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Soil Based Nutrient Management Plan for Tuber Crops in Pathanamthitta District of Kerala

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Abstract

Soil fertility evaluation based on soil test is an inevitable pre-requisite for predicting fertilizer needs of crops. Fertilizer recommendation based on crop requirement and soil nutrient availability is one of the criteria to enhance nutrient use efficiency. In the present scenario of increasing fertilizer cost and over concern on human health, there is an urgent call from all corners for the rationalization of the existing package of practices (POP) recommendations for nutrient management based on innate soil fertility and crop requirement. In this regard, Kerala State Planning Board in collaboration with the Department of Agriculture, Government of Kerala, has initiated a project to develop soil based plant nutrient management plan for Kerala. The Central Tuber Crops Research Institute under Indian Council of Agricultural Research, one of the collaborators of this project, has evolved plant nutrient management plan for Pathanamthitta district based on chemical analysis of 10348 soil samples collected from various crops of the 51 panchayats of the district. As this district is one of the major tuber crops growing zones of Kerala, and 36% of the soil samples received from the district pertained to tuber crops *viz*., cassava, elephant foot yam, yams, taro and tannia, an effort was made to prepare a nutrient management plan for these crops based on the soil test data generated. This paper deals with the innate fertility status (major, secondary and micronutrients) of the tuber crops growing soils as well as the nutrient management strategy developed for these crops based on soil test data. The soil test data indicated that the soils were strongly acidic with high organic C, available P, exchangeable K, Ca, Mg and S and sufficient in all micronutrients *viz.*, Fe, Cu, Mn, Zn and B. As the overall soil nutrient status of the district was found high, application of all the above nutrient containing fertilizers can be restricted to location and crop specific depending upon soil status and crop needs. As tuber crops form one of the major component crops of almost all predominant cropping systems of the district, the soil test data indicated the need for refinement of the existing package of practices of manures and fertilizers to maintain soil health and ensure higher income to farmers.

Key words: Soil testing, major, secondary, micronutrients, tropical root crops, nutrient recommendation

Introduction

The soils of Kerala, and in particular that of Pathanamthitta district are mostly laterites, which are inherently poor in native fertility with many soil problems like P fixation, low CEC, low organic matter content etc. Continuous cultivation in these soils either with over fertilization or under fertilization has resulted in imbalanced soil nutrient status with multiple soil nutritional deficiencies/toxicities and other soil nutritional problems *viz.,* soil acidification, soil compaction, soil degradation etc.

As the land holdings of Kerala are mostly small to marginal with less than one hectare, the agricultural development of the state is possible through the development of suitable production systems in the available land holdings. The humid tropical climate can contribute to high biomass production provided there is adequate supply of nutrients through organic or inorganic sources. On a national basis, the experience over several years, in most of the crops and cropping systems clearly revealed that integrated nutrient management strategy through balanced fertilization can enhance crop yield, improve produce quality as well as maintain soil health. Balanced fertilizer application is possible through assessment of nutrient demand of the crop and innate fertility status of the soil. The fertility status of the soil can be evaluated through soil testing. Hence, with the objective of evolving a soil based plant nutrient management plan for the state *in toto*, through the development of similar plans from the grass root level onwards, Kerala State Planning Board with the financial support from the Department of Agriculture, Government of Kerala has initiated an attempt involving both State as well as Central research institutions.

In this regard, Central Tuber Crops Reseach Institute (CTCRI), one of the associated institutes in this project, was entrusted with the preparation of soil based nutrient management plans of Pathanamthitta and Kottayam districts. This paper describes the nutrient management plan prepared for tuber crops in the district of Pathanamthitta, Kerala, after analyzing 10348 soil samples collected from different crops.

Pathanamthitta is the latest district of Kerala having an area of 23.50 sq.km comprising of 54 panchayats under 12 blocks. The major crops grown are rubber, paddy, coconut, tuber crops *viz.,* cassava, yams, elephant foot yam, taro and tannia, vegetables and spices like ginger, cardamom, pepper, nutmeg etc. Based on the analytical data on pH, organic C, available P, K, Ca, Mg, S and micronutrients *viz.*, Fe, Cu, Mn, Zn and B, nutrient management plan was prepared for the major crops at panchayat, block as well as district level with special emphasis to tropical tuber crops.

Materials and Methods

A total of 10348 samples were collected from 51 panchayats belonging to eight blocks and two municipalities of the district confining only to upland, with major crops *viz.,* rubber, coconut, tuber crops, vegetables and spices by the volunteers of Nehru Yuva Kendra through the technical advice of scientists of Kerala Agricultural University and Central Agricultural Research Institutes and supervision of Agricultural Officers of the Department of Agriculture, Government of Kerala. These samples having definite identification number along with properly filled application forms with farmer and crop details was systematically coded with unique identification number on receipt at CTCRI. They were then properly processed following the normal procedure for soil sample preparation and brought to the analytical laboratory for further chemical analysis. The details of the samples collected block wise including the percentage of samples representing tuber crops soils are given in Table 1.

The parameters analysed included pH, organic carbon (C), available phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), iron (Fe), copper (Cu), manganese (Mn), zinc (Zn) and boron (B) following standard analytical procedures (Jackson,1973).

Table 1. Details of samples received from tuber crops growing soils

Sl. No.	Name of blocks	Total soil samples received	Number of samples from tuber crops growing soils	Percentage of soil samples under tuber crops
1	Pandalam	569	209	38
2	Parakkode	1651	780	49
3	Adoor municipality	150	52	35
4	Elanthur	1069	377	36
5	Konni	1441	434	31
6	Kulanada	585	250	43
7	Pathanamthitta (PTA) municipality	276	180	65
8	Koipram	1222	573	47
9	Mallappally	1314	266	21
10	Ranni	2071	626	30
	Total	10348	3747	36.21

The data generated for individual farmers of each panchayat was interpreted under different systems of classification and the methodology is described below.

The nine class soil fertility system for organic C, P and K

The nine class soil fertility system still followed by the soil testing laboratories and research institutes of Kerala for soil fertility rating and fertilizer (N, P, K) recommendation is presented in Table 2.

General classification as low, medium and high

Based on the soil test values for different nutrients *viz.,* organic C, available N, P and K, the soil samples were classified into three categories *viz.,* low, medium and high as per the ratings suggested by Dev (1997). The ratings of organic C, available P and K are presented in Table 3.

Soil nutrient index value

Parker et al. (1957) put forth the concept of Soil Nutrient Index (SNI). SNI is calculated by giving separate weightages to the number of samples falling in low, medium and high soil fertility classes as

Table 3. Criteria for general classification

Class	Organic C (%)	Available P (kg ha^{-1})	Available K (kg ha^{-1})
Low	<0.5	<10	<120
Medium	0.5-0.75	10-25	120-280
High	>0.75	>25	>280

Source : Dev (1997)

$$\text{Soil Nutrient Index (SNI)} = \frac{(Nl \times 1)+(Nm \times 2)+(Nh \times 3)}{Nt}$$

Nl - Number of samples falling in low category

Nm - Number of samples falling in medium category

Nh - Number of samples falling in high category

Nt - Total number of samples analysed for a given nutrient

Separate indices were calculated for different nutrients. SNI values less than 1.5 were rated as low, between 1.5-2.5 as medium and more than 2.5 as high. Ramamoorthy and Bajaj (1969) had categorized these values as less than 1.67 as low, 1.67-2.33 as medium and more than 2.33 as high and this was used in the present study.

Table 2. Soil fertility classes and N, P, K recommendation for each class as per cent to general recommendations

Soil fertility class	Organic C (clayey/ loamy soil) (%)	Recommendation of N as percentage to general recommendation	Available P (kg ha^{-1})	Exchangeable K (kg ha^{-1})	Recommendation of P and K as percentage to general recommendation
0	0.00-0.16	128	0.0-3.0	0-35	128
1	0.17-0.33	117	3.1-6.5	36-75	117
2	0.34-0.50	106	6.6-10.0	76-115	106
3	0.51-0.75	97	10.1-13.5	116-155	94
4	0.76-1.00	91	13.6-17.0	156-195	83
5	1.01-1.25	84	17.1-20.5	196-235	71
6	1.26-1.50	78	20.6-24.0	236-275	60
7	1.51-1.83	71	24.1-27.5	276-315	48
8	1.84-2.16	63	27.6-31.0	316-355	37
9	2.17-2.50	54	31.1-34.5	356-395	25
10	>2.50	50	>34.5	>395	25

Source: Aiyer and Nair (1985)

Concept of sufficiency and deficiency

Dev (1997) reported that the soil critical level for secondary nutrients *viz.,* Ca, Mg and S were 300, 120 and 5 $\mu g\ g^{-1}$ respectively. For micronutrients, Fe, Cu, Mn, Zn (0.1 N HCl extract) and B (hot water extractable), the critical level values were taken as 5, 1, 1, 1 and 0.5 $\mu g\ g^{-1}$ respectively (KAU, 2012). The soils were rated as sufficient /deficient based on these soil critical level values.

Soil reaction groups based on pH

The soils were classified into seven groups based on soil reaction and the lime requirement for each group is presented in Table 4.

Classification based on nutritional requirement of cassava

Howeler (1996) has classified cassava soils into very low, low, medium, high and very high based on soil chemical characteristics and nutritional requirement of cassava. The criteria is given in Table 5.

Table 4. Soil reaction groups based on pH

Sl. No.	pH	Class	Lime requirement (kg $CaCO_3$ ha^{-1})
1	<3.5	Ultra acid (UA)	1000
2	3.5-4.5	Extremely acid (EA)	850
3	4.5-5.0	Very strongly acid (VSA)	600
4	5.0-5.5	Strongly acid (SA)	350
5	5.5-6.0	Moderately acid (MA)	250
6	6.0-6.5	Slightly acid (SLA)	100
7	≥ 7	Neutral to alkaline (NA)	Not needed

Source: KAU (2012)

Preparation of nutrient management plan based on soil test data

The data generated on chemical parameters *viz.*, pH, organic C, available P, K, Ca, Mg, S, Fe, Cu, Mn, Zn and B for the total number of samples (10348) was tabulated farmer, panchayat, block and district wise. The group of data pertaining to the above parameters were interpreted and fertilizer cum manurial recommendation for the different crops were arrived at taking into account the existing package of practices recommendations (KAU, 2007) in the case of major nutrients and adhoc recommendation in the case of secondary and micronutrients (KAU, 2012).

From the data on bulk samples, data on soil samples of the tuber crops were separately taken and interpreted and that formed the basis of this paper.

Results and Discussion

From the total of 10348 soil samples collected from the district of Pathanamthitta, 3747 samples (36.21%) were from tuber crops like cassava, elephant foot yam, tannia, yams and sweet potato. The soil test results of these samples for each parameter based on the different classification systems along with the suggested nutrient management strategy are discussed below.

Table 5. Approximate classification of soil chemical characteristics according to the nutritional requirement of cassava

Soil parameter	Very low	Low	Medium	High	Very high
pH	<3.5	3.5-4.5	4.5-7	7-8	>8
Organic C (%)	<0.58	0.59-1.16	1.17-2.32	>2.33	
P (kg ha^{-1})	<4.5	4.5-9.0	9.1-34.0	>34.0	-
K (kg ha^{-1})	<87	87-131	131-219	>219	-
Ca ($\mu g\ g^{-1}$)	<50	50-200	200-1000	>1000	-
Mg ($\mu g\ g^{-1}$)	<24	24-48	48-120	>120	-
S ($\mu g\ g^{-1}$)	<20	20-40	40-70	>70	-
B ($\mu g\ g^{-1}$)	<0.2	0.2-0.5	0.5-1.0	1-2	>2
Cu ($\mu g\ g^{-1}$)	<0.1	0.1-0.3	0.3-1.0	1-5	>5
Mn ($\mu g\ g^{-1}$)	<5	5-10	10-100	100-250	>250
Fe ($\mu g\ g^{-1}$)	<1	1-10	10-100	>100	-
Zn ($\mu g\ g^{-1}$)	<0.5	0.5-1.0	1.0-5.0	5-50	>50

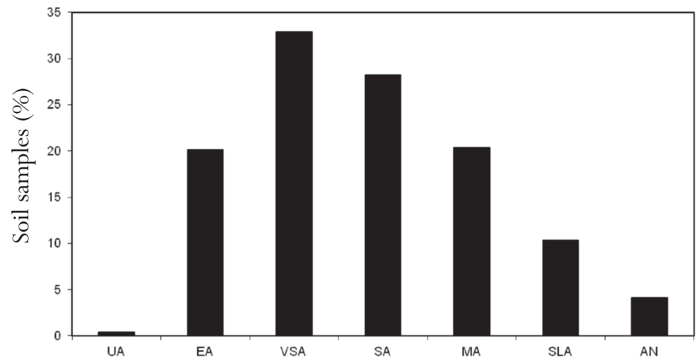
Source: Howeler (1996)

pH

The tuber crop growing soils of this district belong to all the seven pH groups from ultra acid (< 3.5) to acidic-nuetral (>6.5) (Fig.1). However, the major share of the soil (32.87%) comes under very strongly acidic (4.5-5) followed by (28.26%) strongly acid (5-5.5). Based on the survey conducted statewide, Nair et al. (2007) indicated that the soils of Kerala were mostly laterites and basically acidic in soil reaction. As per the Soil Survey Organization, Kerala (2007), the mean pH of the five benchmark soils of Pathanamthitta district was 5.4, coming under the strongly acidic group. Among the soils of 10 blocks, the tuber crops growing soils of Adoor municipality, Ranni and Pandalam were very strongly acidic with pH values ranging from 4.7-4.9. All the other blocks had soils with strongly acidic soil reaction, except Kulanada which was found moderately acidic with a pH of 5.6. Hence, it can be seen that in general the soils of Pathanamthitta district was strongly acidic in soil reaction with a mean pH of 5.2. Susan John et al. (2009a) also reported that the pH of the cassava growing lowland and upland soils of Pathanamthitta district were 5.0 and 4.83 respectively. Based on the soil nutritional requirement for cassava proposed by Howeler (1996), the soils of all the blocks and the district in general were found to be optimum with respect to soil reaction.

Organic C

The organic C status of the soils of this district was found to be very high with 17.26% of the samples having 1.51-1.83% and 16.83% with 1.26-1.50% organic C, which in turn indicated that 92.34% of the samples were high having more than 0.75% organic C (Fig. 2). The high organic C status of these soils can be attributed to the findings of Joseph et al. (1990) and Karthikakuttyamma et al. (1991) that the uplands of Pathanamthitta districts now growing cassava and other tuber crops were once planted with rubber and hence these soils were rich in organic C. All the 10 blocks of the district were found to be high in organic C with values of 1.3-2.1% with a mean value of 1.7% (Table 6). This corroborates with the reports of the Soil Survey Organization (2007) that the mean organic C status of the bench mark soils of Pathanamthitta was 1.36%.The soils of all the blocks and the district as a whole was found to be medium with respect to organic matter status of the soil considering the soil nutritional requirement for cassava. The soil nutrient index value worked out was 2.89, which was high as per Parker et al. (1957) (>2.5) and Ramamoorthy and Bajaj (1969) (>2.33). The organic C content of the cassava growing lowland and upland soils of Pathanamthitta district was reported as 0.86 and 0.88% respectively in a rapid appraisal of the nutrient status of cassava growing soils of Kerala (Susan John et al., 2009a).



UA-Ultra acid, EA- Extremely acid, VSA-Very strongly acid, SA-Strongly acid, MA-Moderately acid, SLA-Slightly acid, AN-Acidic-neutral

Fig.1. Percentage distribution of soil samples under different pH groups

Major nutrients

Available P

The available P status of the tuber crops growing soils of this district was found to be very high as 52.7% of the samples had

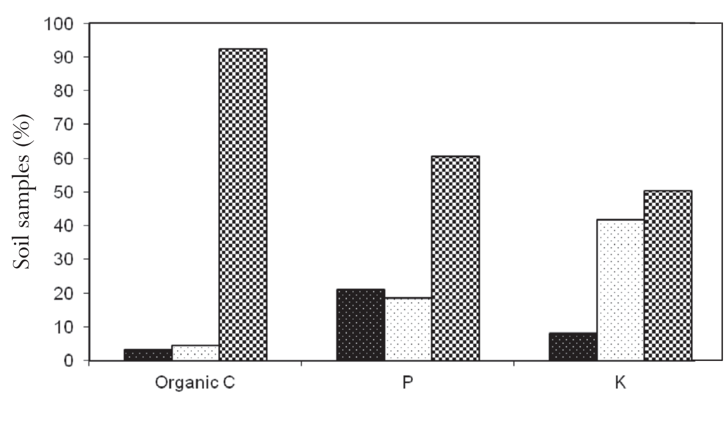


Fig.2. Percentage distribution of soil samples under different major nutrient groups

Table 6. General evaluation of the macro and secondary nutrient status of the tuber crops growing soils of Pathanamthitta district

Name of block	pH	Organic C (%)	Available P (kg ha^{-1})	Exchangeable K (kg ha^{-1})	Exchangeable Ca (μg g^{-1})	Exchangeable Mg (μg g^{-1})	Available S (μg g^{-1})
Elanthur	5.4	1.5	99	289	519	70	21.8
Parakkode	5.4	1.3	95	215	608	54	23.4
Mallappally	5.2	2.1	61	334	736	114	33.3
Adoor municipality	4.7	1.3	38	322	199	36	28.6
PTA municipality	5.1	1.3	81	357	826	78	35.2
Kulanada	5.6	1.3	78	271	889	232	20.2
Ranni	4.9	2.1	41	389	934	315	51.0
Pandalam	4.8	1.5	47	241	440	184	43.9
Konni	5.0	1.8	120	409	599	219	40.3
Koipram	5.2	1.9	63	314	729	159	34.1
Pathanamthitta district	5.2	1.7	75	320	699	167	34.8

available P more than 34.5 kg ha^{-1} (Table 6). Samples under the other 10 groups ranged from 2-9% only. As per the general classification, it was seen that 21, 18 and 61% of the samples fell in the low (<10 kg ha^{-1}), medium (11-25 kg ha^{-1}) and high (>25 kg ha^{-1}) P groups respectively (Fig.2). The soils of all the 10 blocks were very high with respect to available P with values ranging from 38-120 kg ha^{-1} with a mean value of 75 kg ha^{-1} for the district. As per the soil nutritional requirement of P for cassava, the tuber crops growing soils of all the blocks and the district as a whole was found to be high. The soil nutrient index for P was worked out as 2.40, which according to Parker et al. (1957) was medium (< 2.5) and high as per Ramamoorthy and Bajaj (1969) (>2.33). But Susan John et al. (2009a) after evaluating the P status of cassava growing soils of Pathanamthitta, reported the mean content of the lowland and upland soils as medium (15.38 and 13.93 kg ha^{-1} respectively). The Soil Survey Organization (2007) also indicated that the mean P status of the five bench mark soils of Pathanamthitta district was medium to high in the range of 15-35 kg ha^{-1}.

Exchangeable K

A major part (28%) of the soils of Pathanamthitta district belonged to the high K status (>395 kg ha^{-1}). The other 10 groups fell between 1-11% of the samples only. As per the general classification suggested by Dev (1997), 50, 42 and 8% of the samples received from the district were found in the high, medium and low category respectively (Fig.2). In the case of different blocks of the district, the K status of tuber crops growing soils was medium in Parakkode, Kulanada and Pandalam blocks with values ranging from 215-271 kg ha^{-1} and all the other blocks including the district as a whole was found high with respect to exchangeable K. The soil nutritional requirement of cassava as proposed by Howeler (1996) also indicated that the exchangeable K status of all the 10 blocks, except Parakkode, as well as the district in general was high. The soil nutrient index value of K for the tuber crops growing soils of the district was worked out as 2.42, which was medium (>2.5) as per Parker et al. (1957) and high (>2.33) as per Ramamoorthy and Bajaj (1969). Susan John et al. (2009a) indicated that the exchangeable K status of cassava growing upland soils of Pathanamthitta district was 353.2 kg ha^{-1}, whereas the Soil Survey Organization (2007) reported a mean value of 190 kg ha^{-1} for the bench mark soils of Kerala. But Joseph et al. (1990) and Karthikakuttyamma et al. (1991) reported that the soils of Pathanamthitta was deficient in K.

Secondary nutrients

Exchangeable Ca

In the case of exchangeable Ca, 77% of the total soil samples collected from tuber crops growing soils were sufficient having more than 300 μg g^{-1} exchangeable Ca (Fig.3). Exchangeable Ca status of all the blocks, except

Adoor municipality, was satisfactory, ranging from 440-889 $\mu g\ g^{-1}$ with a mean value of 699 $\mu g\ g^{-1}$ for the district as a whole (Table 6). Susan John et al. (2009b) reported that the exchangeable Ca status of the lowland and upland soils of the cassava growing areas of Pathanamthitta district was 600 $\mu g\ g^{-1}$ and 195 $\mu g\ g^{-1}$ respectively. The mean exchangeable K status of the five benchmark soils of Pathanamthitta district was reported as 582 $\mu g\ g^{-1}$ by Soil Survey Organization (2007). According to the soil nutritional requirement for cassava reported by Howeler (1996), all the blocks, except Adoor municipality, was medium with respect to exchangeable Ca having a status of 200-1000 $\mu g\ g^{-1}$.

Exchangeable Mg

Out of the total samples received from tuber crops growing soils, 42% were found to be sufficient in Mg and the rest of the samples had Mg status less than 120 $\mu g\ g^{-1}$ (Fig.3). Considering the district as a whole, only 50% of the blocks *viz.*, Kulanada, Ranni, Pandalam, Konni and Koipram were sufficient in this nutrient and the rest of the blocks had Mg level to the tune of 36-114 $\mu g\ g^{-1}$. The mean exchangeable Mg content of the district was seen as 167 $\mu g\ g^{-1}$. The data in Table 6 also indicated that, except Adoor municipality, all the blocks were medium in Mg having 48-120 $\mu g\ g^{-1}$ Mg as per the criteria fixed by Howeler (1996). Though Mg status under the present study was found to be reasonably good, the earlier reports by Susan John et al. (2009b), Susan John and Venugopal (2005) and Soil Survey Organization (2007) indicated chronic deficiency of this nutrient in this district.

Available S

As per the general rating, in the district, 90% of the total soil samples from tuber crops growing areas were satisfactory with more than 5 $\mu g\ g^{-1}$ S and the rest were deficient (Fig.3). The tuber crops samples from all the blocks were sufficient with values ranging from 20.2-51 $\mu g\ g^{-1}$ (Table 6). The mean value for the district is 34.8 $\mu g\ g^{-1}$. However, as per the ratings suggested by Howeler (1996) for S requirement of cassava, only three blocks *viz.,* Ranni, Pandalam and Konni were medium with 40-70 $\mu g\ g^{-1}$ S and the overall status of the district also was found to be low.

Micronutrients

In the case of micronutrients *viz.*, Fe, Cu, Mn, Zn and B, except B, all were sufficient in the tuber crops growing soils of the district (Fig.3). About 99.82, 89.57, 99.23 and 99.42% samples had $>5\ \mu g\ g^{-1}$ Fe, $>1\ \mu g\ g^{-1}$ Cu, $>1\ \mu g\ g^{-1}$ Mn and $>1\ \mu g\ g^{-1}$ Zn respectively. In the case of B, 56% of the samples were found to be deficient with $<0.5\ \mu g\ g^{-1}$ B. All the 10 blocks were sufficient with respect to Fe, Cu, Mn and Zn. But B was deficient in four blocks *viz.*, Pathanamthitta municipalty, Ranni, Pandalam and Konni with values ranging from 0.2-0.4 $\mu g\ g^{-1}$ (Table 7). The present finding corroborates with the soil nutritional requirement of cassava fixed by Howeler (1996). Similarly Susan John et al. (2009b) reported that Fe, Cu, Mn and Zn status of the cassava growing lowland and upland soils of Pathanamthitta district was 23, 10, 3, 1 and 30, 21, 2 and 1 $\mu g\ g^{-1}$ respectively. Nayyar (1999) also found that the Fe content of Indian soils ranged from 0.8-196 $\mu g\ g^{-1}$ with an average value of 19 $\mu g\ g^{-1}$. Moreover, Sumam George (1994) and Susan John and Venugopal (2005) also found that the status of Fe, Cu, Mn and Zn in Kerala soils were sufficient. However, the district as a whole was found to be well supplied with all the five

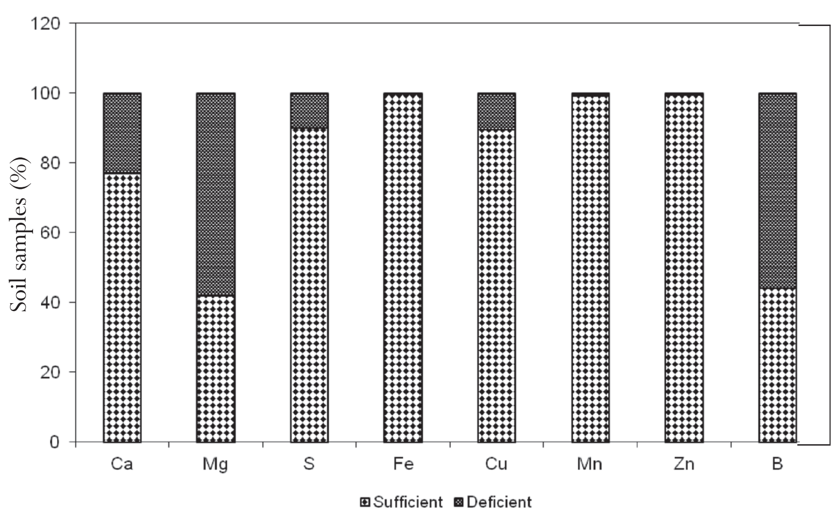


Fig.3. Percentage distribution of soil samples under different secondary and micro nutrient groups

Table 7. Micronutrient status of different blocks of Pathanamthitta district (μg g^{-1})

Name of block	Zn	B	Fe	Cu	Mn
Elanthur	5.1	1.5	38.3	8.2	32.1
Parakkode	5.7	0.8	40.4	3.4	32.8
Mallappally	3.9	0.6	35.1	2.5	41.0
Adoor municipality	2.9	0.6	39.1	1.6	20.4
PTA municipality	7.1	0.4	39.9	4.2	32.6
Kulanada	7.0	0.6	31.4	3.8	31.8
Ranni	3.6	0.3	26.6	3.3	15.2
Pandalam	2.8	0.2	38.3	2.6	14.0
Konni	4.6	0.4	47.5	3.3	26.7
Koipram	4.6	0.8	37.5	5.9	46.6
Pathanamthitta	4.6	0.6	36.8	4.0	29.9

micronutrients.

Soil based nutrient management plan for tropical tuber crops of the district

As the soils of Pathanamthitta district were found to be strongly acidic, in general liming @ 300 kg ha^{-1} is recommended to raise the soil pH as well as to supply Ca. But in the case of tropical tuber crops growing soils, rather than suggesting lime, experimental evidences indicate that it is better to apply dolomitic limestone @ 105 kg ha^{-1} to supply both Ca and Mg, especially in soils where Mg is deficient. As cassava is found tolerant to soil acidity (Susan John and Venugopal, 2006), lime application can be restricted. As the organic C status of all the blocks was very high, organic manure application can be managed site specifically depending upon its soil status and crop needs. Since tuber crops in general require organic manures in large quantities and as the status of organic C was found very high (1-2.5%) in 90% of the soils, the rate of application of organic manure can be reduced to 50-75% of the existing POP recommendation. For cassava, as per the rate of application evolved based on soil organic C status (Susan John et al., 2010), the present recommendation of FYM @ 12.5 t ha^{-1} can be reduced to 5 t ha^{-1}.

In the case of N, application rate can be reduced from 100 kg ha^{-1} to 63-78% depending upon the organic C status (Table 2 and Table 7). Since the available P status of the soils of all blocks was very high, the application can be either skipped for 2-5 years or reduced to 25-50% of the POP depending upon the soil status and crop needs for all tuber crops. As the soil status of K was medium in Parakkode, Kulanada and Pandalam blocks, K application @ 50-100% of the POP recommendation can be resorted to depending upon the situation. In the other seven blocks, as the K content was high to very high, the dose can be reduced up to 25-50 % of POP.

As all the micronutrients were sufficient in the soils of all blocks, no supplementation through micronutrient fertilizers is required. As B was deficient in the soils of the blocks of Ranni, Pandalam, Konni and Pathanamthitta municipality, soil application of B as borax @10 kg ha^{-1} is recommended for cassava. In the case of any Mg deficiency or Zn deficiency, soil application of blanket dose of $MgSO_4$ @ 20 kg ha^{-1} and $ZnSO_4$ @12.5 kg ha^{-1} can be done within 2 months of planting cassava at an interval of 1- 2 weeks between the two applications. However, Susan John et al. (2010) arrived at the need based application of these nutrients for cassava based on soil status as well as their soil critical levels. The superiority of soil based fertilizer cum manurial application over the existing POP with respect to yield, quality and economic parameters was reported in different crops *viz.,* maize (Cassman and Liska, 2007), cassava (Kamaraj et al., 2008; Susan John et al., 2010; Susan John et al. 2011a; 2011b; 2011c), rice (Mukhopadyay et al., 2008) and sugarcane (Singh et al., 2008).

Conclusion

The overall nutrient status of Pathanamthitta district indicated that the soil was strongly acidic with high content of organic C, available P, exchangeable Ca and S, medium to high K and Mg and 100% sufficiency with respect to Fe, Cu, Mn, and Zn. The small extent of Mg and B deficiency noticed in some blocks of the district can be rectified through the application of dolomitic limestone and borax respectively. However, caution may be taken to avoid the continuous application of all micronutrients so that their level do not surpass the toxic concentrations. As the practice of soil based application of manures and fertilizers including secondary and micronutrients in cassava undertaken both on station and on farm was found promising due to saving of N and K fertilizers to the extent of 50-90% and P to 100%, it can be recommended and validated not only for tuber crops but also for other crops in the district of Pathanamthitta. This in turn can convince the farmers on the need based application of nutrients not only to enhance their income but also to sustain soil health and protect human health.

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