.0	381	0.0	45.4	54.5
Ambalakaranpatti	234	88.9	11.1	51	0.0	0.0	100.0	324	0.0	44.4	55.5
Vellalapatti	257	57.4	42.6	32	0.0	44.7	53.3	256	2.1	61.7	36.2
Mean	235	79.9	20.1	34.14	0.0	39.5	60.5	331	0.15	38.5	61.4

nutrients andcycling of applied fertilizer (Johnston, 2007). The organic carbon content of soils in the study area varied from 3.4 to 6.3 g kg^{-1} with a mean value of 4.4 g kg^{-1}. The mean value was significantly high (16.66%) in Surakkundu and low (91%) in kiddaripatti (Table 1). The study revealed that organic carbon content of soil falling under low (<5 g kg^{-1} category). According to Kavitha and Sujatha (2015), high levels of organic matter not only provides part of the N requirement of crop plants, but also enhanced nutrient and water retention capacity of soils and create favourable physical, chemical and biological environment. Similar findings as reports of Babalola *et al.,* (2021), this can be attributed to the presence of more decomposable plant materials and phytocyling.

Available nitrogen

The available nitrogen content was low in most of the revenue villages in Melur block (Table 2), except the Surakundu village had medium in available nitrogen status, which might be due to low organic matter content. According to Ashok Kumar (2000), such variation in N content may be related to soil management, application of FYM and fertilizer to previous crop. The available nitrogen content of soils always depends on temperature, rainfall and altitude.In addition, continuous and intensive cultivation leading to high crop removal together with insufficientreplenishment might be the reason for high degree of nitrogen deficiency in these soils. The mediumnitrogen status recorded in some portion of the study area might be due to application of N fertilizer.

Available phosphorus

Phosphorus is essential for growth, cell division, root growth, fruit development and earlyripening of the crop (Singh *et al.*, 2016). The available phosphorous content of soils in the study area varied from 18 to 52 kg ha^{-1} in soils of Melur block (Table 2). The 39.5 per cent of soil samples were medium in available phosphorus (P_2O_5), 60.5% were high in available phosphorus, which might be due to the high

Table 3: Nutrient index values for the soil samples of study area.

Characteristics	Nutrient index	Values remarks	Nurtient index rating
Organic carbon	1.21	Low	<1.67 Low
Available nitrogen	1.07	Low	1.67-2.33 Medium
Available phosphorus	2.78	High	>2.33 High
Available potassium	2.71	High	

Table 4: Correlation matrix of the soil samples of study area.

Soil properties	OC	N	P	K
OC	1			
N	0.030614*	1		
P	0.083357	0.079688*	1	
K	-0.19351	-0.20267	-0.07621*	1

*indicate correlation is significant at 0.05 level.

input of phosphate fertilizers over a period of time as reported by Anonymous (2010), high level of P in soil not only impairs the availability and uptake of essential nutrients by plants but also leads to soil and water pollution.

Available potassium

Potassium exists in K^+ form and its function appears to be catalytic in nature (Singh *et al.,* 2016).The available potassium content of soils in the study area varied from medium (38.5 per cent) to high (61.4 per cent) in soils of Melur block (Table 2). The soils were higher in available potassium status due to the predominance of K rich micaceous and feldspars minerals in their parent material. In addition, Kaolinite typeof clay mineralogy may be the cause for their medium and low rating for available potassium (Pulakeshi *et al.,* 2012).

Inter-relationship of soil properties

The correlation studies (Table 4) revealed that the nutrient status in the soil was positively correlated with soil parameters *viz.* N (r = 0.030614*), P (r = 0.079688*) and negatively correlated with K (r = -0.07621*).

Management practices

Pulses growing soils are low in organic carbon and available nitrogen and medium to high in available phosphorus and potassium. Pulses are generally fixed atmospheric nitrogen in soil as 80-90 percentages of crop requirements. Hence the following management practices are to be carried out for achieving the productivity in pulses.

1. Application of organic manures before sowing the crops.
2. Application of chemical fertilizer @ 20:60:20 kg ha^{-1}
3. Foliar application nutrients compared to basal.
4. Integrated Nutrient Management as 50% recommended

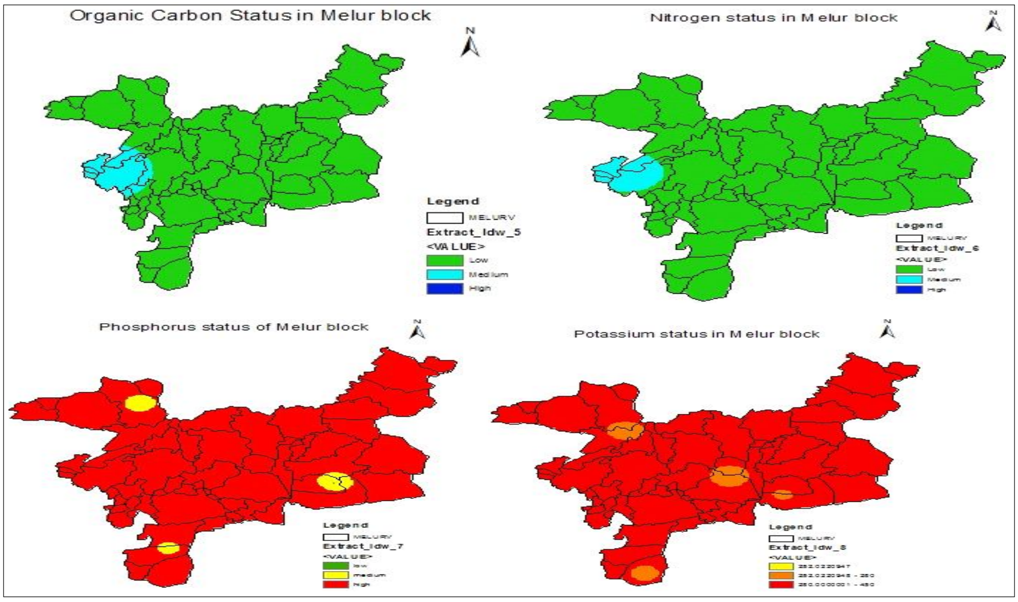

Fig 2: Per cent distribution of soil available organic carbon, nitrogen, phosphorus and potassium status in pulses growing areas of Melur block.

dose of fertilizer (RDF) + FYM at 5 t ha^{-1} + bio-fertilizers (*Rhizobium* + PSB) application are to be adopted.
5. Band placement of phosphate and bio-fertilizers.
6. Application of pulse wonder @ 5 kg ha^{-1} to reduce the flower drops and enhances the yield.

CONCLUSION

Soil fertility assessment of pulse growing soils of Melur block was assessed with one of the GIS tools and Nutrient Availability Index (NAI). The soils were neutral in reaction, low in soluble salt content, low in available nitrogen, medium in available phosphorus and high in potassium. Hence the present study will be used for finding out the deficiency and sufficiency of nutrients in the particular area by seeing thematic maps. The pulse productivity should be improved with application of soil Test based fertilizer application, foliar application of micro nutrients and pulse wonder.

Conflict of interest: None.

REFERENCES

Anonymous (2010). Malaprabha Command Area: Annual Progress report of AICRP on Water Management, Belvatagi, University of Agricultural Sciences, Dharwad (India).

Ashok Kumar, S. (2000). Studies on soil aggregation in Vertisols of North Karnataka. M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad (India).

Babalola, T.S., Ogunleye, K.S., Omoju, O.J., Osakwe, U.C. and Ilori, A.O.A. (2021). Soil Characterization and classification in an upland of southern Guinea Savannah zone of Nigeria. Indian Journal of Agricultural Research. 55(6): 709-714. DOI: 10.18805/IJARe.A-627.

Brady, N.C. and Weil, R.R. (2005). The Nature and Properties of Soil (thirteenth edition), (Macmillan Publishing Co, New York, USA).

Burgess, T.M. and Webster, R. (1980). Optimal interpolation and isarithmic mapping of soil properties: The variogram and punctual kriging. Journal of Soil Science. 31: 315-331.

Denis, M.K.A., Patil, P.L., Kamara, A.M. and Saidu, D.H. (2016). Assessment of soilfertility status using nutrient index approach International Journal of Food, Agriculture and Veterinary Sciences. 6(3): 1-15.

Hanway, J.J. and Heidel, H. (1952). Soil Analysis Methods as Used in Lowa State College. Soil Testing Laboratory, Iowa State Collage Bulletin. 57: 1-131.

Hosamani, V., Chittapur, B.M., Venkatesh and Rajanand, H. (2017). Sustained nutrient management practice for pulse production: A review. Int. J. Curr. Microbiol. App. Sci. 6(11): 3773-3786.

Jackson, M.L. (1973). Soil Chemical Analysis, (Prentice Hall of India Pvt. Ltd., New Delhi, India). 498.

Jeevitha, B., Rathinasamy, A., Mahendran, P.P. and Kannan, P. (2019). Assessment of available sulphur status in majorgreen gram growing blocks of Maduraidistrict of Tamil Nadu and creation of thematicmap using GIS. International Journal of Chemical Studies. 7(5): 4383-4389.

Johnston, A.E. (2007). Soil organic matter, effects on soil and crop. Soil Use and Management. 2(3): 97-105.

Kavitha, C. and Sujatha, M.P. (2015). Evaluation of soil fertility status in various agro ecosystems of Thrissur District, Kerala, India. International Journal of Agriculture and Crop Sciences. 8(3): 328-338.

Kumar, P., Kumar, A., Dyani, B.P., Kumar, P., Shahi, U.P., Singh, S.P., Kumar, R., Kumar, Y. and Sumith, R. (2013). Soil fertility status in some soils of Muzaffarnagar district of Uttar Pradesh, India, along with Ganga canal command area. African Journal of Agricultural Research. 8(14): 1209-1217.

Kumar, R. and Paliyal, S.S. (2018). Physical and chemical properties of soils under mid hill humid conditions of north-west Himalayas. Journal of Pharmacognosy and Phytochemistry. 7: 1482-1485.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soils by extraction with sodium carbonate. USDA Circular. 939: 1-19.

Parker, F.W., Nelson, W.L., Winters, E. and Miles, J.E. (1951). The broad interpretation and application of soil test summaries. Agronomy Journal. 43(3): 103-112.

Pathak, H. (2010). Trends of fertility status of Indian soil. Current Advances in Agricultural Sciences. 2(1): 10-12.

Pulakeshi, H.B.P., Patil, P.L, Dasog, G.S., Radder, B.M. and Mansur, C.P. (2012). Mapping nutrients status by geographic information system (GIS) in Mantagani village under northern transition zone of Karnataka. Karnataka Journal Agricultural Sciences. 25(3): 232-235.

Pushpa, M.S. (2007). An economic analysis of demand and supply response of pulses in India. Karnataka J. Agric. Sci. 20(3): 545-550.

Rahman, O., Ahmad, B. and Afzal, S. (2010). Soil fertility and salinity status of Attock district. Journal of Agricultural Research. 48(4): 505-516.

Ramamurthy, V., Naidu, L.G.K., Kumar, R.S.C, Srinivas, S. and Hegde, R. (2009). Soil based fertilizer recommendations for precision farming. Current Sci. 97(5): 641-647.

RaviKumar, M.A., Patil, P.L. and Dasog, G.S. (2007). Mapping of Nutrients Status of Malaprabha Right Bank Command of Karnataka by GIS Technique. I- Major Nutrients Karnataka. Journal of Agricultural Sciences. 20(4): 735-737.

Roy, B.B. and Landey, R.I. (1962). Studies on red and lateritic soils of Mond watershed area of Raigarh district. Indian Journal of Agricultural Sciences. 32(6): 294-302.

Sainju, U.M., Senwo, Z.N., Nyakatawa, E.Z., Tazisong, I.A. and Reddy, K.C. (2008). Tillage, cropping systems and nitrogen fertilizer source effects on soil carbon sequestration and fractions. Journal of Environmental Quality. 37: 880-888.

Sharawat, K.L. and Burford, J.R. (1982). Modification of alkaline permanganate method for assessing the availability of soil nitrogen in upland soils. Soil Science. 133: 53-57.

Singh, G., Sharma, M., Manan, J. and Singh, G. (2016). Assessment of soil fertility status under different cropping sequences in district Kapurthala. Journal of Krishi Vigyan. 5(1): 1-9.

Thakur, N., Sharma, R., Kumar, A. and Sood, K. (2021). Soil Fertility Appraisal for Pea Growing Regions of Himachal Pradesh using GPS and GIS Techniques. Indian Journal of Agricultural Research. 55(4): 452-457. DOI: 10.18805/IJARe.A-5516.

Wackley, A. and Black, I.A. (1934). Estimation of soil organic carbon by chromic acid titration method. Soil Science. 37: 29-38.