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Nutrient diagnosis of cardamom (*Elettaria cardamomum*) gardens in South India

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ABSTRACT

The nutrient analysis data of 123 samples obtained from cardamom-growing tracts in South India was compared with already worked out leaf nutrient diagnosis and recommendation integrated system (DRIS) indices values to find out the deviation limitation of nutrients from corresponding critical concentrations. The results revealed that 74, 54, 50, 46, 43, 41, and 38% leaf samples analyzed have Zn, K, P, Ca, Mg, Cu and Mo concentrations below the required critical values, respectively. The limiting leaf nutrients were in the order Zn > K > P > Ca > Mg > Cu> Mo> Fe > Mn >N. Correlation analysis showed that the soil nutrients at the base of cardamom plants are significantly and positively correlated with soil nutrients at interspaces, leaf nutrients and cardamom yield. An increase in soil *p*H resulted in increased availability of soil Ca, Mg and B. Soil organic carbon increased leaf N content, while leaf Ca increased leaf Mo content. Soil available P, K, Cu and leaf Cu were significantly and positively correlated with cardamom yield.

Key words: Cardamom, Cardamom yield, Critical soil nutrient concentration, DRIS, *Elettaria cardamomum*

Cardamom (*Elettaria cardamomum* M) is mainly cultivated in warm humid and high rainfall regions, especially on the slopes of western Ghats of South India at an elevation ranging from 800 to1300 m above mean sea level. The productivity of cardamom in India is low (174 kg/ha) compared to Guatemala (315 kg/ha), the main competitor to India. The low productivity is mainly attributed to poor soil fertility, imbalanced manuring, poor management practices and disease incidences (Singh 2007). Though cardamom soils are rich in organic matter, they are, in general, acidic, low in phosphorus and potassium (Thomas and Kuruvilla 2007). Besides, the rate of decomposition of organic matter and thereby release of nutrients in cardamom soils is much slower due to association of forest trees and consequent low mean annual temperature. Diagnosis and recommendation integrated system (DRIS) indices for cardamom leaves were worked out by Sadanandan *et al.* (2000). Krishnakumar and Potty (2002) recommended a fertilizer dose of 75:75:150 kg/ha NPK under rainfed condition for an yield realization of 100 kg/ha. Beneficial effects of liming, zinc and boron application on cardamom have also been demonstrated (Thomas and Kuruvilla 2008). However very little work has been done to identify the nutrients that limit productivity in cardamom. Hence, an attempt was made to identify the major yield-limiting nutrients in cardamom gardens which influence productivity and to find out the inter-relationships among soil nutrients, leaf nutrients and cardamom yield.

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MATERIALS AND METHODS

Leaf nutrient analysis data of farmers' fields from major cardamom-growing areas of South India (Idukki District, Kerala and Coorg District, Karnataka) were compiled. For the purpose fifth pair of leaf in panicle initiation tillers from plantations under normal management system was collected. A total of 123 data were so obtained since 1995. To find out the deviation of nutrients from corresponding critical concentrations, the nutrient analysis data were compared (Senthil Kumar *et al.* 2006) with already worked out leaf nutrient DRIS indices values of cardamom (Sadanandan *et al.* 2000). To find out the interrelationship among soil, leaf nutrients and cardamom yield, data of 48 gardens (18 from Idukki and 30 from Coorg) for which cardamom yield data were available, were grouped separately and computed with respective leaf nutrient analysis data, soil nutrient analysis data (at base and interspaces of cardamom plants separately) and Pearson's correlation co-efficient were worked out (SPSS v 10) to determine the interrelationships among soil properties at the base of cardamom plant and their relationship with cardamom yield.

RESULTS AND DISCUSSION

Population of cardamom gardens having available leaf nutrient concentrations below and above corresponding critical values

Population of cardamom gardens having available leaf nutrient concentrations below and above corresponding critical values is given in Table 1. The results reveal that 74, 54, 50, 46, 43, 41, 38, 30, 23, 6.5% leaf samples analyzed have shown Zn, K, P, Ca, Mg, Cu, Mo, Fe, Mn and N concentrations below the required critical values, respectively. This indicates that Zn, followed by K, P, Ca and Mg are the major yield-limiting nutrients in cardamom fields. Sadanandan *et al.* (2000) reported wide variations in leaf nutrient status of cardamom fields, N from 1.26–2.81%, P 0.10–0.20%, K 1.0–3.4%, Ca 0.60–1.38% and Mg 0.18–0.31%. Generally cardamom growing soils of South India have soil $_p$H 4.7–7.0, CEC 8.6–58.5 c mol (p^+)/kg, organic carbon 3.3–5.9%, P 2.5–6.2 mg/kg and low in K and micronutrients (Krishnakumar and Potty 2002). Thomas and Kuruvilla (2008) have reported decreasing sustainability of cardamom gardens due to climate change, increase in soil acidity, and decrease in organic matter, with wide spread zinc and boron deficiencies. This may be because of the high rainfall status of the region due to which leaching losses of soluble cations like K and Mg will be maximum, thereby making the soil highly acidic.

Table 1 Population of cardamom gardens 123 samples having leaf nutrient concentrations below and above corresponding critical values

Nutrient	Critical value	Samples below critical level*	Samples above critical level*
N	2.04 (%)	8 (6.5)	115 (93.5)
P	0.15 (%)	61 (50)	62 (50)
K	2.25(%)	67 (54)	56 (46)
Ca	0.95 (%)	56 (46)	67 (54)
Mg	0.25 (%)	53 (43)	70 (57)
Fe	253 mg/kg	37 (30)	86 (70)
Mn	371 mg/kg	28 (23)	95 (77)
Zn	33 mg/kg	91 (74)	32 (26)
Cu	28 mg/kg	51 (41)	72 (59)
Mo	0.56 mg/kg	15 (38)	104 (85)

*percentage no. of samples in parentheses

Inter-relationships among soil chemical properties at the base of cardamom plants and their relation to cardamom yield

Pearson's correlation co-efficient were worked out to determine the inter-relationships among soil properties at the base of cardamom plant and their relationship to cardamom yield (Table 2). Results revealed that soil *p*H was significantly and positively correlated with soil Ca and B availability, while soil CEC was negatively correlated with soil Fe, Zn and Cu. Soil organic carbon was positively correlated with soil Ca and soil K was positively correlated with soil Mn and Cu. Soil Fe was positively correlated with soil Mn and negatively with soil B. Soil Zn was positively correlated with soil Cu. Soil P, K and Cu levels were significantly and positively correlated with cardamom yield, highlighting the importance of these nutrients on cardamom yield.

Table 2 Correlations of soil chemical characters at the base of cardamom plants among themselves and with cardamom yield

Soil characters at the base		Correlation co-efficient (r)
Soil *p*H	VS soil Ca	0.360*
	VS soil B	0.362*
Soil CEC	VS soil Fe	–0.299*
	VS soil Zn	–0.442**
	VS soil Cu	–0.354*
Soil OC	VS soil Ca	0.332*
Soil P	VS cardamom yield	0.615**
Soil K	VS soil Mn	0.373**
	VS soil Cu	0.363*
	VS cardamom yield	0.423**
Soil Ca	VS soil Mg	0.465**
	VS soil Cu	0.317*
Soil Fe	VS soil Mn	0.487**
	VS soil B	–0.290*
Soil Zn	VS soil Cu	0.667**
Soil Cu	VS cardamom yield	0.472**

**P= 0.01;*P=0.05.

Relationships between soil chemical properties at the base and interspaces of cardamom plants

The correlations of soil chemical characters at the base of cardamom plants to that of the interspaces are given in Table 3. It was found that soil *p*H at the base of cardamom was significantly and positively correlated with soil *p*H and B and negatively with soil Cu availability in the interspaces. Soil CEC at the base of cardamom was negatively correlated with soil Fe, Zn and Cu availability in the interspaces. Soil organic carbon, P, K, Ca, Mg, Fe, Mn, Zn and Cu at the base of cardamom was significantly and positively correlated with their respective levels in the interspaces indicating that the lateral movement of the applied nutrients/fertilizers at basins through rain water or due to any intercultural operations. This suggests that fertility build-up in the overall field is important for maintaining the productivity level where plant root may intercept and take up nutrients even away from basin.

Correlations of soil chemical characters at the base of cardamom plants to that of leaf and cardamom yield

The correlations of soil chemical characters at the base of cardamom plants to that of leaf and cardamom yield are given in Table 4. It was found that soil *p*H at the base of cardamom

Table 3 Correlations of soil chemical characters at the base of cardamom plants to that at interspaces

Soil characters at the base	Soil characters at interspaces	Correlation co-efficient
Soil *p*H	VS soil *p*H	0.311*
	VS soil Cu	–0.425**
Soil CEC	VS soil B	0.315*
	VS soil Fe	–0.431**
	VS soil Zn	–0.449**
	VS soil Cu	–0.319*
Soil OC	VS soil O.C	0.745**
	VS soil Ca	0.411**
Soil P	VS soil P	0.875**
Soil K	VS soil K	0.718**
	VS soil B	0.375**
Soil Ca	VS soil O.C	0.375**
	VS soil Ca	0.566**
	VS soil Mg	0.399**
Soil Mg	VS soil Mg	0.519**
Soil Fe	VS soil Fe	0.706**
	VS soil Mn	0.562**
	VS soil B	–0.290*
Soil Mn	VS soil Fe	0.413**
	VS soil Mn	0.612**
Soil Zn	VS soil Zn	0.648**
	VS soil Cu	0.469**
Soil Cu	VS soil Zn	0.608**
	VS soil Cu	0.891*
Soil B	VS soil Fe	–0.336*

** P = 0.01;* P = 0.05.

was significantly and negatively correlated with leaf Mn and organic carbon at the base with leaf N. Soil Fe and Cu at the base shown very high correlations with leaf Zn and Cu. Leaf Zn was negatively correlated with leaf Mo and leaf Cu showed highly significant positive correlation with cardamom yield.

The correlations showed that most of the soil nutrients at the base of cardamom plants are significantly and positively correlated with that of interspaces soil nutrients as well as leaf nutrients and cardamom yield. Further, the soil and leaf nutrients in cardamom gardens are interrelated among themselves. An increase in *p*H and CEC resulted in increased soil availability of Ca, Mg and B and decreased availability of Zn, Cu and Fe. Soil organic carbon enhanced leaf N content and leaf Ca increased along with leaf Mo content. This might be due to the increase in *p*H with Ca availability and hence increased Mo availability. Soil available Cu both at the base and leaf Cu were significantly and positively correlated with cardamom yield. This might be due to the use of Cu fungicide in cardamom fields for disease management which keeps the plant healthy and high yielder. The nutrients, especially Zn, P, K, Ca and Mg showed their positive influence on yield suggesting their role as the most influencing nutrients in cardamom production.

Table 4 Correlations of soil chemical characters at the base of cardamom plants to that of leaf and cardamom yield

Soil characters		Correlation co-efficient
Soil *p*H	VS leaf Mn	–0.351**
Soil OC	VS leaf N	0.742**
Soil P	VS leaf Cu	0.291*
Soil Fe	VS leaf Mn	0.325*
	VS leaf Zn	–0.379**
Soil Mn	VS leaf Mn	0.318*
Soil Cu	VS leaf Mg	–0.336*
	VS leaf Fe	–0.298*
	VS leaf Mn	0.293*
	VS leaf Cu	0.376**
Leaf Ca	VS leaf Mo	0.325*
Leaf Fe	VS leaf Zn	0.362*
Leaf Zn	VS leaf Mo	–0.376**
Leaf Cu	VS cardamom yield	0.401**

** P = 0.01; * P = 0.05.

The step-wise forward regression analysis of cardamom leaf nutrient concentrations with that of yield (kg/ha) showed that leaf Cu (mg/kg), Ca (%) and K (%) are the major factors influencing cardamom yield with the following relationship that is significant at P= 0.01 level with an R^2 of 0.340.

Yield = 116.5 + 98.9 (leaf K)–168.8 (leaf Ca) + 0.89 (leaf Cu); (R^2 = 0.340**).

Similar regression analysis with that of soil nutrient availability and cardamom yield (kg/ha) showed the positive influence of soil P, K, Ca, Zn and Cu (mg/kg) and the equation is

Yield = 104.9 + 25.27 (soil P) + 0.11 (soil K)–0.146 (soil Ca)–27.40 (soil Zn) + 8.7 (soil Cu); (R^2 = 0.408**).

The positive correlations of P and K with yield show that the positive response by the crop in terms of its uptake when an input fertilizer dose of 75:75:150 kg N, P_2O_5 and K_2O/ha is recommended under rainfed situation and additional dose of 120:120:240 kg N, P_2O_5 and K_2O/ha under high density trench method of planting (Korikanthimath 2002).

The study revealed that 74, 54, 50, 46, 43, 41, 38% leaf samples collected from cardamom growing gardens of South India have respectively Zn, K, P, Ca, Mg, Cu and Mo concentrations below the required critical values and the order of limiting leaf nutrients was Zn > K > P > Ca > Mg > Cu > Mo > Fe > Mn > N. It was also found that soil nutrients at the base of cardamom plants are significantly and positively correlated with that of interspaces as well as leaf nutrients and cardamom yield. The correlation study revealed the importance of nutrients P, K, Ca, Mg, Zn and Cu in cardamom gardens and warrants balanced fertilization for increasing productivity.

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