Chapter 3

SOIL FERTILITY STATUS IN VARIOUS AGRO ECOSYSTEMS OF THRISSUR DISTRICT

3.1. Introduction

Evaluation of fertility status of the soils of an area or a region is an important aspect in the context of sustainable agriculture (Singh and Misra, 2012), and essential for proper management of soil and improving crop productivity. Soil fertility is a dynamic natural property and it can change under the influence of natural and human induced factors. As human population continue to increase, human disturbance on the earth's ecosystem to produce more food and fibre will place greater demand on soils to supply essential nutrients. Continuous cropping for increased yield remove substantial amounts of nutrients from the soil. The nutrient export through crop removal are to be replaced to sustain soil health and increased crop productivity. Soil fertility fluctuates throughout the growing season each year due to the alteration in the quantity and availability of mineral nutrients through artificial inputs and also by leaching. Soil testing facilitates in assessing the current fertility status and providing information on nutrient availability in soils, which forms the basis for fertilizer recommendations towards maximizing crop yields and maintaining optimum fertility in soil year after year.

The site specific nutrient management practices reduce the cost of cultivation and minimize environmental pollution triggered by the imbalanced application of chemical fertilizers. Farmers must be kept informed on the management techniques necessary to optimize the productivity of soil for specific crops. In this context, soil fertility evaluation of various agro ecosystems assumes great importance for exploring crop specific and site specific management options (Khan *et al*., 2017). Hence, this study mainly focused on the soil fertility evaluation of various agro ecosystems of Thrissur district in Kerala for assessing the deficiency and sufficiency of soil nutrients.

3.2. Materials and methods

3.2.1. Study area

This study was conducted in Thrissur district, which is situated in the central part of Kerala (Fig.1) and came into existence in 1949. Lying between north latitudes 10° 31’ and 10° 52’ and east longitudes 76° 13’ and 76° 21’, the district covers an area of 3032 km^2. There are 17 block panchayats, 92 grama panchayats and six municipalities in the district. The major agro ecosystems in the study area are rubber, paddy, mono and poly cultures of coconut, banana, nutmeg, vegetables, pepper, arecanut etc. Thrissur district is spread over in six agro-ecological units *viz*; northern coastal plain, northern central laterite, kole lands, pokkali lands, northern high hills and southern high hills. The Periyar, Chalakkudy, Karuvannur and Bharathapuzha are the major rivers in the district. The district experiences a humid tropical climate with a very hot summer season and heavy monsoon. The annual average rainfall is 2189.5 mm and the annual average temperature is 27.68 ^{0}C**.**

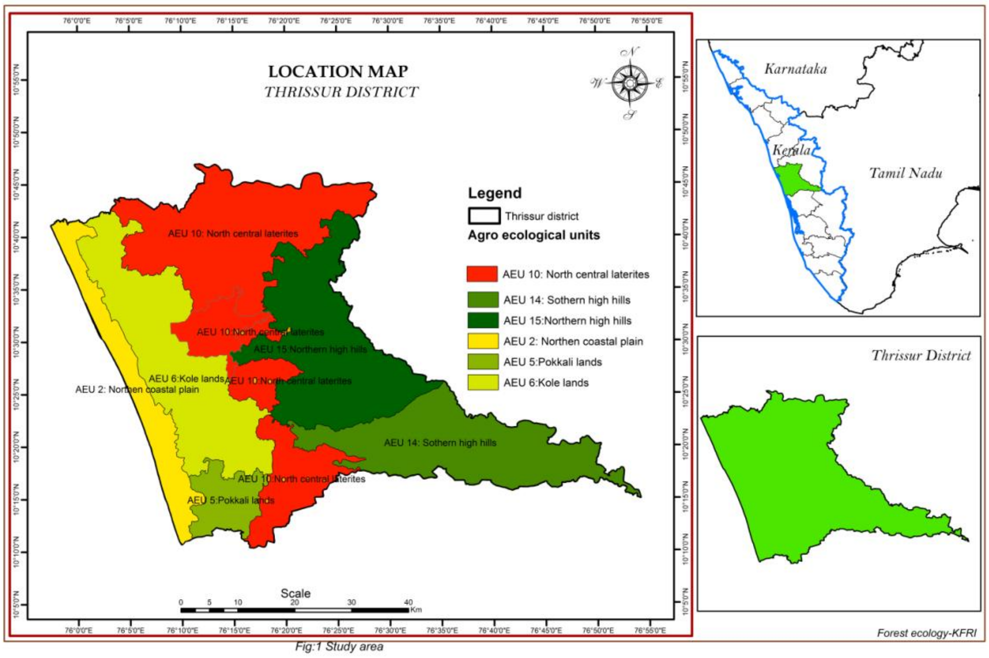

Fig.1. Location map of the study area

Major types of soils found in the region are laterite, brown hydromorphic, hydromorphic saline, coastal alluvium, riverine alluvium and forest loamy soil. Sandy loam soil is commonly seen in Mukundapuram, Thrissur and Chavakkad taluks. Lateretic soils are spread over eastern part of Thrissur and western part of Thalapilly taluks. Extensive areas of clayey soils are found in Mukundapuram taluk and portions of Chavakkad taluk. Hydromorphic saline soils are seen in the coastal tracts of Thrissur.

3.2.2. Soil Sampling

A total of 5120 surface soil samples (0-15 cm) were collected randomly from various agro ecosystems of the study area, depending on the size of the land under cultivation @ one sample ha^{-1} of each agro ecosystem belonging to six agro ecological units in the district. The details of soil samples collected are given in Table 1.

Table 1. Details of soil samples collected from the study area

Agro ecosystems	**Agro ecological units**						Total no. of samples
	Northern Coastal plain	Northern central laterite	Kole lands	Pokkali lands	Northern high hills	Southern high hills	
Paddy	Nil	715	Nil	11	50	Nil	776
Rubber	Nil	93	Nil	5	110	52	260
Coconut	200	400	100	110	125	65	1000
Nutmeg	89	117	37	56	125	76	500
Arecanut	471	345	129	126	157	92	1320
Pepper	18	44	25	4	14	24	129
Vegetables	22	60	16	10	15	12	135
Banana	183	287	111	102	215	102	1000
Total no. of samples	983	2061	418	424	811	423	**5120**

3.2.3. Laboratory Analysis

Collected soil samples were air dried, powdered and passed through 2 mm sieve and kept ready for various analyses as detailed below.

3.2.3.1. Chemical Properties

pH

The pH of the soil: water suspension (1:2.5) was determined using digital type Cyber scan 510 pH meter (Jackson, 1958).

Electrical conductivity

The EC of the soil: water suspension (1:2.5) was measured using conductivity meter (Jackson, 1958).

Organic Carbon

The OC content was estimated by sulphuric acid and potassium dichromate wet digestion method (Walkley and Black, 1934) as described by Jackson (1958).

Available N

Available N was determined using alkaline permanganate distillation method as described by Subbaiah and Asija (1956).

Available P

Available P was extracted by Bray No. 1 extractant (0.03 *N* NH_4F + 0.025 *N* HCl soil solution ratio 1:10; (period of extraction 5 minutes) and the P content was determined colorimetrically by ascorbic acid reduced molybdophophoric blue colour method in hydrochloric acid systems (Wantanabe and Olsen, 1965) by using UV spectrophotometer.

Exchangeable K, Ca and Mg

Exchangeable K, Ca and Mg were estimated from neutral ammonium acetate extract of the soil. Five gram of soil was extracted with neutral normal ammonium acetate (1:15) for 10 minutes, filtered and the filtrate was used to determine K using digital type Elico

(CL - 360) flame photometer (Jackson, 1958). The same filtrate was used to estimate Ca and Mg using atomic absorption spectrophotometer (Varian model. 240).

Available S

S is extracted by 0.15% $CaCl_2$ solution with soil : solution ratio of 1 : 5 and shaking for 30 minutes. The filtered extract is measured for the content of S by turbidimetric procedure. The available S content was estimated from 0.15% $CaCl_2$ extract of the soil and determined by turbidimetric method (Chesin and Yien, 1951).

Micronutrients

Available Fe, Mn, Zn and Cu were determined using 0.1 N HCl as the extractant for acid soils and DTPA for neutral and alkaline soils (soils with pH 6.5 and above).The elements in solution are estimated by atomic absorption spectrophotometry (Varian 240) (Lindsay and Norvell, 1978). Content of B was extracted by hot water and estimated using UV spectrophotometer (Gupta, 1967).

3.2.3.2. Parker's nutrient index

In order to compare the levels of soil fertility of one area with those of another, it is necessary to obtain a single value for each nutrient. The percentage of samples in each of the three classes; low, medium and high were multiplied by 1, 2 and 3 respectively. The sum of the figure thus obtained was divided by 100 to give the index or weighted average (Parker *et al*., 1951).

3.2.3.2.1. *Three tier system:*

NIV = No. of samples (low) x 1 + No. of samples (medium) x 2 + No. of samples (high) x 3) / Total No. of samples

Major nutrients - if the index < 1.67 - low fertility, 1.67 to 2.33 - medium fertility, > 2.33 - high fertility (Ramamurthy and Bajaj, 1969)

Micronutrients - < 1.33 – very low, 1.34 to 1.66 – low, 1.67 to 2.00 – medium, 2.01 to 2.33 – Adequate, 2.34 to 2.66 – high, > 2.66 – very high

3.3. Results and discussion

The present study was undertaken to assess the soil fertility status under various cropping systems of six agro ecological units in Thrissur district. The study mainly focused on various basic soil properties, primary nutrients, secondary nutrients and micronutrients. The results obtained in the study are presented and discussed here under.

3.3.1. Basic soil properties

3.3.1.1. Soil reaction (pH)

Nature of soil reaction, assessed by soil pH showed wide variation among different agro ecosystems. The data presented in Table 2 revealed that the soils of various agro eco systems in general were extremely acidic to slightly alkaline, with pH values varying from 2.9 – 8.4. All the crops were grown even in soils with extremely and very strongly acidic condition. But at the same time, all the cropping systems were also observed in neutral to slightly alkaline soils also.

Table 2. Basic soil properties of various agro ecosystems in Thrissur district

Agro ecosystem	pH	EC(dS m^{-1})	OC (%)
Arecanut	**2.9-7.7**	0.01-4.8	0.3 – 7.6
Banana	3.9-7.1	0.01 -4.8	0.1 - 5.7
Coconut	3.3-7.4	0.01-5.8	0.04 - 4.3
Nutmeg	3.7-7.7	0.01-5.6	0.04 - 4.6
Paddy	3.6 - 8.4	0.01 - 2.6	0.04 - 4.1
Rubber	3.1-7.5	0.01-1.5	0.2 - 4.3
Vegetables	3.7-7.4	0.01- 4.5	0.1- 4.5
Pepper	4.5-7.1	0.02 - 0.5	0.1- 3.6

On considering the various agro ecosystems confined to different agro ecological units separately (Table 3), a great deviation from the general status was observed for all the crops in all the six agro ecological units. The extremely acid and slightly alkaline conditions were observed only in those crops grown in kole lands, pokkali lands and also northern high hills. Coconut, arecanut and banana in kole lands; coconut, arecanut, banana, paddy, nutmeg and rubber in pokkali lands; and coconut, paddy, banana and nutmeg in northern high hills were found cultivated in soils with extreme acidic condition. All the crops in kole lands; coconut and areacanut in pokkali lands; and coconut, arecanut, banana and nutmeg in northern high hills were found cultivated in neutral to slightly alkaline soils. The optimum soil pH in which all the nutrients are moderately available to plants ranged from 5.6 to 6.5 (slightly to moderately acidic). In the present study, 60 % of the samples accounted for optimum pH in arecanut, 10% in paddy, 50 % in coconut, 35 % in vegetables and 50 % in rubber. Similarly extreme to strong acidic conditions were observed in 88% samples in paddy, 30 % in arecanut, 45 % in banana, 40 % in coconut, 23 % in pepper, 60 % in rubber, 45 % in nutmeg and 55 % in vegetables. Slightly neutral soils were observed in 55 % of samples in banana, 60 % in coconut, 12 % in paddy, 87 % in pepper, 40 % in rubber, 65 % in nutmeg and 55 % in vegetables (Fig. 2).

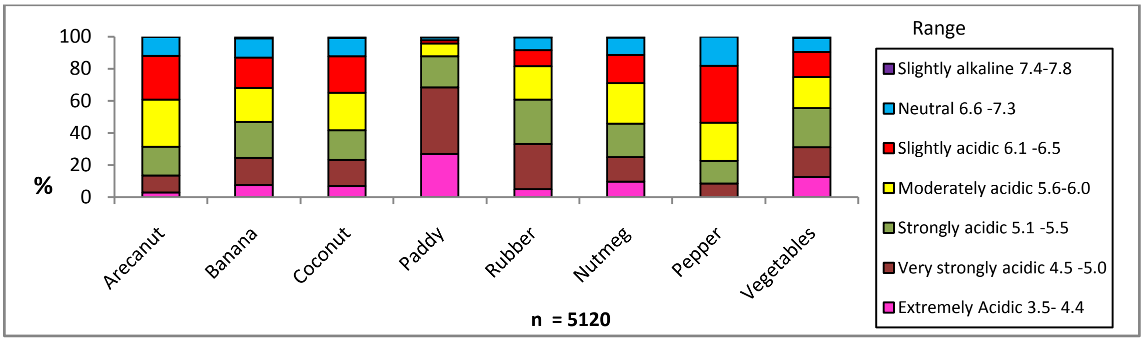

Fig.2. Frequency of soil reaction (pH) classes

Extremely acid soils of the district were concentrated mainly in the special AEUs of the district like pokkali and to some extent in kole lands also. Both pokkali and kole lands contain sulphur bearing minerals. So the extreme acidic condition of the crops grown in pokkali and kole lands are due to the inherent acidic nature of these areas attributed to the high content of Al and S. The continuous application of improved agricultural practices like liming, organic manures, base forming fertilizers, import of ideal soils from outside area etc. might have improved the pH of the soil even to the extent of slightly alkaline condition. But the adoption of improved agricultural practices vary with farmer and also with cropping systems, and hence wide variation in pH is prevalent in the area.

Table 3. Basic soil properties of various agro ecosystems in agro ecological units

Agro ecological units	Agro ecosystems	pH	EC(dSm^{-1})	OC (%)
Northern coastal plain	Coconut	5.4-6.0	0.04-0.2	0.3-1.9
	Arecanut	4.9-6.2	0.05-0.18	0.2-2.0
	Paddy	4.1-5.4	0.10-1.5	1.5-2.7
	Vegetables	5.9-6.2	0.04-0.1	0.8-1.0
	Pepper	5.4-6.1	0.003-0.1	1.1-1.8
	Banana	5.8-6.2	0.05-0.1	0.2-0.9
	Nutmeg	5.2-6.0	0.001-0.3	0.9-1.9
Northern central laterite	Coconut	4.9-6.5	0.1-1.6	0.5-2.0
	Arecanut	4.9-6.5	0.1-1.4	0.5-2.0
	Paddy	4.7-6.1	0.1-0.3	0.8-2.1
	Vegetables	4.5-6.1	0.05-0.2	0.5-1.8
	Pepper	5.3-6.0	0.02-0.4	0.2-1.4
	Banana	4.9-6.7	0.1-1.3	0.5-5.7
	Nutmeg	5.0-6.3	0.1-0.3	0.2-1.7
	Rubber	4.7-6.8	0.1-0.3	0.5-2.6
Kole lands	Coconut	3.3-7.7	0.01-3.5	0.04-7.7
	Arecanut	3.5-7.6	0.03-1.6	0.1-7.7
	Vegetables	4.9-7.6	0.04-0.6	0.08-3.1
	Pepper	4.8-7.1	0.03-0.4	0.04-2.9
	Banana	3.6-7.6	0.03-2.6	0.08-3.2
	Nutmeg	4.4-7.4	0.01-0.4	0.1-7.7
Pokkali lands	Coconut	2.9-7.2	0.01-6.2	0.04-9.5
	Arecanut	2.9-7.2	0.01-0.9	0.1-4.5
	Paddy	3.6-5.6	0.03-2.6	2.3-3.8
	Vegetables	4.1-5.2	0.02-0.06	0.2-3.0
	Pepper	4.3-5.4	0.03-0.1	0.3-1.8
	Banana	2.9-6.8	0.01-6.2	0.08-4.4
	Nutmeg	3.6-6.6	0.02-5.8	0.04-4.3
	Rubber	2.9-4.8	0.02-0.9	0.5-2.9

Southern high hills	Coconut	4.41-6.7	0.02-1.4	0.8-3.8
	Arecanut	4.8-6.4	0.04-0.2	0.8-2.9
	Vegetables	4.7-6.3	0.03-0.1	1.4-3.0
	Pepper	4.9-6.9	0.06-0.5	0.3-3.7
	Banana	4.5-7.0	0.02-0.2	0.8-3.8
	Nutmeg	4.8-6.7	0.02-0.3	0.8-3.8
	Rubber	4.4-6.8	0.02-1.5	0.8-3.9
Northern high hills	Coconut	3.7-7.5	0.01-0.6	0.04-7.6
	Arecanut	4.1-7.4	0.02-0.3	0.2-7.6
	Paddy	3.8-6.3	0.02-0.2	0.6-4.0
	Vegetables	5.3-6.4	0.06-0.1	0.5-2.2
	Pepper	5.8-5.9	0.04-0.09	1.0-2.0
	Banana	3.7-7.5	0.01-0.6	0.04-4.4
	Nutmeg	3.7-7.4	0.01-0.6	0.1-7.6
	Rubber	4.1-6.8	0.01-0.3	0.4-4.3

The results of the study clearly demonstrate the adverse condition of soil acidity triggering poor crop productivity in this region. Cultivation of coconut based agro ecosystem on extreme acid soils of Onattukara region in Kerala was also reported by Mini *et al.* (2015). The soil reaction in the other agro ecological units viz; northern coastal plain, northern central laterite and northern high hills varied between very strongly acidic to slightly alkaline. No appreciable variation in soil reaction was observed, when each cropping system was considered separately in the above agro ecological units. Thus, the results in general pointed out the fact that the wide variation in soil acidity among different agro ecosystems of Thrissur district is due to inherent nature of soils coupled with the practice of continuous application of external soil amendments.

3.3.1.2. Electrical conductivity (EC)

EC is the measure of the current carrying capacity of soil and it gives a clear idea of the content of soluble salts. Soil salinity, assessed by the values of EC revealed wide variation among different agro ecosystems. The data presented in Table 2 revealed that the soils of various cropping systems in the district in general varied from non saline to highly saline with EC values varying from 0.01 – 5.8 dSm^{-1}. Arecanut, coconut, nutmeg and vegetables were found grown even in high saline conditions except paddy, pepper and rubber, which were grown in medium saline conditions. All the above cropping systems were found grown in non saline soils (< 1 dSm^{-1}) also.

As observed in the case of pH, a great variation in salinity from the general status was prevalent in all the crops, when each agro ecological unit was considered separately. The high saline (> 3 dSm^{-1}) conditions were observed only in crops grown in kole and pokkali lands (Table 3). Among the crops, coconut, nutmeg and banana in pokkali lands; and coconut in kole lands were found cultivated in high saline soils. Arecanut and banana in kole lands; paddy in pokkali lands were found cultivated in medium saline conditions (1 – 3 dSm^{-1}).

The high saline soils of Thrissur district were prominent in the special agro ecological units *viz*; kole and pokkali lands. So the extreme conditions of the crops grown in the kole and pokkali lands are due to the inherent saline nature attributed to the close proximity to the sea and resulting intrusion of sea water.

In the present study, above 90 % of the samples accounted for low EC in all the cropping systems in the study area (Fig.3). Excessive amount of dissolved salts in soil solutions causes hindrance in normal nutrient uptake process by imbalance of ions uptake, antagonistic effect between nutrients or excessive osmotic potentials of soil solution (Rehman *et al.*, 2000). This evidently demonstrate poor growth and crop productivity observed in kole and pokkali lands wherein intensive management of soils were not followed.

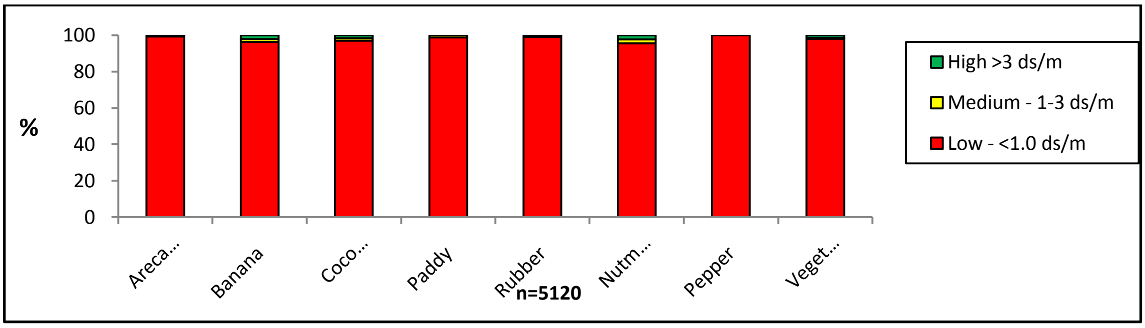

Fig.3. Frequency of classes of EC

3.3.1.3. *Organic carbon (OC)*

The status of OC in the study area varied widely from low to high, the values ranging from 0.04 – 7.6 % (Table 2). The same low to high status of OC were also observed in most of the cropping systems in each agro ecological unit. Relatively very high content of OC were observed in coconut, arecanut and nutmeg grown in kole land and southern high hills. The high content of OC in kole lands is caused by the high deposits of the silt materials, which are washed down by the rivers from mountain as well as the sub surface accumulation of peat in this area. High levels of OC in pokkali had already been reported by Mohan and Sreelatha (2016). Extra ordinary values of OC in the southern high hills might be the contributions from burnt organic residues.

Grouping of soils into different categories of OC revealed that 58% of the samples were high in rubber, 50 % in vegetables, 43 % in nutmeg and 40 % in banana. Deficiency level of OC was more prominent in 29 % of samples in coconut, 26 % in arecanut and 23 % in vegetables (Fig.4). The wide variation of OC in the soils of various agro ecosystem in each AEU is definitely due to the difference in the quantity of organic amendments incorporated into the soil over the years.

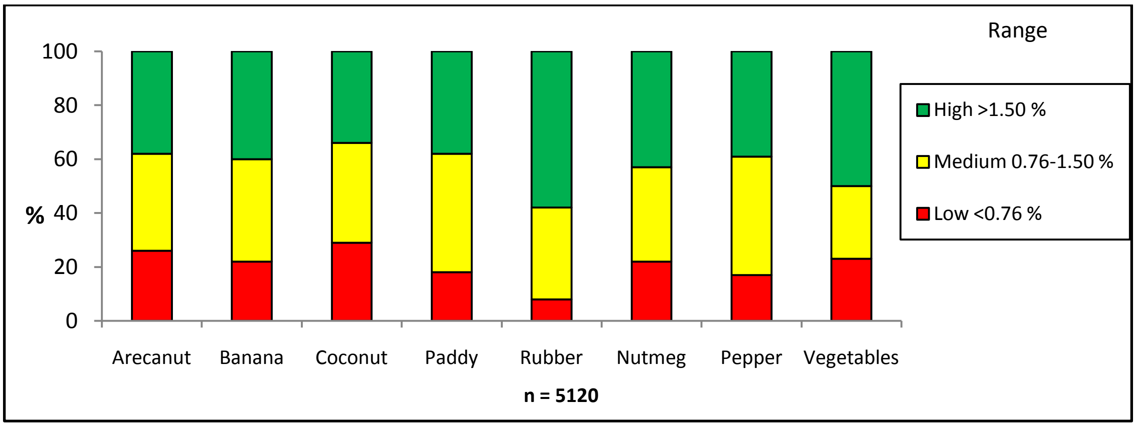

Fig.4. Frequency classes of OC

The farmers, who have low OC in their soils were encouraged to use organic manures such as green manure, farmyard manure and compost so that optimum crop productivity is maintained for a longer period.

3.3.2. Primary nutrients

3.3.2.1. *Nitrogen*

A wide variation in the content of N was observed in different agro ecosystems of the study area. Status of N in the soils of various agro ecosystem was low to high with the values ranging between 22 – 2845 kg ha^{-1} (Table 4). The extreme levels of N (low and high) were observed in all the cropping systems in the district.

On examining the soil N status of various agro ecosystems in each agro ecological units independently, it was noted that (Table 5) very low levels of N < 60 kg ha^{-1} were predominant in kole lands and in some pockets in pokkali lands. Usually, biological transformations of N is very much restricted in strongly acidic conditions and flooded conditions and this substantiates the low levels of N observed in kole and pokkali lands. Extra ordinary accumulation of N >1000 kg ha^{-1} was noted as a general phenomenon in all the agro ecological units except northern coastal plain and northern laterite. Higher accumulation of N noted in kole lands could be attributed due to the run off from upper reaches, in addition to external inputs through chemical fertilizers and organic manures.

Table 4. Content of N, P and K in the soils of various agro ecosystems in Thrissur District

Agro ecosystem	N (kg ha^{-1}))	P (kg ha^{-1}))	K (kg ha^{-1})
Arecanut	112 - 2845	1.7-316	4.7 - 2280
Banana	45 - 2128	1 - 713	28 -1276
Coconut	22 - 1613	0.2 - 777	4 - 1790
Nutmeg	22 - 1725	3.1- 562	16 - 1926
Paddy	22 - 1523	1 - 501	1 - 1474
Rubber	67 - 1612	0.3 - 803	14 - 1941
Vegetables	45 - 1680	1.1-757	28 - 1294
Pepper	45 - 1344	1.2 - 848	20 - 1217

Table 5. Agro ecological zone wise distribution of soil nutrients in various agro ecosystems of Thrissur District

Agro ecological zone	Agro ecosystems	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Northern coastal plain	Coconut	112 - 672	100 - 390	56-557
	Arecanut	67 - 672	74 - 390	41-416
	Paddy	672 - 1120	39 - 164	128-453
	Vegetables	224 - 448	202 - 580	53-79
	Pepper	448 - 672	372 - 531	84-86
	Banana	67 - 3360	60 - 631	41-80
	Nutmeg	224 - 672	269 - 631	80-828
Northern central laterite	Coconut	201 - 672	23 - 394	103-885
	Arecanut	201 - 672	82 - 348	112-985
	Paddy	224 - 619	41 - 164	128-398
	Vegetables	179 - 593	4 - 226	136-331
	Pepper	67.2 - 448	20 - 150	100-345
	Banana	201 - 2240	2 - 423	91-883
	Nutmeg	89 - 672	54 - 234	115-541
	Rubber	179 - 896	38 - 173	56-393
Kole lands	Coconut	22 - 2240	1 - 570	31-2914
	Arecanut	46 - 2240	11 - 758	62-2586
	Vegetables	56 - 1120	11 - 479	58-1671
	Pepper	53 - 1097	24 - 405	64 -1217
	Banana	22 - 1120	1 - 570	31 -2033
	Nutmeg	44 - 2240	11 - 491	53-1926
Pokkali lands	Coconut	48 - 4480	2 - 657	17-1013
	Arecanut	44 - 1792	2 - 657	17 - 812
	Paddy	896 - 1344	7 - 278	376 - 583
	Vegetables	67.2 - 2240	4 - 128	80-338
	Pepper	112 - 672	24 - 320	41 - 158
	Banana	82 - 1568	2 - 587	17 - 606
	Nutmeg	52 - 1568	3 -496	41 - 812
	Rubber	224 - 1120	6.6-39.8	17-575

Southern high hills	Coconut	225 - 2240	0.2-777	92-2364
	Arecanut	218 - 1120	1.7-194	139 - 693
	Vegetables	448 - 1120	1.1 - 622.7	105 - 456
	Pepper	220 - 2240	1.2 -345	145 -523
	Banana	224 - 2210	1 - 407	90 - 1478
	Nutmeg	213 - 2240	1 - 562	82 - 840
	Rubber	224 - 2240	0.3-803	91 - 1941
Northern high hills	Coconut	82 - 2240	0.6 -748.5	4.3-1494.1
	Arecanut	89 - 2160	2 - 608	5 - 1494
	Paddy	224 - 2240	1.2-258	1.5 - 458
	Vegetables	179 - 896	1.3-111.3	193 - 433
	Pepper	448 - 672	53 - 362	147 - 344
	Banana	22 - 2240	1 - 698	4 - 1275
	Nutmeg	44 - 2240	0.6 - 748.5	41 - 1276
	Rubber	134 - 2240	3 - 532	41- 886

The wide variation of N in the study area may be due to the external input of N through green leaves, farmyard manures and chemical fertilizers, the mineralization of which are also dependent on temperature, rainfall and altitude (Denis *et al*., 2016). Northern coastal plains in general are sandy in texture and the practice of applying N containing fertilizers and manures are not common in this region. Hence relatively less accumulation of N was observed in this locality.

It was also inferred from the data that high levels of N were observed in 58 % of the samples in rubber, 50 % in vegetables, 43 % nutmeg, 40 % in banana. Low levels of N were in 29 % of the samples in coconut, 26 % in arecanut, 22 % in banana, 22 % in nutmeg, 23 % in vegetables, 17 % in pepper and 8 % in rubber (Fig. 5).

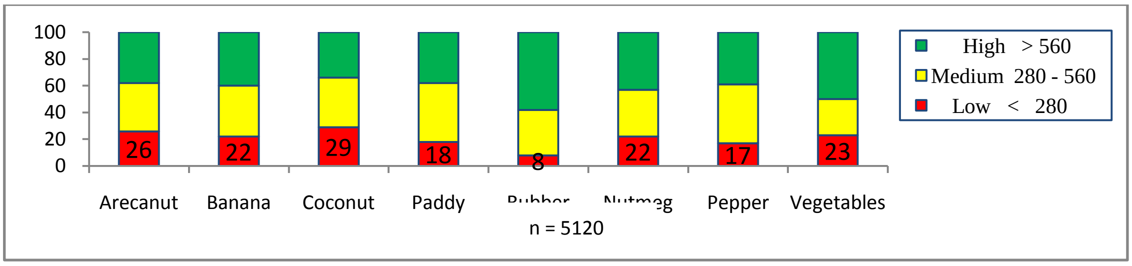

Fig.5. Frequency of N classes

3.3.2.2. Phosphorus

As in the case of N, a wide variation in P ranging from 0.2 – 848 kg ha^{-1} was also observed in all the cropping systems in Thrissur district (Table 4). Among the agro ecological units, all the cropping systems in northern coastal plain and most of the cropping systems in northern central laterite except banana and vegetables were with very high levels of P. In all other agro ecological units, extremely low levels of P were observed in almost all the ecosystems. In the study area, 94.2 % of soil samples accounted for high status of P in arecanut, 93.3 % in pepper, 85% coconut, 85.2 % in banana. Deficient level of P was noted in 83.7 % of samples in vegetables and 20.7 % in nutmeg and 19.2 % in paddy (Fig.6).

Continuous and indiscriminate application of P containing fertilizers and manures might be the reason for higher levels of P recorded in the study. Higher levels of P in Onattukara based sandy soils and some of the cropping systems in Thrissur (Dt.) of Kerala have already been reported by Mini *et al*. (2015) and Bastin *et al*. (2014).

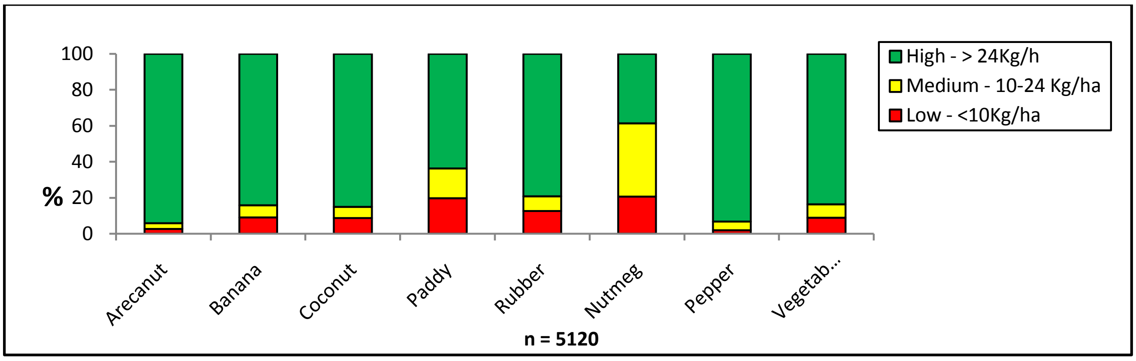

Fig.6. Frequency classes of P

The soils of Kerala in general are lateritic in nature and reported to be with low levels of P due to its fixation as aluminum and iron phosphates. So in cropping systems, where no P containing fertilizers were added, remained in extremely low status of P.

Significant amount of soluble P exist in the run-off water from these sites and can significantly impact water quality in nearby streams and lakes (Dinesh *et al*., 2014).

3.3.2.3. Potassium

The status of K in various agro ecosystems in the study area was low to high, the values ranging from 1.0 – 2280 kg ha^{-1} (Table 5). On considering various ecosystems separately, extreme values of K towards lower and higher sides were observed in all the cropping systems of kole lands. As in the case of N and P, the data in general indicated that inherent nature of soils coupled with variations in the management practices could be the reason for wide variation of K observed in kole lands.

In the study area, 47.3 % of soil samples accounted for high status of K in rubber, 40 % in banana and 34.3 % in nutmeg. The deficiency level was 50.5 % in paddy, 42.9 % in coconut, 58.7 % in arecanut, 29.9 % in pepper, 30.3 % in vegetables, 23.5 % in banana, 33 % in nutmeg and 9.2 % in rubber (Fig.7).

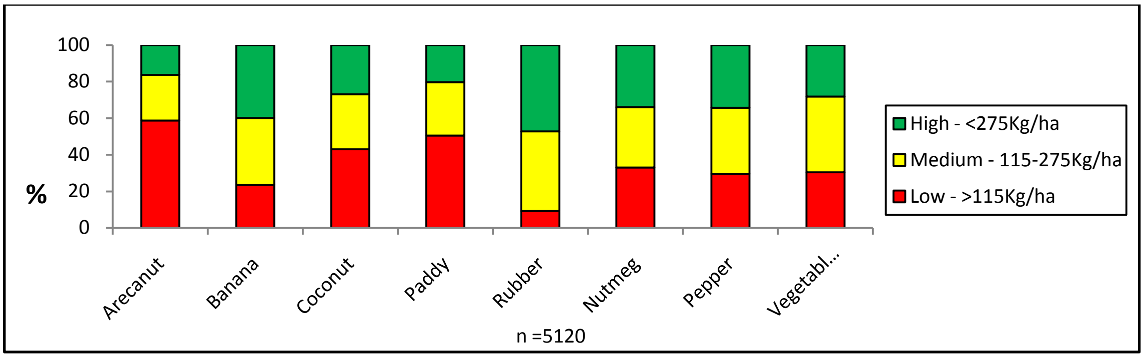

Fig.7. Frequency classes of K

Intensive leaching of K by irrigation or heavy rain, high removal by the crops than addition by farmers, and imbalanced use of fertilizers are thought to be the major reasons for the low status of K in the other agro ecological units. The deficiency was more severe in areas where intensive cropping systems were being followed (Naidu *et al.*, 2011).

3.3.3. Secondary nutrients

3.3.3.1. Calcium

A great deviation from the general status was observed in all the crops, on taking into account each agro ecological units separately (Table 7). Very low content of Ca was mainly concentrated in all the cropping systems in pokkali lands except paddy; all the agro ecosystems in southern high hills except arecanut and pepper; and all the crops in northern high hills except vegetables and pepper. Adequate level of Ca was prominent in all the cropping systems in northern coastal plain except banana; all the cropping systems in northern central laterite; and in kole lands except banana and coconut. The study also revealed that 82.2 % of the samples accounted for adequate levels of Ca in arecanut, 81.9 % in pepper, 76.5 % in nutmeg, 74 % in banana, 73.8 % in rubber, 70 % in coconut, 69.6 % in vegetables and 59% in paddy (Fig.8).

Table 6. Content of Ca, Mg and S in the soils of various agro ecosystems in Thrissur District

Agro ecosystem	Ca (mg kg^{-1})	Mg (mg kg^{-1})	S (mg kg^{-1})
Arecanut	55 - 3515	3 - 711	0.06 - 138
Banana	37.7 - 1631	11.7 - 323.7	0.03 - 322
Coconut	20.6 - 1888.5	9.8 - 518.4	0.1-336
Nutmeg	101.3 - 1409.5	3 -206.5	0.2 - 526
Paddy	45.2 - 1930	7.2 - 315.7	0.09 - 400
Rubber	21.4 - 2230	5.9 - 524	0.1-150
Vegetables	35.2 - 1390.4	14.7 - 247.8	0.2 - 143
Pepper	94.2 - 1730	7.1- 431	0.06 - 134

The adequate levels of Ca content in the study area is attributed mainly to the continuous application of improved agricultural practices like liming and also the contribution from applied organic manures. Results in general revealed that deficiency of Ca was not that much deficient in most of the cropping systems except paddy. But deficiency of Ca in coconut based cropping system of Onattukara was reported by Mini *et al*. (2015). The soils in the study area were acidic in reaction though sufficient calcium were present in the soil. It is because, in Kerala acidity is mainly contributed by the aluminum ions present in the soil, and the calcium ions (ca^{2+}) are unable to neutralize the aluminum ions (Al^{3+}) Liming practices in agricultural soil normally accumulate more calcium in the soil.

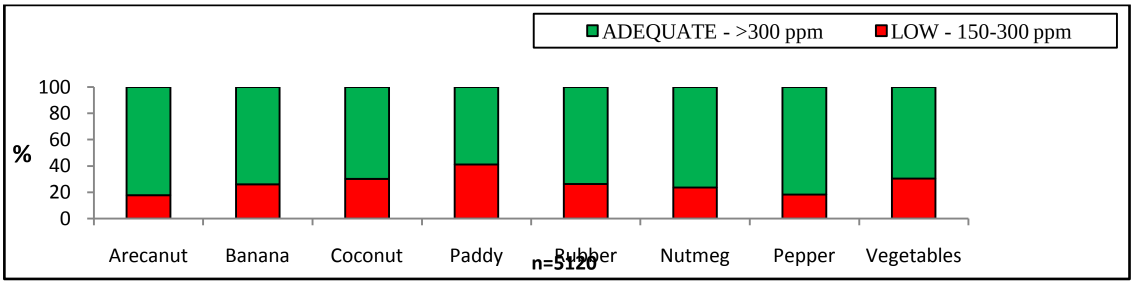

Fig.8. Frequency classes of Ca

Table7. Agro ecological zones wise distribution of Ca, Mg and S in various agro ecosystems of Thrissur District

Agro ecological zone	Agro ecosystems	Ca(mg kg^{-1})	Mg(mg kg^{-1})	S(mg kg^{-1})
Northern coastal plain	Coconut	524.8-821.8	37.6-75.2	4.3-11.5
	Arecanut	138.9-918.7	32.6-134.7	3.7-11.5
	Paddy	184.0-756.3	42.1-107.7	1.9-167.1
	Vegetables	330.3-669.4	32.7-40.1	12.8-26.3
	Pepper	372.7-592.9	39.5-40.8	11.4-17.3
	Banana	126.8-310	30.2-35	13.6-32.2
	Nutmeg	310-797	34.9-104.2	4.8-13.9
Northern central laterite	Coconut	235.5-843.9	27.3-152.7	2.2-22.3
	Arecanut	406.3-959.9	28.4-152.6	2.2-25.6
	Paddy	201.2-730.8	42.1-99.9	2.0-21.7
	Vegetables	289.5-875.1	61.3-113.8	2.3-26.1
	Pepper	193-1237	52.1-171.3	0.2-9.1
	Banana	241-1255	25.2-176.3	1.7-25.5
	Nutmeg	217-936	39.4-201.7	1.7-17.5
	Rubber	289-1220	43-192	0.5-26.1
kole lands	Coconut	100-1888	5.7-315	0.2-196
	Arecanut	161-1507	27-215	0.1-138
	Vegetables	208-875	13.4-208.0	0.5-35.5
	Pepper	349-879	12.8-210	0.1-43.6
	Banana	131-1632	5.7-251	0.2-175
	Nutmeg	161-973	26.7-203	0.1-24.8
Pokkali lands	Coconut	32.6-1306	7.7 -366	0.1-373.9
	Arecanut	55 - 1306	10.5 -102.9	0.09-36
	Paddy	134 - 266	21 - 96.8	36.1-400
	Vegetables	47-345	15.8-60.8	4.8-22.3
	Pepper	57-118	22.9-38.2	3.1-22.9
	Banana	38 - 1306	10 -150	0.1-414.8
	Nutmeg	52 -910	14 -366	0.3 - 415
	Rubber	52.8-135.2	18.2-49.8	15.1-36.1

Southern high hills	Coconut	131-1476	2.4-250	0.1- 47
	Arecanut	180 - 1476	26.9-167.9	1.7-25.1
	Vegetables	66 - 920	15 -199	0.5-12.7
	Pepper	352 - 1095	43.6-86.4	1.2-24.2
	Banana	103 - 1476	12 - 260	0.03-45.3
	Nutmeg	101 - 1409	2 -250	0.2-45.3
	Rubber	21-1430	6 - 248	0.1-54.7
Northern high hills	Coconut	62 - 1525	10 - 227	0.1-47.1
	Arecanut	55 - 944	12 - 260	0.03 - 32.8
	Paddy	45 - 1054	9 - 212	0.3-25.4
	Vegetables	232 - 457	42.6-59.8	4.9-16.3
	Pepper	335 - 607	41 - 152	2.0-16.3
	Banana	55 - 1188	10 - 260	0.1 - 37.3
	Nutmeg	42 - 912	9.8 - 227.2	0.1-47.1
	Rubber	96.8 - 1188	12.8 - 227.2	0.2 - 24.3

3.3.3.2. *Magnesium*

The data presented in Table 6 showed that the status of Mg in the soils of various agro ecosystems in Thrissur district in general was low to high, with the values varying from 3 – 711 mg kg^{-1}. The same low - high status of Mg was noted in each agro ecosystems of the district.

When the Mg status of agro ecosystems confined to each agro ecological unit was examined separately, low values (< 20 mg kg^{-1}) were observed mainly in the kole lands, pokkali lands, southern high hills and northern high hills. But on the contrary, in the coastal plain and northern central laterite, the values towards higher side were relatively less (> 200 mg kg^{-1}) compared to other ecological units. The data also revealed variation in the content of Mg, in the same cropping systems grown in different agroecological units.

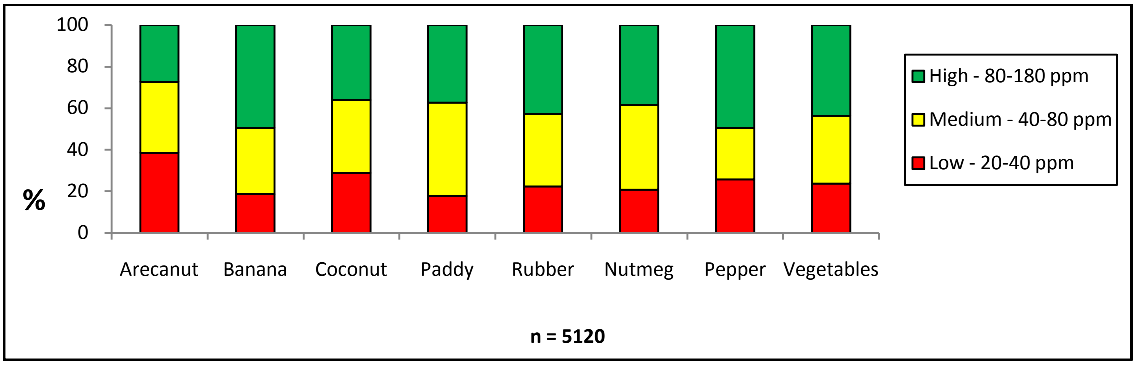

Fig.9. Frequency classes of Mg

In the study area, 49.6 % of the soil samples accounted for high content of Mg in banana, 49.5 % in pepper, 43.7 % in vegetables and 42.7 % in rubber (Fig.9). Cultivation of coconut based cropping systems in chronic Mg deficient sandy soils of Onattukara was reported by Mini *et al*. (2015) and similar trend was observed in all the crop production systems except vegetables.

Most of the soils in the study area were acidic in reaction. Leaching of Mg through runoff water during rainy season coupled with acidic condition resulted in critical deficiency of Mg in the soils of the study area. Wide variation in the content of Mg in different agro ecosystems is attributed due to the variation in the management practices followed in the area.

3.3.3.3. *Sulphur*

The content of S also showed wide variation among different agro ecosystems. The data presented in Table 6 revealed that the status of S in the soils of various agro ecosystems in the Thrissur district showed very low to high values ranging from 0.1 - 400 mg kg-1 (Table 6). The proximity to sea leading to inundation of salt water coupled with artificial inputs through S containing fertilizers can be the reason for the relatively higher status in most of the agro ecosystems of northern coastal plain. But Mini *et al.* (2015) reported deficiency of S in 18% of the samples from coconut based systems of sandy soils Onattukara region.

Low content of S was mainly concentrated in all the crops in all the agro ecological zones except vegetables, pepper and banana in northern coastal plain; and paddy in pokkali lands. Extremely high content of S was mainly located in coconut, arecanut and banana in kole lands; coconut, paddy, banana and nutmeg in pokkali lands (Table 7). This is due to the contribution from S containing minerals such as FeS present in kole and pokkali lands. Most of the phosphatic fertilizers contain sulphur as an additional constituent and this is responsible for fairly satisfactory levels of S in various agro ecosystems in the study.

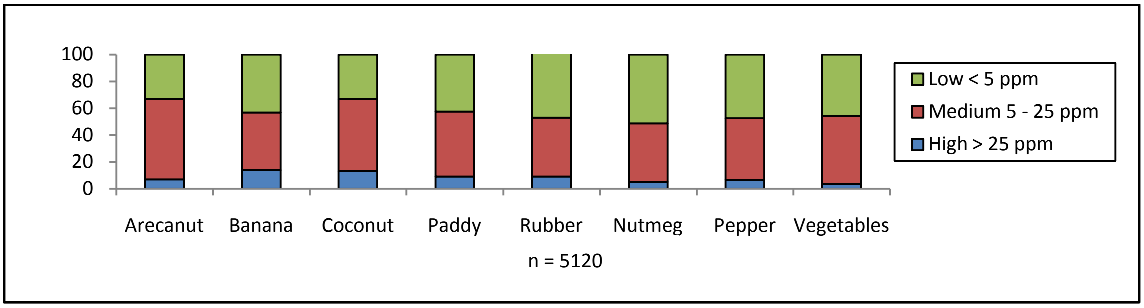

Fig.10. Frequency of S classes

In the study area 50 % of the soil samples accounted for deficient level of S in rubber, 45 % in vegetables, 43 % in banana and 40 % in paddy (Fig.10). The soils of Kerala in general are sufficient in S. Since retention of S is not possible in soils, the soluble phosphate form is subjected to leaching during heavy rainfall. This could be the reason for the deficient levels of S noted in various agro ecosystems in the study area.

3.3.4. Micronutrients

Micronutrients *viz* ; Fe, Cu, Zn, Mn and B were determined in all the agro ecosystems in the soils of study area, and as observed in the case of macronutrients, the content of all micronutrients also showed wide variation from low to high status. The values of Fe ranged between 0.1 - 675 mg kg^{-1}, Cu between 0.01 – 54 mg kg^{-1}, Zn between 0.01 – 100.2 mg kg^{-1}, Mn between 0.1 – 280 mg kg^{-1} and B between 0.001 – 0.4 mg kg^{-1} (Table 8).

The data in Table 9 indicated that sufficiency of Fe was prominent in all the crops in various agro ecological units. Deficiency of Fe was mainly concentrated in arecanut and banana in northern central laterite; coconut in pokkali lands; coconut, vegetables and nutmeg in southern high hills; coconut, arecanut and nutmeg in northern high hills. Normally, deficiency of Fe seldom occurs in acidic lateritic environment. Low availability of Fe in some of the cropping systems as mentioned above is attributed to the relatively higher pH, brought about by the addition of liming amendments. Deficiency of Cu was mainly noted in pepper and banana in northern central laterite; all crops in kole lands, pokkali lands and southern high hills; all crops in northern high hills except vegetables. Deficiency of Cu is generally seen in soils with high level of organic matter due to the chelating action of organic matter with Cu. But, under flooded condition, formation of insoluble CuS due to the reduction of SO_4^{2-} to sulphide aggravate the problem (Sureshkumar *et al*., 2013). So relatively higher status of organic matter in high hills, kole lands and pokkali lands could be considered as the dominant factor for the deficient level of Cu in these regions. Deficient level of Zn was mainly observed in banana in northern central latrite; all the agro ecosystems in kole lands; most of the agro ecosystems in pokkali lands except paddy; and all the crops except pepper in northern high hills. High levels of P present in these soils definitely reduce the availability of Zn, through the formation of zinc phosphate. Similarly, excessive levels of Al, Mn and Fe leading to ion competition is another probable reason for the deficient levels of Zn observed in some pockets. The sufficiency of Mn was prominent in all the crops in various agro ecological units. Deficient level of Mn was mainly concentrated in coconut and banana in kole lands; coconut, arecanut, vegetables, pepper, banana and nutmeg in Pokkali lands; banana, nutmeg and rubber in southern high hills. Elevated pH triggered by the application of lime could be the only reason for the deficient level of Mn noted in isolated pockets. Prominent deficiency of B was found in all the crops in various agro ecological units. Even though, the acid soils support increased solubility and availability of B, most of this nutrient is usually lost through run off water during intense rain, leaving the soil at deficient level.

Table8. Content of micronutrients in the soils of various agro ecosystems in Thrissur district

Agro ecosystem	Zn(mg kg^{-1})	B(mg kg^{-1}	Fe(mg kg^{-1})	Cu(mg kg^{-1})	Mn(mg kg^{-1})
Arecanut	0.02 -100.2	0.004 -0.2	0.1 - 675	0.01-54	0.1-240.8
Banana	0.02-18.9	0.01-0.2	2.2 - 220.9	0.08 - 43.6	0.5 - 184
Coconut	0.03 - 56	0.003 -0.3	0.1 - 546.9	0.01- 41.5	0.1- 243
Nutmeg	0.04 - 33	0.01-0.2	1.22 - 552.3	0.01-15.5	0.1- 254
Paddy	0.01 -31.5	0.02-0.4	0.7 - 475.6	0.05 - 28	0.1 - 152
Rubber	0.03 - 51	0.01-0.2	0.2 - 160.9	0.01-20.4	0.5 - 175
Vegetables	0.01-31	0.001-0.2	1.6 - 484	0.04 -24.7	0.6 -280
Pepper	0.03 - 33	0.001-0.2	3.1- 133.6	0.1 - 19.7	1.1- 250

Table9. Agro ecological zone wise distribution of soil micronutrients in various agro ecosystems of Thrissur district

Agro ecological zone	**Agro ecosystems**	**Zn (mg kg^{-1})**	**B (mg kg^{-1})**	**Fe (mg kg^{-1})**	**Cu (mg kg^{-1})**	**Mn (mg kg^{-1})**
Northern coastal plain	Coconut	1.1-22.5	0.03-0.04	46.1-136	0.9-4.7	5.8-127.0
	Arecanut	2.3-14.5	0.02-0.04	46.1-141.7	1.0-4.4	1.7-107.4
	Paddy	1.3-4.9	0.01-0.08	13.1-77.8	0.8-3.1	11.3-61.7
	Vegetables	2.7-5.7	0.05-0.2	33.4-42.3	1.6-2.3	3.5-15.1
	Pepper	3.2-4.3	0.04-0.2	39.5-50.3	1.9-2.6	3.6-7.7
	Banana	1.9-2.8	0.01-0.15	33.5-68.2	1.8-2.8	2.1-2.5
	Nutmeg	2.8-19.4	0.02-0.2	27.7-152.1	0.6-10.8	2.5-121.0
Northern central laterite	Coconut	1.5-7.7	0.01-0.2	10.1-163.3	0.7-31.6	4.6-117.1
	Arecanut	1.5-6.5	0.01-0.1	0.1-163.3	0.6-17.4	5.5-140.2
	Paddy	1.4-9.4	0.01-0.20	13.1-61.8	0.8-19.1	4.8-114.3
	Vegetables	1.9-22.0	0.01-0.2	35.0-299.3	0.9-19.3	5.7-114.9
	Pepper	3.1-23.4	0.02-0.2	36.9-183.7	0.1-3.6	17.1-66.5
	Banana	0.4-5.5	0.01-0.2	2.2-115.3	0.09-16.3	3.8-140.2
	Nutmeg	1.1-5.8	0.02-0.09	11.1-220.4	0.8-34.4	6.5-71.7
	Rubber	1.6-8.5	0.01-0.2	9.6-142.2	0.8-19.8	5.7-123.5

Kole lands	Coconut	0.2-25.9	0.01 - 0.6	10.7-274	0.1-23.7	0.7-192.3
	Arecanut	0.5-12.2	0.01- 0.6	12.5-226	0.2-23.7	1.4-154.6
	Vegetables	0.8-6.5	0.01 - 0.1	18.9-200	0.3-3.6	2.8-17.4
	Pepper	0.5-3.8	0.01 - 0.09	11.6-53	0.2-2.9	1.1-15.4
	Banana	0.5-18.9	0.007 - 0.6	10.8-200	0.2-14.2	0.7-171
	Nutmeg	0.5-2.5	0.006 - 0.09	19.3-60	0.2-2.5	1.4-17.7
Pokkali lands	Coconut	0.004-3.8	0.006 - 0.2	3.5-175	0.1-6.3	0.02-46
	Arecanut	0.004-3.0	0.006-0.2	9.2-174.5	0.1-1.0	0.02-37.4
	Paddy	1.3-6.6	0.04-0.1	10.5-144	0.2-2.6	3.4-23.4
	Vegetables	0.1-3.0	0.04-0.06	23.1-136	0.1-0.6	0.8-29.7
	Pepper	0.1-0.9	0.03-0.07	6.4-108	0.09-0.6	0.1-19.2
	Banana	0.02-7.3	0.006-0.2	6.4-174.5	0.06-6.3	0.02-46.2
	Nutmeg	0.06-6.0	0.02-0.2	6.4-151.8	0.06-3.9	0.1-37.5
	Rubber	0.1-1.3	0.05-0.07	10.2-126.2	0.1-0.5	1.2-23.4
Southern high hills	Coconut	0.02-9.1	0.04-0.1	1.2-140.1	0.01-6.3	2.5-108.6
	Arecanut	0.07-8.8	0.05-0.1	20.0-76.3	0.1-1.3	4.9-72.9
	Vegetables	0.2-9.0	0.04-0.1	1.2-80.5	0.04-1.1	4.1-64.7
	Pepper	0.1-31.4	0.01-05	11.5-115.4	0.8-15.5	43.2-249.5
	Banana	0.02-12.8	0.04-0.1	5.1 - 133.0	0.02-17.6	0.5-154.6
	Nutmeg	0.1-33.1	0.04-0.1	1.2-123.3	0.03-13.9	0.1-254.3
	Rubber	0.03-17.8	0.04-0.1	3.9-117.6	0.05-9.8	0.5-121.3
Northern high hills	Coconut	0.02-56.1	0.002-0.2	2.8-188.2	0.02-41.5	1.9-210.6
	Arecanut	0.1-100	0.002-0.2	0.3-211	0.2-54	2.6 - 182
	Paddy	0.03-31.5	0.004 - 0.1	6.3-298.5	0.3 - 28	3.6 - 115
	Vegetables	0.5-2.7	0.02-0.2	35.9-69.4	1.4 - 4.1	10.3-54.6
	Pepper	1.6 - 13.0	0.01 - 0.1	15 - 71	1.0 - 25.7	9.3 - 82.0
	Banana	0.02-76.0	0.002 - 0.2	3.1- 150.8	0.01-51.8	3.6 - 210.6

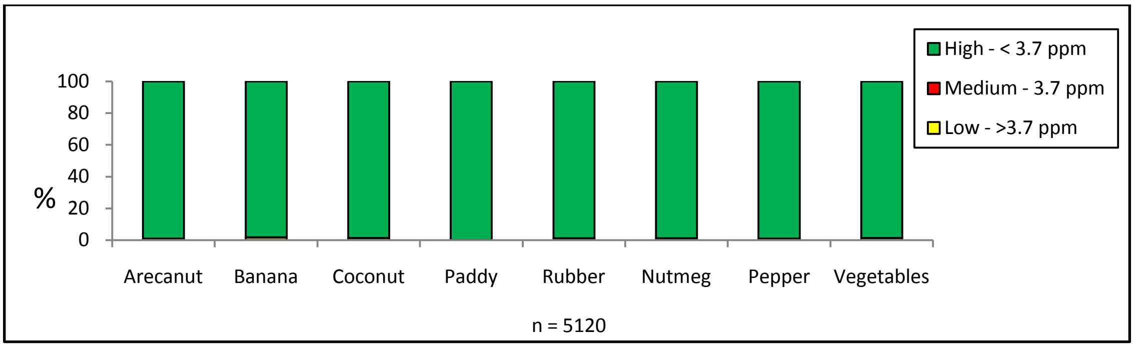

Fig.11. Frequency of Fe classes

In the case of Fe, 99.9 % of the soil samples accounted for high content in paddy, 99 % in arecanut and pepper, 98.8 % in rubber, 98.7 % in nutmeg, 98.5 % vegetables and 98.2 % in banana (Fig.11), revealing no severe deficiency of Fe in all the agro ecosystems.

With respect to Cu, 84.3 % of soil samples accounted for high content in coconut, 82.1% in paddy, 68.1% in arecanut, 66.7 % in vegetables, 66.3 % in nutmeg and 61.5 % in banana (Fig.12). Copper is an ingredient in common fungicide and their frequent application either to soil or in crops might elevate the level of this nutrient.

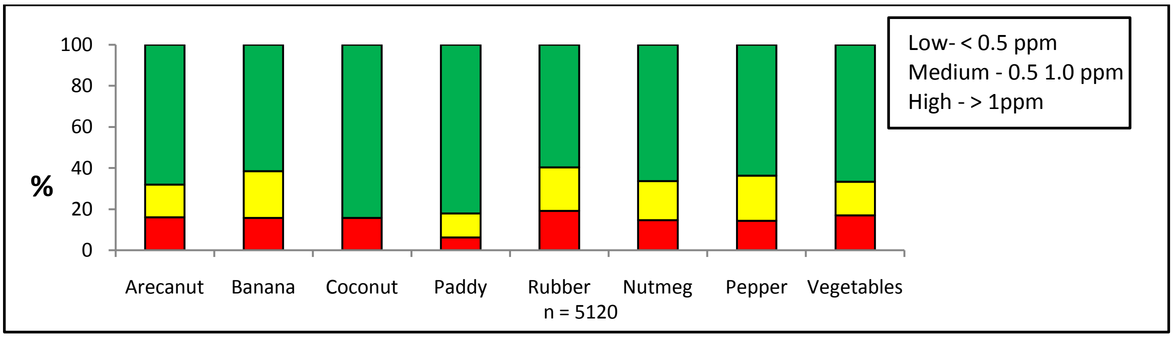

Fig.12. Frequency of Cu classes

In the study area 75.9 % of the soil samples accounted for high content of Zn in arecanut, 77.2 % in paddy, 74.3 % in pepper, 70.4 % in banana, 72.6 % in coconut, 68.8 % in rubber and 64.4 % in vegetables (Fig.13). Mini *et al*. (2015) also reported Zn deficiency in 66 % of the sandy soils of coconut based cropping systems of Onattukara in Kerala.

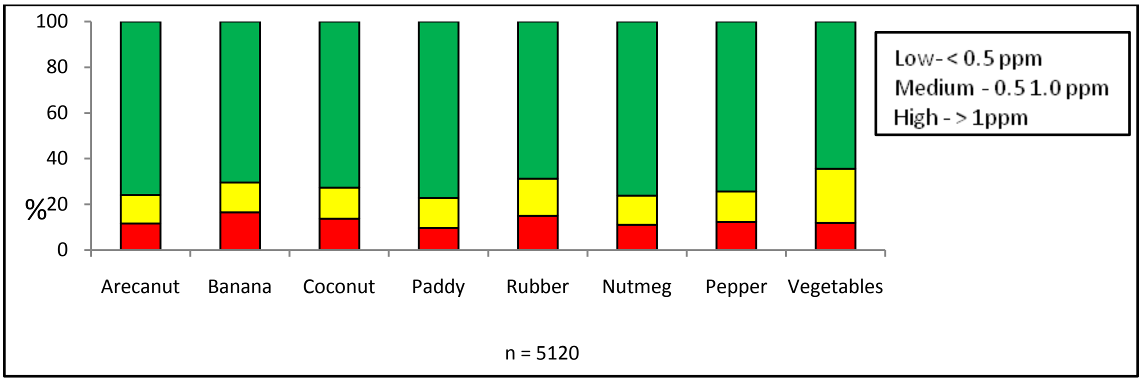

Fig.13. Frequency of Zn classes

A very high content of Mn were noted in 98.4 % of soil samples in rubber, 94.3 % in pepper, 93.4 % in banana, 98.4 % in rubber, 93 % in nutmeg, 86 % in coconut, 89 % in paddy and 81.5 % in vegetables (Fig.14).

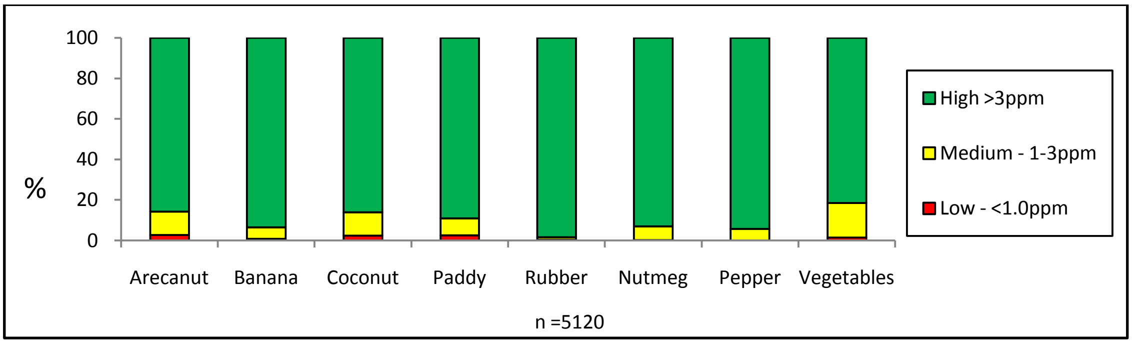

Fig.14.Frequency of Mn classes

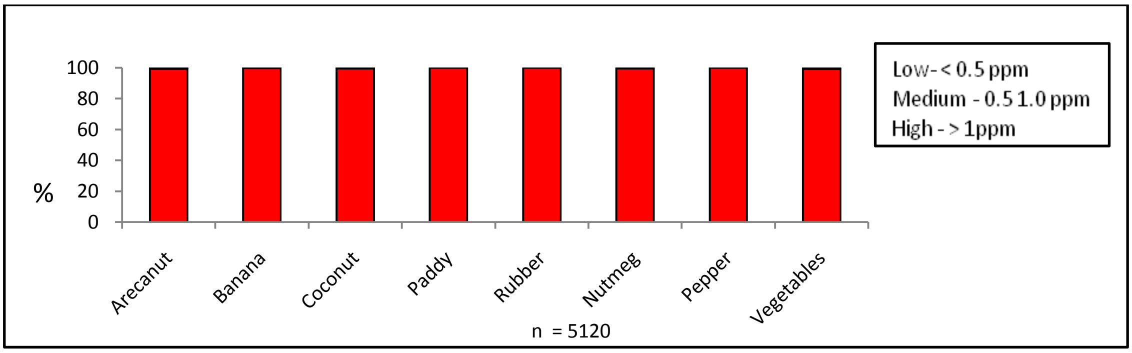

Fig.15. Frequency of B classes

In the case of B, 100 % of the soil samples accounted for the deficiency in paddy, rubber and pepper, 99.7 % in coconut, 99.8 % in banana, 99.6 % in nutmeg, 99.5 % in arecanut and 99.3 % in vegetables (Fig.15). This revealed that among the micro nutrients, deficiency of B was severe in the study area. B is a water soluble element and so it escapes from the soil through leaching during heavy rainfall. This might be the major reason for the acute deficiency of B in all the cropping systems and hence requires immediate attention for proper addition of B fertilizers. Deficiency of B normally affects the fruit and seed development of plants. However, in the light of high levels of P, soil application may not ensure plant uptake of B due to antagonistic effects. Thus the results in general indicated that the content of micronutrients varied with various agro ecosystems. The decreasing order of deficiency of micronutrients in Thrissur district were B (99.3 % – 100 %) > Cu (61.5 % – 84.3 %) > Zn (64.4 % – 75.9 %) > and Mn (81.5 % – 98.4 %) > Fe (98.2 % - 99.9 %). Among the various agro ecosystems, the deficiency due to B was severe in all the crops, Cu in rubber, vegetables, coconut, banana and arecanut, Zn in rubber, coconut, banana and vegetables, and the deficiency level was negligible in the case of Fe and Mn in all the crops.

3.3.2. General status of soil fertility parameters in various ecosystems

The general status of soil fertility parameters as indicated by various indices are given in Table 10. Nature of soil reaction, assessed by soil reaction index showed that in all the agro ecosystems soils were acidic except arecanut and pepper, wherein the soils were in neutral condition. EC of soil, determined by salt index revealed normal condition in all the cropping systems in the study area. The status of OC, which was evaluated by nutrient index values were high only in the case of nutmeg and rubber. In all other crops its status was moderate (Table 10).

The status of all macro and micro nutrients were also assessed based on the nutrient index value. This revealed high N status in the soils of rubber based cropping system and medium in all other crops. The status of P was high in the soils of all agro ecosystems. The status of K was low in arecanut, high in rubber and medium in all the other crops. On the other hand, Mg was medium in all the agro ecosystems in the study area. The status of S was low in the soils of rubber, vegetables and pepper (Table 11). There was only low and adequate levels in the case of Ca, so it was difficult to calculate the index without low, medium and high catagories.

Table 10. General status of pH, EC, and OC in the soils of various agro ecosystems of Thrissur District

Agro ecosystem	pH	EC (dSm^{-1})	OC (%)
Arecanut	Neutral	Normal	Moderate
Banana	Acidic	Normal	Moderate
Coconut	Acidic	Normal	Moderate
Nutmeg	Acidic	Normal	High
Paddy	Acidic	Normal	Moderate
Rubber	Acidic	Normal	High
Vegetables	Acidic	Normal	Moderate
Pepper	Neutral	Normal	Moderate

Table 11. General status of primary and secondary nutrients in the soils of various agro ecosystems of Thrissur District

Agro ecosystems	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Mg (mg kg^{-1})	S (mg kg^{-1})
Arecanut	M	H	L	M	M
Banana	M	H	M	M	M
Coconut	M	H	M	M	M
Nutmeg	M	H	M	M	M
Paddy	M	H	M	M	M
Rubber	H	H	H	M	L
Vegetables	M	H	M	M	L
Pepper	M	H	M	M	L

L= Low; M= Medium; H= High

The status of micronutrients evaluated by nutrient index showed very high status of Zn in the soils of nutmeg and paddy, and high in other agro ecosystems. Status of B was very low in the soils of all the cropping systems. On the other hand Cu was very high in the soils of paddy and coconut, and high in other cropping systems. The status of Fe and Mn were very high in the soils of all the crops grown in Thrissur district (Table 12).

Table12. Status of micronutrients in the soils of various agro ecosystems of Thrissur District

Agro ecosystems	Zn ($mg\ kg^{-1}$)	B ($mg\ kg^{-1}$)	Fe ($mg\ kg^{-1}$)	Cu ($mg\ kg^{-1}$)	Mn ($mg\ kg^{-1}$)
Arecanut	H	VL	VH	H	VH
Banana	H	VL	VH	H	VH
Coconut	H	VL	VH	VH	VH
Nutmeg	VH	VL	VH	H	VH
Paddy	VH	VL	VH	VH	VH
Rubber	H	VL	VH	H	VH
Vegetables	H	VL	VH	H	VH
Pepper	H	VL	VH	H	VH

VH = Very high; H = High; VL = Very low

The nutrient indices for N, P and K in the soils of Kerala in 1967 was 2.1, 1.1 and 1.0; in 1977 it was 1.7, 1.7 and 2.0; and in 1997 it was 1.66, 2.35 and 1.98. The corresponding fertility status in 1967, 1977 and 1997 were M-L-L, M-M-M and L-H-M respectively. In the present study, there is an increasing trend in the nutrient indices for N and P (1.66 and 2.35) and no much change in the case of K (1.98). Thus a drastic change in the fertility status to low and high levels of N and P, and medium in K were observed within a period of 15 years (Pathak, 2010). Ravikumar and Somashekar (2013) reported the NPK status in the soils of Karnataka as L-L-H and in Uttar Pradesh as L-M-M (Kumar *et al.* 2013).

Based on the above study it is concluded that soil fertility status of Thrissur district varied between various agro ecosystems. Among the cropping systems, status of N, P and K was high in rubber. Acute deficiency K was observed in arecanut plantations while the deficiency of S was noted in rubber, vegetables and pepper. High accumulation of P, acute deficiency of B and relatively higher levels of Fe, Cu, Zn and Mn were observed in all the agro ecosystems.