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RESEARCH ARTICLE Agricultural Science Digest, Volume Issue : ()

Evaluation of Soil Fertility Status of Agro Ecological Zones of Kerala using Nutrient Index Approach

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ABSTRACT

Background: Soil fertility evaluation is much imperative in order to sustain soil fertility and also food grain production in long run. A study was undertaken across five agro ecological zones of Kerala comprising nine districts *viz.*, Thiruvananthapuram, Alappuzha, Ernakulam, Thrissur, Palakkad, Malappuram, Kozhikode, Wayanad and Kannur with the aim of evaluating the soil fertility status using nutrient index approach.

Methods: Soil sampling was carried out using GPS representing all the five agro ecological zones of Kerala. Field study was also undertaken in order to collect the basic data. Based on the nutrient index calculation, soil samples were categorized in to low, medium and high classes.

Result: The analytical results revealed that the nutrient index class for soil organic carbon fall under medium class for the major share of samples analysed. Available N was in the medium class for all the districts, except Kozhikode where it was in the low category. However, the available P content falls under the high class for most of the soil samples. Available K was in the medium category of soil fertility for the majority of the samples analysed.

Key words: Agro ecological zones, GPS, Nutrient index, Soil fertility status.

INTRODUCTION

Intensive cultivation and inadequate soil management practices can lead to the depletion in soil fertility. Rapid expansion in human population also triggers the exploitation of soil fertility. Continuous cropping for enhanced yield removes substantial amounts of nutrients from soil. Imbalanced and inadequate use of chemical fertilizers, improper irrigation and various cultural practices also deplete the soil quality rapidly (Medhe *et al.*, 2012).

Soil fertility decline is naturally more alarming in intensively cultivated regions wherein nutrient withdrawals by crops are high and replenishment is inadequate and this has grave implications in terms of (i) more acute and wide spread deficiencies, (ii) declining nutrient use efficiency and returns from money spent on nutrient and other inputs, (iii) a weakened foundation for high yielding sustainable farming and (iv) escalating remedial costs for rebuilding depleted soils (Denis *et al.*, 2017). Besides, use of high yielding varieties, imbalanced use of fertilizers particularly excessive use of straight fertilizers, lack of application of organic manure and unscientific cultivation practices triggered the occurrence of wide spread deficiencies of micronutrients all over the world. Therefore, it is very essential to maintain the soil fertility and soil health in order to achieve sustainable crop production.

Geographically Kerala is wedged between the Lakshadweep Sea and the Western Ghats and lies between north latitudes, 8°18′ and 12°48′ and east longitudes, 74°52′ and 77°22′. Kerala experiences humid equatorial tropical climate and soils are generally acidic, showing high variability with respect to the concentration of plant available nutrients. In general, Kerala has wide variation and complexity of soils due to diverse nature of physiography, parent materials, land type, drainage conditions and agro ecology. Depending on these aspects, the state has been divided into five agro ecological zones (AEZ), which varied greatly in respect of area, land and soil, climate and cropping intensity (Estelitta, 2016). Soil fertility assessment of each AEZ will give an idea about possible potential crop production and its challenges.

Though enormous volume of soil test data is available, a consolidated user-friendly data for the very specific use is almost lacking. Hence arise the need to collect precise and reliable data from a vast area with no compromise on its accuracy and efficiency. Evaluating the soil fertility status and alleviating the nutrient deficiencies through external fertilization based on crop need is a promising strategy to sustain soil fertility. The fertility status of soils can be evaluated using nutrient index method. The nutrient index of soils using organic carbon, available P and available K concentrations as a

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How to cite this article: Bastin, B., Beena, V.I., Rajimol, R.P. and Dey, P. (2022). Evaluation of Soil Fertility Status of Agro Ecological Zones of Kerala using Nutrient Index Approach. Agricultural Science Digest. DOI: 10.18805/ag.D-5509.

Submitted: 05-10-2021 **Accepted:** 02-07-2022 **Online:** 29-07-2022

measure of soil fertility in Varahi River basin, India was evaluated by Ravikumar and Somasekhar, (2013). Similar studies were conducted by Pulakeshi *et al.* (2012) and Denis *et al.* (2017). However, studies on the evaluation of fertility status of soils of Kerala are often limited. Hence, the present study was undertaken with an objective to evaluate the fertility status of soils of agro ecological zones of Kerala.

MATERIALS AND METHODS

Study area

The study area covers all the five agro ecological zones of Kerala *viz.*, coastal plain, midland laterites, foot hills, high hills and Palakkad plains. Soil samples were collected from nine districts of Kerala *viz.*, Thiruvananthapuram, Alappuzha, Ernakulam, Thrissur, Palakkad, Malappuram, Kozhikkode, Wayanad and Kannur representing these agro ecological zones (Fig 1).

Methodology of soil sampling

Georeferenced soil samples were collected from 15 cm depth at 50 m grid interval by using random sampling method from the selected villages under different taluks of the districts. Besides, a detailed district wise survey work was carried out and collected details regarding total geographical area, cultivated area, irrigated area, rainfed area, soil types in the village, major crops and cropping system, types of fertilizers used by the farmers, per cent of area under each cropping system *etc.*

Geo-referenced soil samples were taken from six selected farmers' from each village by following the random sampling procedure. The location of sampling was geo referenced by using GPS to identify the actual locations (Latitude, longitude and altitude data) of samples collected for the work.

Estimation of primary nutrients

The collected samples were characterized for pH and EC by following standard procedures as outlined by Jackson (1958). The organic carbon was estimated by wet oxidation method (Walkley and Black, 1934). Available nitrogen in the soil samples was estimated by using alkaline $KMnO_4$ method (Subbiah and Asija, 1956). Soil phosphorus was extracted by Bray's extraction technique (Bray and Kurtz, 1945) and quantified spectrophotometrically at 660 nm. Ammonium acetate extracted potassium was quantified by using flame photometer as outlined by Jackson (1958). Mean values of each nutrient were calculated following standard procedures as described by Gomez and Gomez (1984).

Calculation of nutrient index value

The nutrient index value categorization and calculations were done as proposed by Ramamoorthy and Bajaj (1969).

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

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.

The nutrient index rating chart followed for organic carbon and primary nutrients is mentioned below:

Classes	Values
Low	<1.66
Medium	1.66-2.33
High	>2.33

RESULTS AND DISCUSSION

Status of soil pH and EC

Soil pH

Soil pH is a measure of hydrogen ion concentration indicating soil acidity or alkalinity. The mean low (5.48) and high soil pH (6.99) were observed in the samples collected from Thiruvananthapuram and Palakkad districts, respectively (Table 1). Among the nine districts, 97.22 per cent of the samples collected from Thiruvananthapuram and Alappuzha were acidic in nature. On the contrary, 37.78 per cent samples from Palakkad were neutral in nature. Similarly, the highest percentage of soils showing alkaline reaction (27.78%) was also reported from Palakkad (Table 1). This analytical data further substantiated the fact that majority of

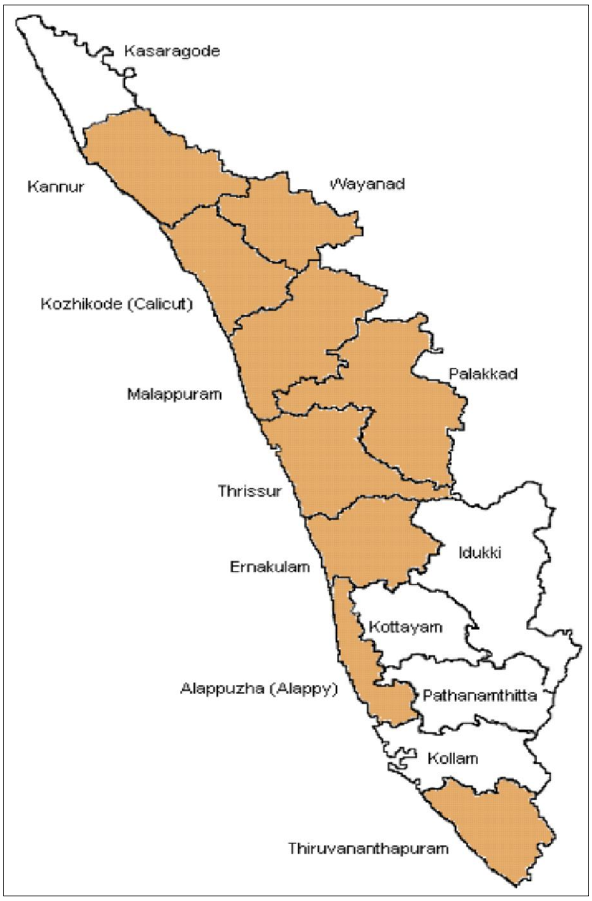

Fig 1: Study area.

Table 1: Descriptive statistics of soil pH of agro ecological zones of Kerala.

Districts	No. of samples	Range	Mean	Per cent sample category		
				Acidic	Neutral	Alkaline
Kannur	96	4.60-7.50	5.74	93.21	5.06	1.73
Wayanad	36	5.27-6.98	6.22	80.56	19.44	0.00
Kozhikode	102	5.14-6.83	6.22	94.29	5.71	0.00
Malappuram	156	4.40-7.20	5.82	90.97	9.03	0.00
Thrissur	246	3.50-7.40	5.64	92.19	7.81	0.00
Palakkad	90	5.58-8.58	6.99	34.44	37.78	27.78
Ernakulam	156	4.29-7.28	5.56	89.27	10.73	0.00
Alappuzha	54	3.91-7.50	5.52	97.22	0.00	2.78
Thiruvananthapuram	60	4.69-6.82	5.48	97.22	2.78	0.00

the soils from Kerala are acidic in reaction (Maji *et al.*, 2012). High rainfall, leaching of bases, mineralization of organic matter, external inputs of acid-forming chemical fertilizers and inappropriate agriculture practices are the major reasons for soil acidification and its intensification (Nair *et al.*, 2019).

Electrical conductivity (EC; dS m^{-1})

The EC is an indirect measure of soluble salts concentration in the soil which plays a major role in determining the salinity of soils. The lesser the EC value, low will be the salinity value of soil and vice versa. The highest mean EC of 0.18 dS m^{-1} was noticed in the soil samples collected from Ernakulam district and was closely followed by soil samples from Wayanad where the EC ranged from 0.02-0.17 dS m^{-1} (Table 2). The lowest mean EC of 0.06 dS m^{-1} was observed in samples from Thrissur district. Soil conductivity is influenced by many factors, high conductivities are usually associated with clay-rich soil and low conductivities are associated with sandy and gravelly soils. Inherent salinity can also be attributed to higher EC of coastal soils as observed in Ernakulam. This is a result of the shape and physical properties of the particles which make up the soil (Ravikumar and Somashekar, 2013).

Table 2: Descriptive statistics of soil EC of agro ecological zones of Kerala.

Districts	No. of samples	Range (dS m^{-1})	Mean (dS m^{-1})
Kannur	96	0.02-0.93	0.14
Wayanad	36	0.02-1.10	0.17
Kozhikode	102	0.01-1.31	0.12
Malappuram	156	0.01-0.28	0.07
Thrissur	246	0.01-0.46	0.06
Palakkad	90	0.03-0.85	0.15
Ernakulam	156	0.002-1.32	0.18
Alappuzha	54	0.02-1.60	0.16
Thiruvananthapuram	60	0.02-0.28	0.10

Organic carbon (OC%)

The mean OC content (0.99%) in the samples from both Malappuram and Wayanad districts was higher than the rest of the districts where it ranged between 0.12 to 2.19 per cent and 0.11 to 1.70 per cent, respectively. The lowest mean OC content of 0.57 per cent was recorded in the soil samples collected from Thiruvananthapuram district (Table 3). Organic carbon content was medium in 79.21% of samples of Kozhikode district, whereas 11.34 per cent samples collected from Malappuram fall under the high category of organic carbon. The study further revealed that 48.89 per cent of the soil samples fall in the low category of organic carbon (Fig 2). Organic carbon content in the soil in turn related to the soil texture. Matus *et al.* (2008) observed that soil organic C tends to be associated with the fine fraction of soils and it can be three times greater in clay-rich soils than in coarser soils. Fine texture soil shows more stable aggregates, which in turn may act as a media of greater amount of organic C (Raiesi, 2006). The low organic carbon content in Palakkad district can be ought to the high temperature and intensive cropping in these areas. Denis *et al.* (2017) opined that low input of FYM and crop residues as well as rapid rate of decomposition due to high temperature, organic matter degradation and removal has taken place at faster rate coupled with low vegetation cover, thereby leaving less chances of accumulation of organic matter in the soil which could further exacerbate the situation.

Available N (kg ha^{-1})

The available N content in the entire study area showed wide variation (Table 3). Among the selected nine districts, the highest mean available N was observed in the samples from Palakkad (625.66 kg ha^{-1}) where it ranged from 194.43 to 2037.40 kg ha^{-1}. The lowest mean available N content (283.59 kg ha^{-1}) was recorded in the samples collected from Alappuzha where the N content ranged between 137.98 to 514.30 kg ha^{-1}. Similar to Alappuzha, soil samples collected from Thiruvananthapuram also showed low mean available N content (285.03 kg ha^{-1}). Nearly 50 per cent of the soil samples from both Thiruvananthapuram and Alappuzha fall under low available N category (Fig 3). On the contrary, 72.22 per cent soil samples from Wayanad and 59.26 per cent samples from Malappuram were in the medium and high available N category, respectively. The variations in precipitation, temperature, vegetation, topography, parent material and other soil properties can be attributed for the observed difference in N content of the soil (Liu *et al.*, 2021).

Table 3: Descriptive statistics of OC and other major nutrients in the soils of agro ecological zones of Kerala.

Districts	No. of samples	OC (%)		Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
Kannur	96	0.23-3.53	0.95	151.12-1090.07	521.38	3.95-311.35	71.50	56.00-924.00	206.28
Wayanad	36	0.11-1.70	0.99	219.77-760.27	449.80	3.60-89.64	27.02	140-980	425.44
Kozhikode	102	0.03-2.22	0.88	119.17-934.53	336.48	6.14-585.79	163.89	28.0-560.0	243.37
Malappuram	156	0.12-2.19	0.99	75.26-1501.37	604.07	0.70-393.53	45.19	33.60-873.60	276.92
Thrissur	246	0.13-1.76	0.69	32.17-2229.70	518.62	1.36-657.42	148.58	26.88-1400.00	292.84
Palakkad	90	0.15-1.31	0.60	194.43-2037.40	625.66	4.48-152.32	44.81	48.16-1034.88	223.72
Ernakulam	156	0.17-1.91	0.90	6.40-1744.81	494.97	5.60-473.20	126.25	50.40-890.40	246.36
Alappuzha	54	0.12-2.73	0.64	137.98-514.30	283.59	1.87-210.80	73.83	39.20-579.60	233.52
Thiruvananthapuram	60	0.20-1.63	0.57	125.44-702.46	285.03	1.88-63.13	14.65	22.40-546.00	105.70

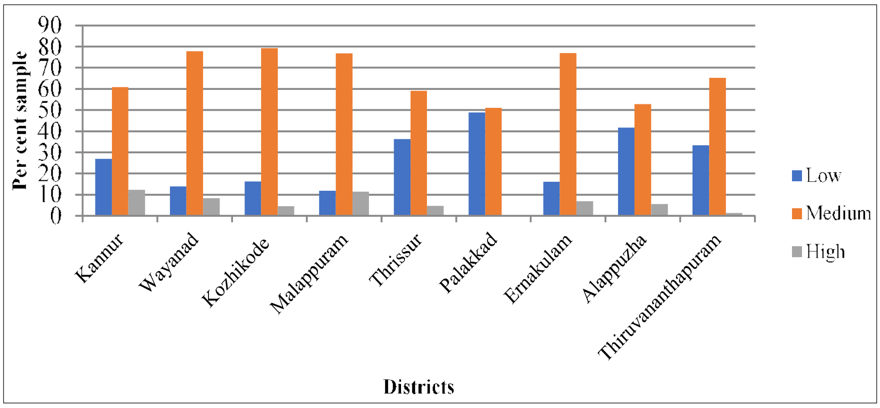

Fig 2: Status of organic carbon in the soils of agro ecological zones of Kerala.

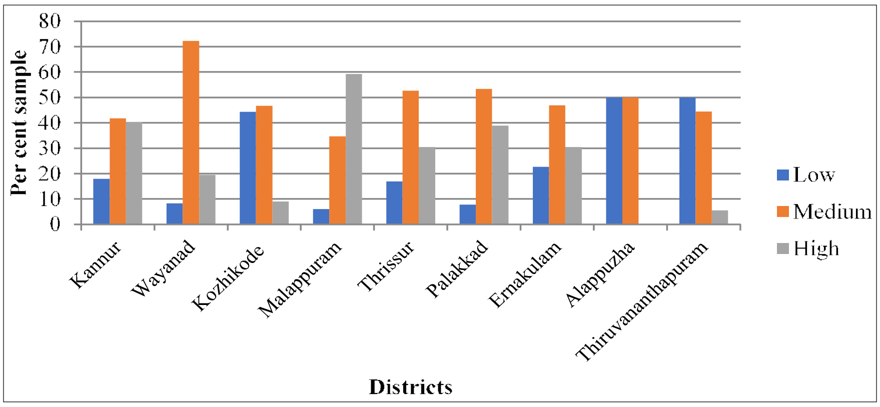

Fig 3: Status of available N in the soils of agro ecological zones of Kerala.

This medium to high value of available nitrogen content may be due to the presence of high amount of organic matter in these soils and the faster mineralization of nitrogen due to the activity of micro-organisms (Santhi *et al*., 2017). Ashok Kumar (2000) opined that such variation in N content may be ascribed to soil management, application of FYM and fertilizer to previous crop. The results of the present investigation are in line with the findings of Denis *et al.* (2017) who observed that the nitrogen content in soils is dependent on temperature, rainfall and altitude. Besides, continuous and intensive cultivation leading to high crop removal together with insufficient replenishment might be the reason for the high degree of nitrogen deficiency in soils.

Available P (kg ha^{-1})

Soil samples collected from Kozhikode and Thiruvananthapuram were noticed with highest (163.89 kg ha^{-1}) and lowest (14.65 kg ha^{-1}) mean available P, respectively (Table 3). Nearly 98 per cent of the samples from Kozhikode district fall under high category of available P (Fig 4). Conversely, nearly 46 per cent of the soil samples collected from Thiruvananthapuram was in the low available P category. In general, the entire study area except Thiruvananthapuram had their major share in high category with regards to available P (Fig 4).

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 (Denis *et al*., 2017). Soils showing low to medium status in available P can be supplemented by adequate phosphorus nutrition as required by the crops. The low P content in the samples from Thiruvananthapuram can be ascribed to its highly acidic nature of the samples where the P may get fixed with Fe and Al/Mn.

Available K (kg ha^{-1})

Among the nine districts, the highest (425.44 kg ha^{-1}) and lowest (105.70 kg ha^{-1}) mean available K content was observed in the samples from Wayanad and Thiruvananthapuram districts, respectively (Table 3). The available K content in Wayanad and Thiruvananthapuram ranged from 140 to 980 kg ha^{-1} and 22.40 to 546 kg ha^{-1}. Nearly 69 per cent of the samples from Wayanad fall under high category of available K and was fairly large compared to other districts (Fig 5). The highest percentage of soil samples (62.5%) collected from Thiruvananthapuram fall under low category with respect to available K content. Overall, the major proportion of the samples from the entire study area was in the medium category of available K. The content of K in soil depends up on the soil properties, mineralogical composition, leaching, external K fertilization and crop removal. The observed low K content can be attributed to low use of potassium fertilizers as suggested by Denis *et al*. (2017).

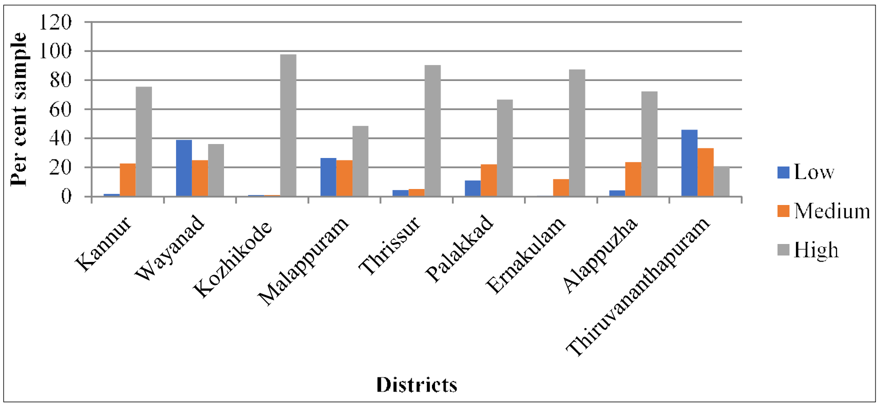

Fig 4: Status of available P in the soils of agro ecological zones of Kerala.

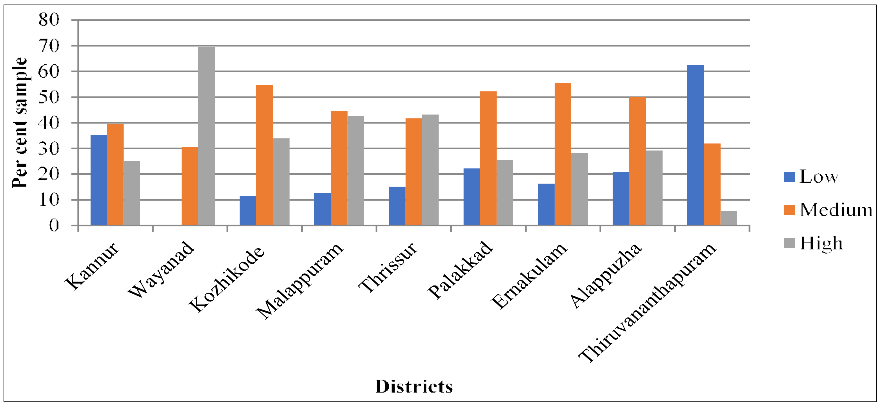

Fig 5: Status of available K in the soils of agro ecological zones of Kerala.

Table 4: Nutrient index values and soil fertility rating of the soils of agro ecological zones of Kerala.

Districts	OC		N		P		K	
	NIV	Fertility rating	NIV	Fertility rating	NIV	Fertility rating	NIV	Fertility rating
Kannur	2.42	High	2.25	Medium	2.71	High	1.90	Medium
Wayanad	2.78	High	2.11	Medium	1.97	Medium	2.69	High
Kozhikode	1.53	Medium	1.32	Low	2.40	High	1.79	Medium
Malappuram	2.05	Medium	2.02	Medium	2.22	Medium	2.30	Medium
Thrissur	1.64	Medium	2.27	Medium	2.86	High	2.42	High
Palakkad	1.51	Medium	2.31	Medium	2.56	High	2.03	Medium
Ernakulam	1.91	Medium	2.08	Medium	2.87	High	2.14	Medium
Alappuzha	1.64	Medium	1.46	Medium	2.65	High	2.13	Medium
Thiruvananthapuram	1.68	Medium	1.56	Medium	1.75	Medium	1.48	Medium

Soil nutrient indices

Nutrient index value (NIV) is the measure of nutrient supplying capacity of soil to plants. The soil nutrient index of the study area (Table 4) was calculated from low, medium and high ratings of soil nutrients. Based on the index values depicted above, the ratings were made. Nutrient index value for OC was in the medium range for the study area except for Kannur and Wayanad districts. Except Kozhikode district, all other districts were medium with respect to available N status. The majority of samples were high with regard to available P content except those from Wayanad, Malappuram and Thiruvananthapuram districts. Apart from the samples of Wayanad and Thrissur, all others were in the medium range of available K. Compared to the results obtained for soil fertility categories by Verma *et al.* (2005), there is no wide variation in soil fertility status across the agro ecological zones of Kerala. Ravikumar and Somasekhar (2013) also opined no wider variations in soil fertility status in the Varahi River basin.

CONCLUSION

The study has revealed that the pH of soils was in the acidic range, whereas the EC was normal. Based on the nutrient index values, soil organic carbon, available N and K were in the medium range for majority of the samples. However, the available P content was high for most of the soil samples. The situation therefore demands the adoption of appropriate management practices in order to boost the fertility status. These practices may include site specific nutrient management, liming, increased use of organic nutrient sources and sustainable land use and cropping systems.

ACKNOWLEDGEMENT

We would like to acknowledge Division of INM, Department of Agriculture and Cooperation, Ministry of Agriculture for rendering the financial support and AICRP on STCR and Department of Soil Science and Agricultural Chemistry, Kerala Agricultural University, Thrissur for the technical assistance.

Conflict of interest: None.

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