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Status of major nutrients in soils of cardamom (*Elettaria cardamomum* Maton) plantations in Kodagu District, Karnataka, India

V S Korikanthimath, A V Gaddi & S J Ankegowda

Indian Institute of Spices Research
Cardamom Research Centre
Appangala, Madikeri - 571 201, Karnataka, India.

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Abstract

Soils were collected from various cardamom (*Elettaria cardamomum*) plantations in Kodagu District (Karnataka, India) and assessed for nutrient status. The soils were acidic (5.0 to 6.6 pH) in nature with high organic carbon content, which decreased with depth of the soil. The soils were medium (56.82%) to high (43.18%) in available nitrogen, low (79.55%) in available phosphorus and low (38.63%) to medium (52.27%) in available potassium. The soil profile collected from cardamom fields indicated relatively higher level of available nitrogen and organic matter than from uncultivated area due to recycling of organic materials in the former. The organic carbon content was correlated positively and significantly with available nitrogen content.

Key words : cardamom, *Elettaria cardamomum*, nutrient status, soil.

Introduction

Cardamom (*Elettaria cardamomum* Maton) is cultivated in the evergreen forests of Western Ghats of India, 500 to 1500 m above MSL, which normally receives 1500 to 3250 mm rainfall and has a temperature range of 15 to 32°C. Leaching of nutrients is common in cardamom plantations due to heavy rainfall and undulating topography. Besides, continuous cultivation of cardamom on the same land leads to depletion of nutrients is the soil resulting in poor growth and reduced yields. A study was hence undertaken to assess the fertility status of soils of cardamom plantations in various locations in Kodagu District, Karnataka (India).

Materials and methods

Two soil profiles each (from cardamom area and uncultivated area) were collected from surface (0–15 cm) and subsurface (15–30 cm) regions from 44 locations in Kodagu District, Karnataka. The pH of the soil was determined in 1:2.5 soil to solution ratio (Jackson 1973). The wet-oxidation method (Walkley & Black 1934) was used to determine the organic carbon content. The available nitrogen was determined by alkaline permanganate method (Subbaiah & Asij 1956). The available phosphorus in soil was extracted by Brays and Kurtz method and concentration of P in the solution was estimated colorimetrically by spectrophotometer (Jackson 1973). Available potassium and exchangeable calcium were extracted with neutral normal ammonium acetate. The concentration of K^+ and Ca^{2+} in the solution were measured by flame photometer and versenate titration method, respectively (Black 1965).

The nutrient levels in the soils were classified as low, medium and high in status according to the classification given by Velayutham & Bhattacharyya (2000). The classification is as follows:

Nutrient	Class		
	Low (kg ha^{-1})	Medium (kg ha^{-1})	High (kg ha^{-1})
Available nitrogen	<280	280–560	>560
Available phosphorus	<10	10–25	>25
(P_2O_5)	(22.9)	(22.6–57.25)	(>57.25)
Available potassium	<110	110–180	>180
(K_2O)	(132)	(132–216)	(>216)

Results and discussion

The soils collected from various locations were acidic in reaction and the pH values ranged from 5.2 to 5.9 and 5.2 to 5.6 in cardamom and uncultivated field profiles, respectively. Its contents decreased with depth in both the profiles. Relatively higher pH was observed in cardamom fields when compared to uncultivated fields owing to higher calcium content in the soil (Table 1). The decrease observed down the profile may also be due to decrease in calcium content with profile depth. High rainfall coupled with leaching of bases from the soil and increase in the activity of exchangeable aluminium in the soil probably lead to development of soil acidity (Sahu *et al.* 1990).

The surface soils were high in organic carbon, which ranged from 0.6 to 1.53% and 0.39 to 1.38% in first and second profile, respectively. Higher organic matter build up was observed in surface layer, indicating that addition of leaf litter and farm yard manure application was retricted to surface layer only. Similar results were reported earlier by Korikanthimath (1994). All the nutrients namely, N, P and K decreased with depth in both the profiles. The nitrogen in soil profile ranged from 209.9 to 383.2 kg ha^{-1} and 126.1 to 357.0 kg ha^{-1} in first and second profile, respectively. The available nitrogen status was low to medium in both the profiles; however, slightly higher amount of nitrogen was observed in the profile from cardamom field than in uncultivated field probably due to the higher organic carbon content in the former.

The phosphorus content ranged from 22.8 to 51.7 kg ha^{-1} and 21.6 to 57.0 kg ha^{-1} and potassium content varied from 89.22 to 130.0 kg ha^{-1} in first and second profile, respectively. The available phosphorus in soil was low to medium and potassium was low in status. Both the nutrients decreased with profile depth probably because application of nutrients is confined to surface layer. The low potassium content in these soils may be due to the type of parent material (shale) from which they have been developed. The main source of potassium in these soil appears to be K-feldspars which resist the release of potassium because of bonding of K in the silicate structure that offers considerable resistance to release (Ponda 1978).

The soil profile collected from cardamom fields had relatively higher content of organic carbon as well as available nutrients. The addition of leaf biomass was more in cardamom fields compared to uncultivated fields. This might have resulted in higher organic carbon and available nutrients in the soil (Korikanthimath 1994).

The soils collected from surface and subsurface layers in different plantations were also analysed for pH, organic carbon and major nutrients (Table 2). The soils were acidic in nature which indicates

Table 1. Major nutrient distribution in soil profiles of cardamom fields and uncultivated fields

Depth (cm)	pH (1:2.5)	O C (%)	Av. N (kg ha^{-1})	Av. P_2O_5 (kg ha^{-1})	Av. K_2O (ppm)	Ca
I Profile (cardamom field)						
0–15	5.9	1.53	383.2	51.7	130.0	537.5
15–30	5.8	1.39	292.7	47.8	98.0	287.5
30–45	5.8	1.28	266.6	45.8	92.0	250.0
45–60	5.7	0.69	248.8	34.4	90.0	212.5
60–75	5.6	0.63	214.2	22.9	89.2	175.0
75–90	5.5	0.60	209.9	22.8	89.2	167.5
II Profile (uncultivated field)						
0–15	5.6	1.38	357.0	57.0	130.0	212.5
15–30	5.5	0.80	245.1	45.8	102.0	162.5
30–45	5.4	0.60	207.1	42.4	90.0	162.5
45–60	5.2	0.43	185.6	36.6	83.0	150.0
60–75	5.2	0.39	161.8	30.9	80.0	147.0
75–90	5.2	0.39	126.1	21.6	80.0	142.0

O C = Organic carbon

Table 2. Fertility status of soils in different cardamom plantations

Location	Depth (cm)	pH (1:2.5)	O C (%)	Av. N (kg ha^{-1})	Av. P_2O_5 (kg ha^{-1})	Av. K_2O (kg ha^{-1})
Madikeri Taluk						
1. Neerkaji Estate	0-15	5.0	0.9	334 (M)	27.5 (M)	195.0 (M)
Biligere - A	15-30	5.1	0.9	316 (M)	11.0 (L)	114.0 (L)
2. Neerkaji Estate	0-15	5.8	0.9	364 (M)	UDL	123.0 (L)
Biligere - B	15-30	5.4	0.8	348 (M)	UDL	114.0 (L)
3. Neerkaji Estate	0-15	5.6	0.9	316 (M)	65.3 (H)	153.0 (M)
Biligere - C	15-30	5.5	0.5	300 (M)	2.2 (L)	114.0 (M)
4. M M Cariappa Estate,	0-15	5.7	1.8	518 (M)	UDL	144.0 (M)
Heravanadu	15-30	5.4	0.5	478 (M)	UDL	144.0 (M)
5. M C Chengappa Estate,	0-15	5.8	1.5	52 (M)	UDL	332.4 (H)
Bettageri	15-30	5.5	0.9	434 (M)	UDL	310.0 (H)
6. M C Ganapathy Estate,	0-15	5.7	1.8	610 (H)	52.0 (H)	294.0 (H)
Bettageri	15-30	5.5	1.4	516 (M)	UDL	231.0 (H)
7. Ganagava Estate,	0-15	5.9	1.5	452 (M)	11.1 (L)	105.0 (L)
Bettageri	15.30	5.7	1.4	376 (M)	UDL	81.0 (L)
8. B M Ganapathy Estate,	0-15	5.9	0.6	328 (M)	11.1 (L)	111.0 (L)
Bettageri	15-30	5.7	0.5	230 (L)	UDL	94.0 (L)
9. M A Somaiah Estate,	0-15	6.1	0.9	446 (M)	2.2 (L)	387.0 (H)
Aruvathoklu	15-30	5.9	0.8	288 (M)	UDL	306.0 (H)
10. M A Thimmaiah	0-15	5.6	1.5	448 (M)	UDL	171.0 (M)
Estate, Cherambane	15-30	5.4	1.3	382 (M)	UDL	165.0 (M)
11. M A Kusyalappa	0-15	5.5	1.5	510 (M)	11.0 (L)	120.0 (L)
Estate, Kopatty	15-30	5.3	1.3	412 (M)	UDL	93.0 (L)
12. P A Basappa Estate,	0-15	5.8	2.1	602 (H)	UDL	174.0 (M)
Kopatty	15-30	5.6	1.3	498 (M)	UDL	123.0 (L)
13. N B Krishalappa Estate,	0-15	6.0	1.9	674 (H)	UDL	204.0 (M)
Kolagadal	15-30	5.9	1.5	624 (H)	UDL	171.0 (M)
14. M A Kushalappa Estate,	0-15	5.9	2.1	622 (H)	4.3 (L)	219.0 (M)
Cherambane	15-30	5.8	1.4	560 (M)	UDL	174.0 (M)
15. P M Devaiah Estate,	0-15	5.9	1.7	604 (H)	UDL	195.0 (M)
Cherambane	15-30	5.7	1.4	468 (M)	UDL	111.0 (L)
16. Vijaya Estate,	0-15	5.6	1.7	566 (M)	UDL	201.0 (M)
Kolagadal	15-30	5.5	1.4	518 (M)	UDL	162.0 (M)
17. M M Uthaiah Estate,	0-15	5.9	1.8	594 (H)	6.8 (L)	225.0 (H)
Kargunda	15-30	5.7	1.1	516 (M)	UDL	171.0 (M)
18. Joyappa Estate,	0-15	5.8	1.5	484 (M)	UDL	152.0 (M)
Singathur	15-30	5.6	1.1	516 (M)	UDL	93.0 (L)
19. B A Achiah Estate,	0-15	5.9	1.8	372 (M)	UDL	195.0 (M)
Bhagamandala	15-30	5.7	1.4	338 (M)	UDL	153.0 (M)
20. Annappa Estate,	0-15	5.4	1.3	672 (H)	UDL	129.0 (L)
Bhagamandala	15-30	5.3	1.2	504 (M)	UDL	111.0 (L)
Cardamom Research Centre, Appangala, Madikeri Taluk						
21. Block 1	0-15	5.9	1.9	548 (M)	UDL	111.0 (L)
	15-30	5.8	1.8	526 (M)	UDL	95.0 (L)

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Table 2. (Continued)

Location		Depth (cm)	pH (1:2.5)	O C (%)	Av. N (kg ha^{-1})	Av. P_2O_5 (kg ha^{-1})	Av. K_20 (kg ha^{-1})
22.	Block 2	0-15	5.4	1.3	502 (M)	UDL	111.0 (L)
		15-30	5.2	1.2	460 (M)	UDL	102.0 (L)
23.	Block 3	0-15	5.8	1.9	554 (M)	UDL	153.0 (M)
		15-30	5.6	1.3	464 (M)	UDL	144.0 (M)
24.	Block 4	0-15	5.3	2.4	644 (H)	8.9 (L)	195.0 (M)
		15-30	5.2	1.6	492 (M)	UDL	136.0 (L)
25.	Block 5	0-15	6.3	1.7	630 (H)	25.5 (M)	116.0 (L)
		15.30	6.0	1.3	620 (H)	18.6 (L)	112.0 (L)
26.	Block 6	0-15	6.3	1.8	630 (H)	34.0 (M)	116.0 (L)
		15-30	5.9	1.4	460 (M)	30.8 (M)	74.0 (L)
27.	Block 7	0-15	6.5	2.2	572 (M)	UDL	82.0 (L)
		15-30	6.3	1.9	540 (M)	UDL	120.0 (L)
28.	Block 8 A	0-15	6.2	1.8	784 (H)	UDL	116.0 (L)
		15-30	6.0	1.2	476 (M)	UDL	100.0 (L)
29.	Block 8 B	0-15	6.4	1.2	492 (M)	UDL	144.0 (M)
		15-30	5.9	1.0	468 (M)	UDL	134.0 (L)
30.	Block 8 C	0-15	6.6	1.4	628 (H)	54.4 (M)	102.0 (L)
		15-30	6.0	1.0	590 (H)	47.2 (M)	82.0 (L)
31.	Block 8 D	0-15	5.9	1.4	510 (M)	32.4 (M)	132.0 (L)
		15-30	5.6	0.9	334 (M)	22.6 (L)	78.0 (L)
32.	Block 9	0-15	6.0	1.5	726 (H)	UDL	96.0 (L)
		15-30	5.6	1.0	316 (M)	UDL	58.0 (L)
33.	Block 10	0-15	6.3	1.7	560 (M)	34.3 (M)	152.0 (M)
		15-30	6.0	0.9	476 (M)	30.4 (M)	128.0 (L)
34.	Block 11	0-15	5.8	1.9	566 (M)	UDL	134.0 (L)
		15-30	5.4	1.5	616 (H)	UDL	114.0 (L)
35.	Block 12 A	0-15	6.0	1.8	574 (M)	UDL	186.0 (M)
		15-30	5.8	1.1	420 (M)	UDL	120.0 (L)
36.	Block 12 B	0-15	6.3	2.0	628 (H)	UDL	168.0 (M)
		15-30	6.0	1.6	540 (M)	UDL	72.0 (L)
37.	Block 13	0-15	5.9	2.0	872 (H)	UDL	190.0 (M)
		15-30	5.3	1.8	666 (H)	UDL	86.0 (L)
38.	Block 14 A	0-15	6.6	2.8	314 (M)	55.0 (M)	146.0 (M)
		15-30	6.2	2.2	280 (L)	44.6 (M)	70.0 (L)
39.	Block 14 B	0-15	6.2	1.8	622 (H)	11.2 (L)	178.0 (M)
		15-30	6.0	1.1	608 (H)	UDL	74.0 (L)
40.	Black 15 A	0-15	6.1	2.1	608 (M)	15.6 (L)	120.0 (L)
		15-30	5.8	1.4	468 (M)	UDL	80.0 (L)
41.	Block 15 B	0-15	5.8	1.7	468 (M)	UDL	170.0 (M)
		15-30	5.4	1.1	454 (M)	UDL	80.0 (L)
42.	Block 16	0-15	6.0	1.8	730 (H)	UDL	138.0 (M)
		15-30	5.9	1.5	712 (H)	UDL	76.0 (L)
43.	Block 17	0-15	6.1	2.0	720 (H)	61.0 (H)	188.0 (M)
		15-30	5.8	1.7	628 (H)	13.2 (L)	98.0 (L)
44.	Block 18	0-15	6.2	2.1	568 (M)	UDL	116.0 (L)
		15-30	5.7	1.4	558 (M)	UDL	104.0 (L)

OC = Organic carbon; UDL = Undetectable; L = Low; M = Medium; H = High

Table 3. Correlation between organic carbon and available nutrients in cardamom soils

	pH	O C	N	P_2O_5	K_2O
pH	–	0.341*	0.146	0.132	0.177
O C		–	0.382**	-0.055	0.042
N			–	-0.198	0.038
P_2O_5				–	-0.071

O C = Organic carbon

that these soils have been developed under humid tropical conditions with high rainfall and temperature. The pH ranged from 5.0 (Plot No. 1) to 6.6 (Plot No. 31) and in all the soils studied, the surface soils recorded relatively higher pH when compared to the subsurface horizon.

All the soils were high in organic matter except Plot No. 8 which was medium (0.6%). Some of the plots namely, Nos. 12, 14, 25, 28, 37, 38, 39, 41 and 44 recorded more than 2% of organic carbon and it was higher at surface layer than the lower layer. Organic carbon content was positively and significantly correlated with available nitrogen (r=0.382**). This indicates enhanced availability of nitrogen with higher organic matter content. However, there was a negative and non significant relationship with available phosphorus. Thus it is obvious that organic carbon is a main source of organic P which is not available to the plant (Table 3).

Table 4. Classification of soils in cardamom plantations based on fertility status

Nutrient/ Class	Av. N (%)		Av. P_2O_5 (%)		Av. K_2O (%)	
Low	–	–	35*	(79.6)**	17*	(38.6)**
Medium	25*	(56.8)**	7	(15.9)	23	(52.3)
High	19	(43.2)	2	(4.5)	4	(9.5)

* Number of samples in a particular class
** Percentage to corresponding class

According to the classification, the soils studied were medium (56.82%) to high (43.18%) in available nitrogen status (Table 4). The highest available nitrogen of 784.0 kg ha^{-1} was noticed in Plot No. 29 and lowest of 316.0 kg ha^{-1} in Plot No. 3. In general the distribution or availability of nitrogen followed the distribution of organic carbon content in the soil (r=0.382**). Most of the soils were medium in available nitrogen, so it is necessary to provide nitrogen to the plants through organic or inorganic means. However, while supplying the inorganic source care must be taken to avoid fertilizers which aggravate the problem of soil acidity.

The availability of phosphorus in the soils was very low (79.5%) except in Plot Nos. 1 (27.5 kg ha^{-1}), 3 (65.3 kg), 6 (52.0 kg), 26 (25.5 kg), 27 (34.0 kg), 31 (54.4 kg), 32 (32.4 kg), 39 (55.0 kg) and 40 (61.0 kg) and even some of the soils recorded undetectable level of phosphorus. It indicates that the soils are deficient in soil phosphorus and the applied phosphorus may get chemisorbed because of the presence of higher amounts of free and total sequioxides in soils. Sushma (1994), who observed that change of absorbed P from chemicsorbed state, which is an irreversible form, also reported similar results.

The soils were low (36.63%) to medium (52.27%) in available potassium except in Plot Nos. 5 (387.0 kg ha^{-1}), 6 (294.0 kg), 9 (387.0 kg) and 17 (225.0 kg), which were high in potassium status. All the soils recorded more of available potassium at surface layer as compared to the lower depths and were correlated positively and non significantly with organic carbon. Similar results were reported by Krishnamurthy *et al.* (1989) and Zachariah (1975).

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