Research Article

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Identifying and mapping leaf nutrient based constraints for coconut productivity in Coimbatore and Tiruppur districts of Tamil Nadu state, India

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Abstract

In the existing perennial plantations like coconut, leaf nutrient testing will be a promising tool to identify the existing crop nutrition related constraints and for formulating the suitable management options to improve the crop productivity. Therefore this study was conducted with the objectives of identifying the nutrient deficiency and mapping the spatial distribution of leaf based nutrient deficiency for site specific nutrient management. The study area was coconut land cover of Coimbatore and Tiruppur districts of Tamil Nadu state, India. Leaf samples and yield data were collected from 110 geo-referenced sites. Leaf samples were analysed for macro and micronutrients. The nutrient deficiency maps were developed for macro and micronutrient management. Thematic maps showed that N status was deficient in 95.99 per cent, P in 86.19 per cent, K in 1.42 per cent and Mg in 0.81 per cent area of the coconut land cover area. Ca and S were observed to be sufficient. Fe was found to be deficient in 0.64 per cent, Mn in 0.84, Zn in 0.54 per cent, Cu status in 2.62 per cent and B in 10.72 per cent of the coconut land cover area.

Keywords: Coconut, constraints, GIS, leaf nutrient status, mapping

Introduction

Coconut (*Cocos nucifera* Linn.) was grown in 1.90 million hectares in India in the year 2010-11 with a production of 10,840 million nuts and an average productivity of 5,718 nuts ha^{-1} $year^{-1}$ (Bijay Kumar, 2011). Considering the larger extent of area under coconut and its importance in the livelihood of farmers, developing site specific nutrient management strategies based on the nutrient deficiencies identified to improve the coconut performance will be a major contributor for the agricultural growth of coconut growing regions and strengthening and sustaining farmer's livelihood.

Leaf analysis has been recognized as a reliable method for detecting nutrient deficiencies in perennial crops like coconut. It is possible to measure the degree of nutrient deficiency by leaf analysis and to assess the level at which nutrients should be supplemented. In tree crops like coconut, the plant diagnostic methods give more reliable information on the nutritional status of plants in relation to soil fertility. Leaf analysis enables us to directly measure the nutritional status of the trees. The nutrient supply then can be adjusted to bring the levels of nutrients in the tissues back to within the determined limits. Hence this study was carried out with the objectives to assess and map the nutritional status of coconut based on leaf nutrient status so as to tailor the nutrient management strategies to improve the nutritional status of the coconut groves and productivity.

Materials and methods

The study area covers Coimbatore and Tiruppur districts of Tamil Nadu state. Coimbatore district has a geographical area of 4,722 sq. km and geographically positioned within North latitude

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between 10°10' and 11°30'and East longitude between 76°40' and 77°30'. Total cultivated area of Coimbatore district is 1,87,782 ha. This district has coconut as major crop with an area of 79,532 ha and with a productivity of 14,470 nuts ha^{-1} $year^{-1}$ (CDB, 2010). Geographical area of Tiruppur district is 5,186.34 square kilometers with the total cultivated area of 2,28,556 ha. Tiruppur district has 47,826 ha of coconut with the productivity of 3864 nuts ha^{-1} $year^{-1}$ in the year 2009-10 (CDB, 2010). Since coconut is the major crop in these two districts, study area of this present study covers both the districts.

A survey was carried out covering 110 geo-referenced collection sites located across the coconut land cover of Coimbatore and Tiruppur districts. The coconut plantations in these districts were not contiguous, hence, only the area under coconut land cover was considered for the field studies. The sampling points were distributed accordingly to represent the major coconut growing areas in the district. In Coimbatore district 73 sites were sampled, while 37 sites were sampled in Tiruppur district.

Leaf samples were collected from the index leaf (14^{th} frond) of all the sampled palms. The middle three leaflets of both the sides of the frond were collected. Samples were processed and wet digestion of a known quantity of plant material was carried out with di-acid mixture (H_2SO_4 and $HClO_4$ in the ratio of 5:2 respectively) for N estimation, di-acid mixture of HNO_3 and $HClO_4$ in the ratio of 9:4 respectively for S estimation and triacid mixture (nitric, sulphuric and perchloric acid in the ratio of 9:2:1, respectively) for P, K, Ca, Mg, Fe, Mn, Zn, Cu and B estimation (Piper, 1966). The digested samples were made up to the desired volume and used for the estimation of macro and micronutrients as per the standard methods *viz*., N by Microkjeldahl method (Humphries, 1956), P by vanadomolybdate yellow colour method (Jackson, 1973), K by flame photometer (Stanford and English, 1949), Ca and Mg by versenate titration (Diehl *et al.*,1950), S by turbidimetry (Chaudry and Cornfield, 1966), Fe, Mn, Zn and Cu by atomic absorption spectrophotometer (Jackson, 1973) and B by azomethane H reagent (Berger and Troug, 1939).

The sample plantations were geocoded using the latitude and longitude recorded using GPS from the survey conducted. The base map was prepared using the digital map of the study area developed from the toposheets, coconut land cover map and the digitized sample plantations. Database on leaf nutrient status were developed and updated with sample numbers using Microsoft Excel package. The database then exported to ArcGIS 8.2 *via* dBase IV format and the attribute table was geocoded. Using the coconut land cover map, thematic maps on leaf nutrient status were generated from the attribute table.

Results and discussion

Leaf nutrient status of coconut plantations in the study area

The observed leaf macro nutrient status and observed deficiency are given in Table 1 and leaf micronutrient status and deficiency are given in Table 2.

Primary nutrients

In the overall study area, the leaf N content was found to be in the range of 0.71 to 2.63 per cent and mean of 1.42 per cent with a CV of 31.97 per cent. The deficiency of leaf N content was observed in 69 per cent of the samples in the study area. The low available N found might be due to the low organic C content found in this area since major portion of the N pool is contributed by organic matter. Similar results were reported by Padmavathi (2011), who also reported low N status in Udumalapet block and medium status in Avinashi block of these districts. In the study area, 63 per cent of the samples showed deficiency in the leaf P content. The leaf P content ranged from 0.05 to 0.15 per cent with the mean of 0.11 per cent and CV of 19.90 per cent. Leaf potassium content was mostly sufficient and only 16 per cent of the samples in the study area showed K deficiency. The coconut leaf K content ranged from 0.51 to 1.76 per cent and the mean and CV was 0.99 and 24.21 per cent.

Secondary nutrients

In the study area the leaf Ca content was found to be in the range of 0.54 to 1.92 per cent and mean of 0.88 per cent with the CV of 30.82 per cent. All the samples were sufficient in leaf Ca status. Around 18 per cent of the samples showed Mg deficiency. The coconut leaf Mg content ranged from

0.11 to 1.51 per cent and the mean and CV was 0.47 and 42.84 per cent. The Mg deficiency might have been resulted by the higher Ca in calcareous soils and/or high K content which shows antagonistic relationship with Mg uptake. The low Mg content of some of the coarse red soils may also lead to deficiency of Mg in coconut. In the overall study area, the leaf S content was found to be in the range of 0.16 to 2.14 per cent and mean of 0.62 per cent with the CV of 64.60 per cent. Leaf S content was found to be sufficient in all the samples. Similarly high available S content in soils was observed in these two districts by Poongothai *et al.* (2000).

Micronutrients

Leaf Fe content of the study area showed 6 per cent of the samples as deficient. The leaf Fe content ranged from 37 to 392 mg kg^{-1} with a mean of 231 mg kg^{-1} and CV of 30 per cent. In the study area 7 per cent of the samples showed Mn deficiency. The coconut leaf Mn content ranged from 158 to 634 mg kg^{-1} and the mean of 315 mg kg^{-1} and CV of 33 per cent. Around 15 per cent of the samples showed Zn deficiency. The coconut leaf Zn content ranged from 6.6 to 40.7 mg kg^{-1} and the mean of 19.1 mg kg^{-1} and CV of 43.7 per cent. Leaf Cu content of 11 per cent of the samples showed deficiency. The leaf Cu content ranged from 2.0 to 54.8 mg kg^{-1} with the mean of 10.8 mg kg^{-1} and CV of 66.8 per cent. Cu deficiency might be caused by the high pH observed which might have reduced the Cu availability by precipitation of Cu as its hydroxides. B deficiency was found in 17 per cent of the leaf samples in the study area. B deficiency in the soil was also reported by Poongothai *et al.* (2000) in the Coimbatore district. The coconut leaf B content ranged from 3.1 to 23.8 mg kg^{-1} and the mean 12.6 mg kg^{-1} and CV was 36.1 per cent.

Mapping leaf nutrient based constraints

Thematic maps of coconut leaf macro and micronutrients were prepared using the attribute data of leaf nutrient status and coconut land cover map of the study area (Table 3 and Fig. 1 and 2).

Primary nutrients

Leaf N status of most of the coconut land cover of the Coimbatore and Tiruppur districts

Table 1. Primary and secondary nutrient status of coconut leaf in the coconut landcover of Coimbatore and Tiruppur districts of Tamil Nadu state

Nutrient	District	Min. (%)	Max. (%)	Mean (%)	CV (%)	Per cent sample	
						Deficient	Sufficient
N	Coimbatore	0.76	2.63	1.44	33.43	68	32
	Tiruppur	0.71	1.90	1.38	28.67	69	31
	Overall study area	0.71	2.63	1.42	31.97	69	31
P	Coimbatore	0.07	0.14	0.11	14.80	56	44
	Tiruppur	0.05	0.15	0.10	27.19	78	22
	Overall study area	0.05	0.15	0.11	19.90	63	37
K	Coimbatore	0.51	1.76	0.99	24.89	12	88
	Tiruppur	0.51	1.43	0.99	23.13	22	78
	Overall study area	0.51	1.76	0.99	24.21	16	84
Ca	Coimbatore	0.54	1.32	0.84	24.7	0	100
	Tiruppur	0.54	1.92	0.96	37.33	0	100
	Overall study area	0.54	1.92	0.88	30.82	0	100
Mg	Coimbatore	0.12	1.51	0.49	39.12	14	86
	Tiruppur	0.11	1.24	0.42	50.08	28	72
	Overall study area	0.11	1.51	0.47	42.84	18	82
S	Coimbatore	0.16	1.94	0.56	62.06	0	100
	Tiruppur	0.18	2.14	0.76	62.93	0	100
	Overall study area	0.16	2.14	0.62	64.60	0	100

Table 2. Micronutrient status of coconut leaf in the coconut landcover of Coimbatore and Tiruppur districts of Tamil Nadu state

Nutrient	District	Min (%)	Max (%)	Mean (%)	CV (%)	Per cent sample	
						Deficient	Sufficient
Fe	Coimbatore	103	391	246	23	0	100
	Tiruppur	37	392	199	42	17	83
	Overall study area	37	392	231	30	6	94
Mn	Coimbatore	185	614	320	27	1	99
	Tiruppur	158	634	305	44	19	81
	Overall study area	158	634	315	33	7	93
Zn	Coimbatore	6.6	40.7	20.2	42.6	12	88
	Tiruppur	7.4	35.2	16.9	43.8	19	81
	Overall study area	6.6	40.7	19.1	43.7	15	85
Cu	Coimbatore	2.0	29.4	11.2	56.1	10	90
	Tiruppur	3.6	54.8	10.0	88.5	14	86
	Overall study area	2.0	54.8	10.8	66.8	11	89
B	Coimbatore	3.1	23.8	12.9	36.4	16	84
	Tiruppur	5.1	22.3	12.0	35.3	19	81
	Overall study area	3.1	23.8	12.6	36.1	17	83

(95.99 per cent, 1 08,493 ha) was found to be deficient (<1.8%N). Only 4.01 per cent (4,529 ha) of the coconut land cover area was sufficient (>1.8% N) in leaf N. Around 86.19 per cent (97,408 ha) of the area registered deficiency (<0.12% P) in leaf P content and 13.81 per cent of the land cover was sufficient (>0.12% P). The maximum area (1,11,416 ha, 98.58%) of the coconut land cover showed sufficiency (>0.8% K) in leaf K status. Around 1.42 per cent (1,605 ha) of the coconut land cover showed deficiency (<0.8% K) in leaf K status.

Secondary nutrients

There were no deficiency areas delineated for leaf Ca (<0.5% Ca) and S content (0.15% Ca). Considering leaf Mg, major area (1,12,104 ha) was sufficient (<0.3% Mg) and 0.81 per cent of the coconut land cover was found to be deficient.

Micronutrients

Deficiencies of leaf Fe, Mn, Zn, Cu and B were prevailing in the coconut land cover of the Coimbatore and Tiruppur districts. Leaf Fe was found to be sufficient (>100 ppm Fe) in 1,12,296 ha (99.36%) and 726 ha area showed deficiency (<100 ppm Fe) in leaf Fe status. Around 1,12,047 ha (99.14%) area was found to be sufficient

Table 3. Leaf nutrient status based nutrient deficiency identified for coconut and their area extent in the existing coconut land cover of Coimbatore and Tiruppur district derived from the thematic maps

Nutrient	Range		Area (ha)	Per cent to the total area
N (%)	<1.8	Deficient	108493	95.99
	>1.8	Sufficient	4529	4.01
P (%)	<0.12	Deficient	97408	86.19
	>0.12	Sufficient	15614	13.81
K (%)	<0.8	Deficient	1605	1.42
	>0.8	Sufficient	111416	98.58
Ca (%)	<0.5	Deficient	0	0.00
	>0.5	Sufficient	113022	100.00
Mg (%)	<0.3	Deficient	917	0.81
	>0.3	Sufficient	112104	99.19
S (ppm)	<0.15	Deficient	0	0.00
	>0.15	Sufficient	113022	100.00
Fe (ppm)	<100	Deficient	726	0.64
	>100	Sufficient	112296	99.36
Mn (ppm)	<200	Deficient	975	0.86
	>200	Sufficient	112047	99.14
Zn (ppm)	<10	Deficient	612	0.54
	>10	Sufficient	112410	99.46
Cu (ppm)	<6	Deficient	2962	2.62
	>6	Sufficient	110060	97.38
B (ppm)	<10	Deficient	12116	10.72
	>10	Sufficient	100905	89.28

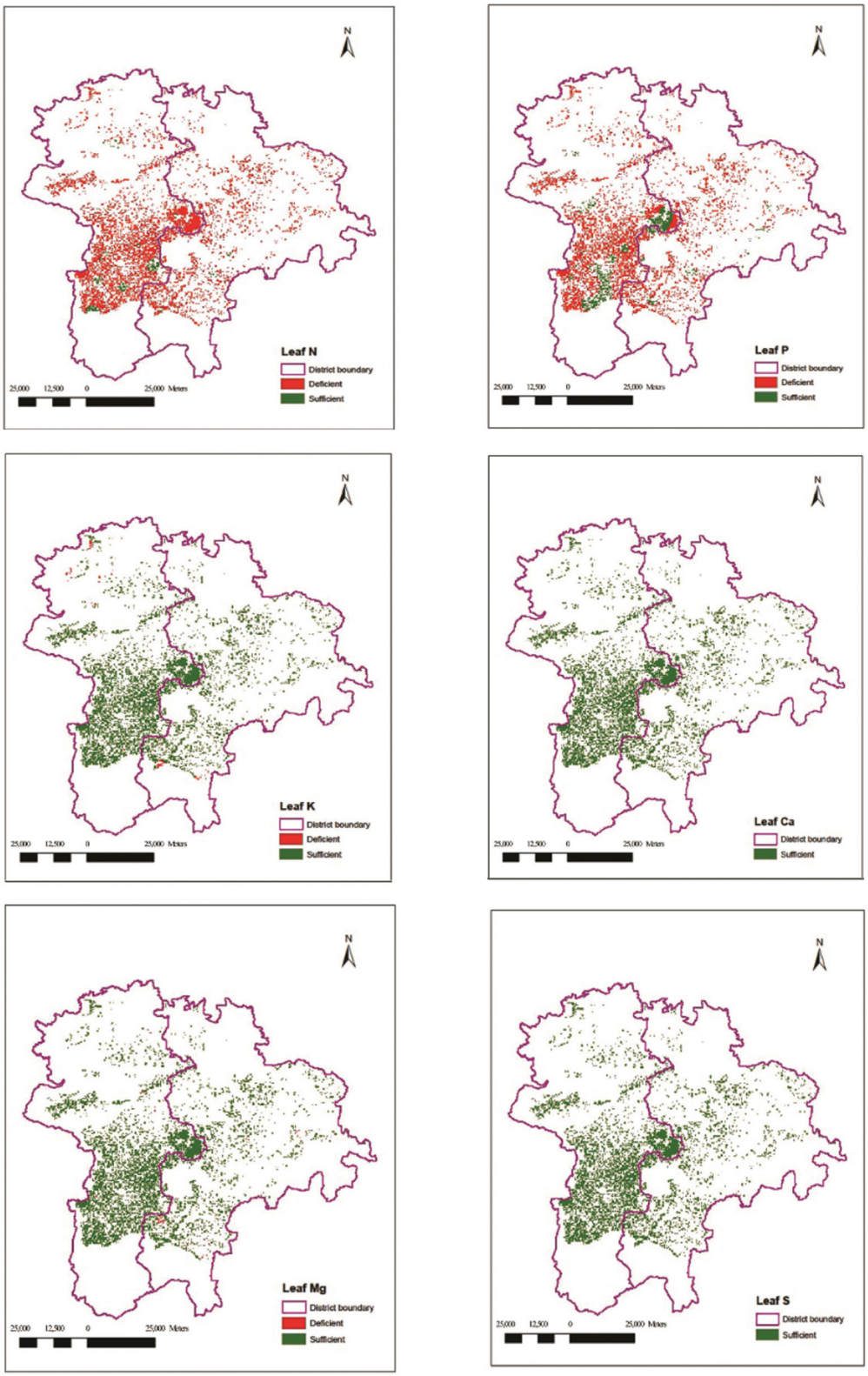

Fig. 1. Spatial distribution of leaf macro nutrient status in the coconut land cover of Coimbatore and Tiruppur districts of Tamil Nadu state

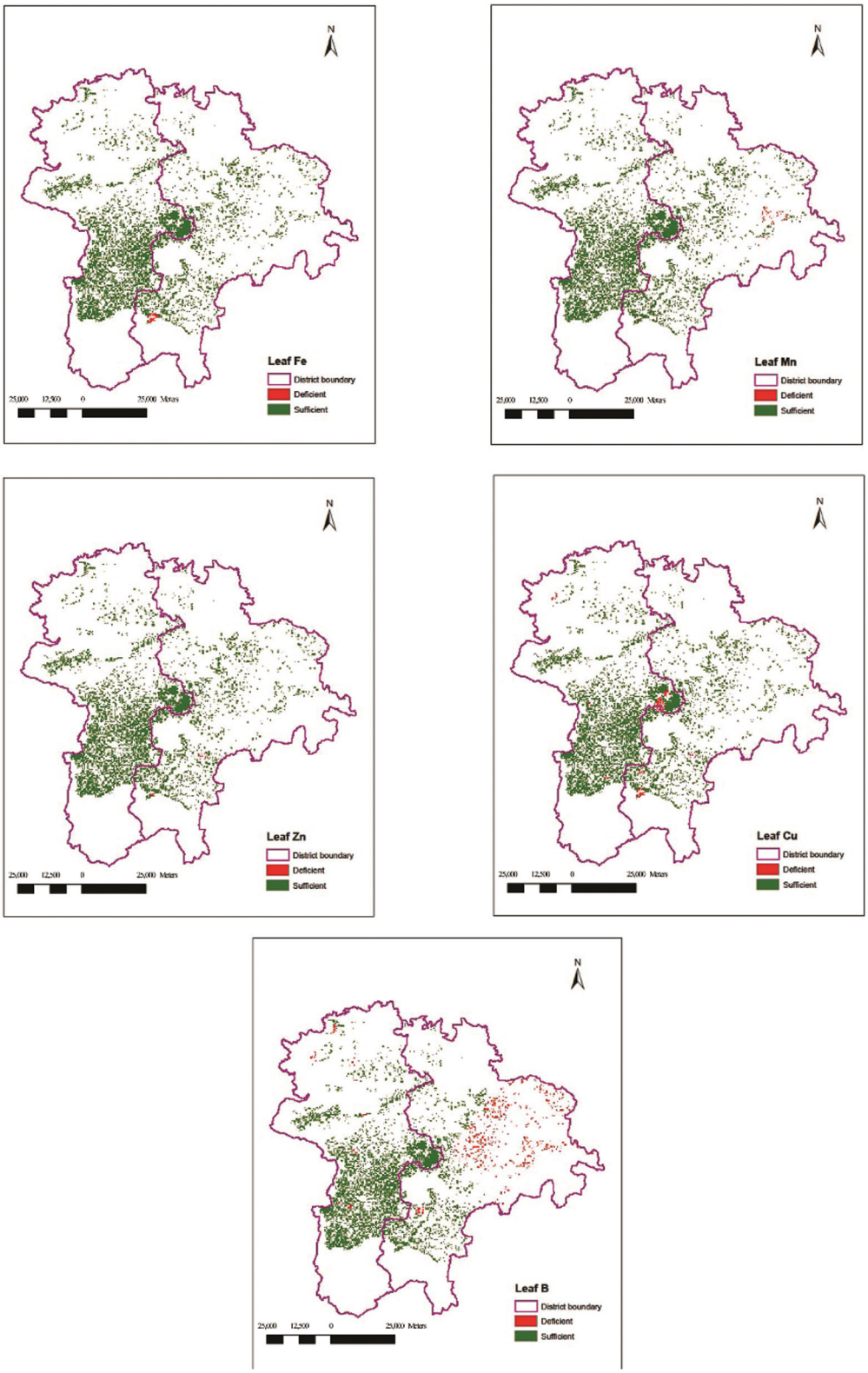

Fig. 2. Spatial distribution of leaf micronutrient status in the coconut land cover of Coimbatore and Tiruppur districts of Tamil Nadu state

(>200 ppm Mn) in leaf Mn and 975 ha (0.86%) was found to be deficient (<200 ppm Mn). Leaf Zn status of 612 ha (0.54%) was deficient (<10 ppm Zn) and 1,12,410 ha (99.46 %) area was sufficient. Regarding leaf Cu status 2.62 per cent (2,962 ha) area was deficient (<6 ppm Cu) and 97.38 per cent (1,10,060 ha) area was sufficient. Leaf B status of 10.72 per cent (12,116 ha) of the coconut land cover area was found to be deficient (<10 ppm B) and 89.28 per cent (1,00,905 ha) of the area was sufficient.

Conclusion

The spatial information generated may be useful in formulating site specific nutrient management strategies to improve the nutrient status of the deficient nutrients observed for improving the coconut productivity in this region.

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