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Nutrient diagnosis of black pepper (*Piper nigrum* L.) gardens in Kerala and Karnataka

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Abstract

Diagnosis and Recommendation Integrated System (DRIS) indices were worked out for soil and leaf nutrient status of black pepper (*Piper nigrum*) at Calicut (Kerala). The nutrient analysis data obtained from extensive (130 samples) surveys of major black pepper growing tracts of Kerala and Karnataka was compared with already worked out soil and leaf nutrient DRIS indices values to find out the deviation of nutrients from the corresponding critical concentrations. The results revealed that the soils in most of the gardens were acidic (pH 4.4 to 6.7). Soil sample analysis showed that 88% gardens had organic carbon (OC) status below the critical values, 74% gardens had Zn and 36% gardens had P and 28% gardens had Ca status below the required levels. Leaf analysis results showed that 46% samples had Mg, 39% samples had Cu and 12% samples had P, K and Zn status below the required critical values. The order of limiting nutrients was: OC > Zn > P > Ca > K > Mg for soil and Mg > Cu > P=K=Zn > Mn for leaf samples. The study revealed the importance of manuring black pepper gardens with organic manures supplemented with secondary and micronutrients.

Keywords: black pepper, *Piper nigrum*, soil and leaf nutrient status.

Introduction

Black pepper (*Piper nigrum* L.) is mainly cultivated in warm, humid and high rainfall regions, especially on the slopes of Western Ghats of South India. The soils in this region are generally shallow in nature and well drained, low in cation exchange capacity (CEC), exchangeable potassium and zinc. The low productivity of black pepper in India is mainly attributed to imbalanced manuring, poor management practices and disease incidence. Sadanandan *et al*. (2000) worked out the Diagnosis and Recommendation Integrated System (DRIS) indices for black pepper growing soils. Here an attempt is made to find out how far the available status of essential nutrients in black pepper growing areas differ from their corresponding required DRIS indices values (Sadanandan *et al*. 2000; Kumar *et al.* 2006) and the nutrients which are the most limiting for black pepper production.

Materials and methods

Soil and leaf nutrient analysis data of farmer's fields from major black pepper growing gardens of South India (Idukki, Wayanad, Kozhikode and Kannur districts of Kerala and

Kodagu District of Karnataka) were compiled. A total of 130 soil and leaf sample data were so obtained since 1995. From the analytical data, ranges of nutrients for each district were worked out separately. To find out the deviation of nutrients from the corresponding critical concentrations, the nutrient analysis data obtained above was compared with already worked out soil and leaf nutrient DRIS indices values of black pepper gardens (Sadanandan *et al.* 1996, 2000; Kumar *et al.* 2006) for each district separately and together.

Results and discussion

Status of soil nutrients

Soil pH varied from 4.4 to 6.7, organic carbon(OC) from 0.51% to 3.7% with a mean of 2.2% for Kodagu, 2.5% for Idukki and Wayanad and 2.1% for Kozhikode districts. Bray extractable P varied from 1.6 to 154.0 mg kg^{-1} with a mean of 37.0 mg kg^{-1} for Kodagu, 35.0 mg kg^{-1} for Idukki, 63.0 mg kg^{-1} for Wayanad and 24.0 mg kg^{-1} for Kozhikode districts. Exchangeable K varied from 61 to 1194 mg kg^{-1}, exchangeable Ca from 244 to 3310 mg kg^{-1} and exchangeable Mg from 24 to 455 mg kg^{-1}. Available Mn varied from 5.8 to 31.0 mg kg^{-1}. Available Zn varied from 0.62 to 14.00 mg kg^{-1} with a mean of 2.70 mg kg^{-1} for Kodagu, 2.40 mg kg^{-1} for Idukki, 2.80 mg kg^{-1} for Wayanad and 1.90 mg kg^{-1} for Kozhikode districts. Available Cu varied from 1.5 to 55.0 mg kg^{-1}. Available Mo varied from 0.02 to 0.66 mg kg^{-1}. Hamza *et al.* (2004) reported wide variation among soil nutrients and black pepper yield of various locations particularly at low and high elevations.

OC content of the soils was below the required DRIS indices value of 2.0%–7.5% in 88% of the surveyed gardens (Table 1). Similarly, 74% soils in gardens surveyed had available Zn status below the corresponding DRIS indices/critical values of 2.1–7.0 mg kg^{-1}, 36% soils in gardens surveyed had available P below the corresponding DRIS indices/critical values of 12–96 mg kg^{-1}; 28% soils in gardens surveyed had available Ca status below the corresponding DRIS indices /critical values of 610–1390 mg kg^{-1} and 17% soils in gardens surveyed had available K status below the corresponding DRIS indices/ critical values of 91–286 mg kg^{-1} (Table 1).

OC followed by Zn, and P were the most limiting nutrients in Kodagu and Idukki districts, whereas OC followed by Zn, P, K, Ca and Mg were the limiting nutrients in Wayanad District, and OC followed by Zn

Table 1. Population of black pepper gardens having available soil nutrient status below and above corresponding critical value

Soil character / Nutrient	Optimum value*	No. of samples below critical level**	No. of samples in optimum range**	No. of samples above critical level**
pH	4.80–6.25 (5.50)*	2 (2)	103 (79)	25 (19)**
OC	2.00–7.50 (4.75%)	114 (88)	16 (12)	0 (0)
Bray P	12–96 (54 mg kg^{-1})	47 (36)	62 (48)	21 (16)
Exch. K	91–286 (189 mg kg^{-1})	22 (17)	40 (31)	68 (52)
Exch. Ca	610–1390 (1000 mg kg^{-1})	36 (28)	49 (38)	45 (34)
Exch. Mg	40–194 (117 mg kg^{-1})	10 (8)	74 (57)	46 (35)
DTPA Fe	12–65 (39 mg kg^{-1})	0 (0)	128 (98)	2 (2)
DTPA Mn	5–35 (20 mg kg^{-1})	0 (0)	104 (80)	26 (20)
DTPA Zn	2.1–7.0 (4.5 mg kg^{-1})	96 (74)	26 (20)	8 (6)
DTPA Cu	0.51–7.70 (4.10 mg kg^{-1})	0 (0)	82 (63)	48 (37)

Total number of gardens =130; *Critical values in parenthesis; ** Percentage of samples in parenthesis and Ca were the limiting nutrients for Kozhikode District. In general, soil OC content followed by available Zn, P and Ca are the most limiting soil nutrients that affect black pepper productivity in the surveyed areas (Table 2).

Table 2. Population of black pepper gardens having available soil nutrient status below corresponding critical value soil character with optimum value

Soil character /Nutrient	Optimum value*	No. of samples below critical level**			
		Kodagu (16 Nos.)	Idukki (35 Nos.)	Wayanad (59 Nos.)	Kozhikode (20 Nos.)
pH	4.80–6.25 (5.50)	1 (6)	2 (6)	1 (2)	0 (0)
OC	2.00–7.50 (4.75%)	5 (31)	32 (91)	55 (93)	8 (40)
Bray P	12–96 (54 mg kg^{-1})	4 (25)	16 (46)	17 (29)	1 (5)
Exch. K	91–286 (189 mg kg^{-1})	0 (0)	0 (0)	15 (25)	2 (10)
Exch. Ca	610–1390 (1000 mg kg^{-1})	2 (13)	7 (20)	11 (19)	8 (40)
Exch. Mg	40–194 (117 mg kg^{-1})	0 (0)	0 (0)	6 (10)	4 (20)
DTPA Fe	12–65 (39 mg kg^{-1})	0 (0)	1 (3)	2 (3)	4 (20)
DTPA Mn	5–35 (20 mg kg^{-1})	0 (0)	0 (0)	0 (0)	0 (0)
DTPA Zn	2.1–7.0 (4.5 mg kg^{-1})	4 (25)	25 (71)	47 (8)	9 (45)
DTPA Cu	0. 51–7.70 (4.10 mg kg^{-1})	0 (0)	0 (0)	0 (0)	0 (0)

Total number of gardens =130; *Critical values in parenthesis; ** Percentage of samples in parenthesis

Status of leaf nutrient concentration

Leaf N varied from 1.9% to 2.7%, leaf P from 0.06% to 0.50%, leaf K from 0.9% to 4.7%, leaf Ca from 1.1% to 4.9%, leaf Mg from 0.12% to 1.60%, leaf S from 0.08% to 0.53%, leaf Fe from 110 to 537 mg kg^{-1}, leaf Mn from 33 to 810 mg kg^{-1}, leaf Zn from 18 to 46 mg kg^{-1}, leaf Cu from 7.6 to 750.0 mg kg^{-1} and leaf Mo from 0.23 to 2.60 mg kg^{-1}. There were not much differences among leaf nutrient concentrations of various locations as that of soil nutrients.

The survey indicated that 46%, 39%, 12% and 12% samples collected had leaf Mg, Cu, P and Zn status below their critical range, respectively. Only 1% sample collected had N status below required level (Table 3). In Kodagu District, 50%, 25% and 13% samples

Table 3. Population of black pepper gardens having leaf nutrient concentrations below and above corresponding critical value

Nutrient	Optimum value*	No. of samples below critical level**	No. of samples in optimum range**	No. of samples above critical level**
N	1.06–1.64 (1.35%)	0 (0)	1 (1)	129 (99)
P	0.11–0.26 (0.19%)	16 (12)	92 (71)	22 (17)
K	1.18–2.84 (2.01%)	15 (12)	73 (56)	42 (32)
Ca	1.42–3.33 (2.38%)	2 (1)	62 (48)	66 (51)
Mg	0.40–0.69 (0.54%)	60 (46)	39 (30)	31 (24)
S	0.09–0.29 (0.19%)	2 (1)	128 (99)	0 (0)
Fe	126–445 (256 mg kg^{-1})	7 (5)	123 (95)	0 (0)
Mn	109–321 (215 mg kg^{-1})	11 (8)	50 (38)	69 (54)
Zn	21–67 (44 mg kg^{-1})	16 (12)	114 (88)	0 (0)
Cu	16–120 (68 mg kg^{-1})	51 (39)	62 (48)	17 (13)

Total number of gardens =130; *Critical values in parenthesis; ** Percentage of samples in parenthesis had Mg, Fe, and Zn status below required values, respectively (Table 4). In Idukki District, 40%, 14% and 9% samples had Cu, P and Mg status below required values, respectively. In Wayanad District, 58%, 54%, 24%, 19% and 15% samples, had Cu, Mg, K, Mn, P and Zn status below required values, respectively,. In Kozhikode District, 55% samples had Mg and Cu status below required values. In general, Mg and Cu were the most limiting leaf nutrients affecting black pepper productivity in major growing areas.

It was reported that high rainfall status of black pepper growing areas, especially on the slopes of Western Ghats made the soil less productive, more acidic and low in P, K, Ca and Zn status due to leaching and erosion losses of these nutrients (Sadanandan 2000). Peter *et al.* (2000) stated that an adult black pepper vine removes 233.4 g N, 16.8 g P, 171.9 g K, 18.3 g Mg, 75.0 g Ca, 365 mg Fe, 281 mg Mn, 104 mg Zn, 89 mg Cu and 60 mg B. The study warrants the essentiality of manuring these gardens with Zn, P, and K enriched organics for increasing black pepper production. The study also corroborates the findings of earlier work on black pepper nutrition. Sadanandan & Hamza (1995) reported low available P status of black pepper growing soils and response to P fertilization. Response to zinc (Hamza & Sadanandan 2002) and lime application (Hamza & Sadanandan 2005a) in improving crop yield and quality of black pepper has also been reported. Reduced spike shedding and increase in yield and quality of black pepper by foliar spray of zinc sulphate 0.5% has also been reported (Geetha & Nair 1990, Muthumanickam 2003; Hamza & Sadanandan 2005b). All these results support the above findings of nutrient disorders in black pepper gardens.

The study revealed that one of the reasons for low productivity of black pepper gardens was improper/imbalanced manuring and the order of limiting nutrients were in the order: OC > Zn > P > Ca > K > Mg for soil and Mg > Cu > P = K = Zn > Mn for leaf samples. This warrants the need for improvement of soil fertility and productivity by judicious use of organic manures containing P, Ca, Mg, Cu and Zn for higher black pepper production.

Table 4. Population of black pepper gardens having available leaf nutrient status below corresponding critical value in various districts

Nutrient	Optimum value*	No. of samples below critical level**			
		Kodagu (16 Nos.)	Idukki (35 Nos.)	Wayanad (59 Nos.)	Kozhikode (20 Nos.)
N	1.06–1.64 (1.35%)	0 (0)	0 (0)	1 (2)	0 (0)
P	0.11–0.26 (0.19%)	0 (0)	5 (14)	9 (15)	1 (5)
K	1.18–2.84 (2.01%)	0 (0)	0 (0)	14 (24)	0 (0)
Ca	1.42–3.33 (2.38%)	1 (6)	0 (0)	1 (2)	0 (0)
Mg	0.40–0.69 (0.54%)	8 (50)	3 (9)	32 (54)	11 (55)
S	0.09–0.29 (0.19%)	1 (6)	0 (0)	4 (7)	0 (0)
Fe	126–445 (256 mg kg^{-1})	4 (25)	1 (3)	1 (2)	2 (10)
Mn	109–321 (215 mg kg^{-1})	0 (0)	2 (6)	11 (19)	0 (0)
Zn	21–67 (44 mg kg^{-1})	2 (13)	0 (0)	9 (15)	3 (15)
Cu	16–120 (68 mg kg^{-1})	1 (6)	14 (40)	34 (58)	11 (55)

Total number of gardens =130; *Critical values in parenthesis; ** Percentage of samples in parenthesis

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