Journal of Spices and Aromatic Crops
Vol. 13 (1) : 6–9 (2004)

Indian Society for Spices

Influence of soil physico-chemical properties on productivity of black pepper (*Piper nigrum* L.)

S Hamza, A K Sadanandan & V Srinivasan

Indian Institute of Spices Research
Calicut – 673 012, Kerala, India
E-mail: hamzaiisr@yahoo.co.in

Received 15 March 2003; Revised 16 January 2004; Accepted 21 May 2004

Abstract

Soil surveys were conducted to study the physico-chemical characteristics of major black pepper (*Piper nigrum*) growing soils in Kerala and their relationship with black pepper productivity. Soil samples were collected from four major black pepper growing districts, namely, Idukki, Wayanad (high elevation), Kozhikode and Kannur (low elevation) and were classified based on yield as high, moderate and low yielding gardens. The relationships between elevations, physico-chemical properties and black pepper productivity were studied. The investigation revealed that soils of high yielding gardens were high in sand and low in clay fractions. These soils had high pH, base saturation, cation exchange capacity, organic carbon, phosphorus, potassium, calcium, magnesium and zinc status compared to low yielding gardens. These factors favoured good growth of black pepper vines with higher productivity.

Key words: black pepper, *Piper nigrum*, productivity, soil physico-chemical properties.

Introduction

Black pepper is grown in about 1.9 lakh ha in India on a wide range of soils and climatic conditions and the productivity of the crop is the lowest (294 kg ha^{-1}) in the world compared to Thailand (3594 kg ha^{-1}), Malaysia (1888 kg ha^{-1}), Vietnam (1100 kg ha^{-1}) and Brazil (883 kg ha^{-1}) (Sadanandan 2000). About 80% of the total production of black pepper in India is from Kerala, and is confined to four districts, namely, Idukki, Wayanad (high elevation), Kozhikode and Kannur (low elevation), with varying levels of productivity. The reasons for low productivity have been attributed to variation in land forms (hilly, terrain and plains), land use, management practices and soil characteristics (Sadanandan & Hamza 1993). Among them, soil characteristics is the most important parameter affecting crop productivity and sustainability. An attempt has been made in this study to find out the reasons for the lower productivity of black pepper in certain regions, by conducting soil surveys in these areas and the relationship between elevations, soil physico-chemical properties and productivity.

Materials and methods

The soil surveys were conducted during 1996 in two high elevation districts (Idukki and Wayanad) and two low elevation districts (Kozhikode and Kannur). Samples taken from above 750 m MSL were grouped under high altitude and below 750 m MSL as low altitude. Three gardens were surveyed in each district (one each with high, moderate and low yielding vines). An yield level of up to 3 kg (green) plant^{-1} was considered as low, 3 to 5 kg (green) plant^{-1} as moderate and more than 5 kg (green) plant^{-1} as high.

Soil profile samples were taken from these gardens during February–March 1996 at four depths namely, 0–20, 20–40, 40–60 and 60–80 cm. The samples were processed and analysed for various physico-chemical properties as per standard procedures (Jackson 1973). The data obtained were grouped based on location (high and low altitudes) and yield performance (high, moderate and low yielders) and the relationships between elevations, soil physico-chemical properties and black pepper productivity were studied.

Results and discussion

Physico-chemical properties of soils grouped on basis of altitude

The various meteorological, physical and chemical properties of black pepper growing soils grouped on basis of altitude are depicted in Tables 1, 2 and 3, respectively. Soils of black pepper gardens at higher altitudes had significantly higher sand fraction, exchange-

Table 1. Meteorological data of major black pepper growing regions of Kerala (average of 1996–99)

Location	Altitude MSL (m)	Rainfall (mm)	No. of rainy days	RH (%)	Temperature (°C)
High altitude					
Idukki	1100	2124	204	65-98	16.4-29.8
Wayanad	975	2142	121	56-91	15.5-31.6
Low altitude					
Kozhikode	55	4069	132	45-94	23.6-35.7
Kannur	95	4259	124	71-94	19.4-38.8

Table 2. Physico-chemical properties of soils of black pepper growing areas

Location	Order	Great group	Colour	pH	Sand	Silt	Clay	BS	CEC
					(g (100 g)$^{-1}$)				(C mol (p+) kg^{-1})
High altitude									
Wayanad	Mollisols	Argiustoll	10.0 YR 2/2	5.82	49.0	13.0	38.0	63.0	12.7
Idukki	Ultisols	Haplohumult	10.0 YR 2.5/2	5.37	45.0	16.0	41.0	29.0	11.3
Low altitude									
Kozhikode	Inceptisols	Humitropept	7.5 YR 4/4	5.36	43.0	12.0	43.0	14.0	9.8
Kannur	Inceptisols	Humitropept	7.5 YR 2/3	5.43	35.0	16.0	49.0	28.0	10.9
CD (P=0.05)	-	-	-	0.08	1.4	0.9	1.2	1.4	0.5

BS=base saturation; CEC=cation exchange capacity

Table 3. Nutrient status of soils of black pepper growing areas

Location	OC	Bray	Exchangeable			Available	DTPA				Available
	(%)	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	Mo
		(mg kg^{-1})									
High altitude											
Wayanad	1.27	8.5	254	1850	516	41.0	48.0	40.0	1.50	3.3	0.27
Idukki	1.32	4.9	142	553	123	48.0	42.0	17.0	0.77	3.4	0.81
Low altitude											
Kozhikode	1.24	3.8	126	226	49	72.0	28.0	3.8	0.51	1.7	0.94
Kannur	1.26	2.1	134	278	139	60.0	23.0	5.8	0.60	2.9	0.42
CD (P=0.05)	0.12	1.9	24	73	29	6.7	3.0	2.6	0.21	0.5	0.33

OC=organic carbon

Table 4. Physico-chemical properties of black pepper growing soils grouped based on yield performance

Yield performance	pH	Sand	Silt	Clay	BS	CEC
			(g (100 g)$^{-1}$)			C mol (p+) kg^{-1}
High	5.79	51.0	15.0	34.0	52.0	12.2
Moderate	5.53	39.0	14.0	47.0	27.0	10.7
Low	5.16	40.0	15.0	45.0	22.0	10.6
CD (P=0.05)	0.07	1.2	0.8	1.1	1.3	0.4

BS=base saturation; CEC=cation exchange capacity

able Ca, Fe and Mn status whereas soils of black pepper gardens at lower altitudes had significantly higher clay fraction and S status.

The yield of vines was higher at higher altitudes, compared to lower altitude areas. Since the clay content is lower at higher altitudes, fixation of nutrients would also be lower. Root penetration and growth of vines is likely to be maximum in such areas. As in other crops, the optimum temperature required for photosynthesis may be lower than that for respiration which could be one of the reasons for the higher yield at higher altitudes. Lower decomposition rate of organic matter due to low temperature leading to high fertility at high altitude areas might be another reason for the higher yield. It was reported that the principal factor determining micronutrient uptake by plants was the degree of saturation of clay (Broadbent 1986). At higher altitudes, utilization of organic matter and nutrients were higher due to better availability that favours growth of black pepper vines. Sand fraction was high and clay and available S status were low at higher altitudes. Heavy rainfall at higher altitudes might have resulted in loss of clay and soluble S, leaving behind sand and silt fractions. It is reported that availability of nutrients would be reduced with increasing clay content (Brennan 1992; Siddiqui *et al.* 1993). At lower altitudes where soil is highly acidic, rich in clay and S contents and low in essential nutrients, water stagnates and limits root growth leading to poor growth of vines. Chattopadhyay *et al.* (1996) reported that soils at higher altitudes contain more micronutrients, than those at lower altitudes.

Physico-chemical properties of soils grouped on basis of yield

The physico-chemical properties of soil of black pepper gardens grouped based on yield performance are given in Tables 4 and 5. Soils of high yielding gardens were characterized by significantly higher soil pH, sand fractions, base saturation, cation exchange capacity (CEC), organic carbon, Bray P, exchangeable K, Ca, Mg and DTPA-extractable Zn as compared to low yielding gardens. But with regard to clay fractions, S and Mo status, a reverse trend was observed and were significantly lower in high yielding gardens.

Mathew *et al.* (1995) reported significant positive correlations of soil pH, organic carbon, exchangeable Ca, Mg and negative correlations of available Fe and S with black pepper yield. Application of manures and fertilizers even in fertile soil, is a necessity to maintain

Table 5. Nutrient status of black pepper growing soils grouped based on yield performance

Yield performance	OC	Bray	Exchangeable			Available	DTPA				Available
	(%)	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	Mo
						(mg kg^{-1})					
High	1.32	9.3	225	1177	326	28.0	35.0	12.0	1.20	2.6	0.38
Moderate	1.21	3.7	154	633	161	51.0	34.0	19.0	0.67	3.7	0.80
Low	1.14	1.5	114	370	132	88.0	36.0	19.0	0.65	2.1	0.91
CD (P=0.05)	0.10	1.6	21	63	25	5.8	2.6	2.3	0.18	0.5	0.15

OC=organic carbon

soil fertility and replenish nutrients removed by the crop. It was reported that red and lateritic soils of Kerala, though possessing good physical properties, are acidic, low in organic carbon, CEC and other nutrients and their productivity can be increased only by judicious application of organic and inorganic fertilizers (Nair 1983). It is clear from the study that one of the reasons for the low productivity of black pepper in some areas is low status of soil pH, sand fraction, base saturation, CEC, organic carbon, K, Ca, Mg and Zn contents in soil. This indicates that appropriate management of soils could increase black pepper productivity. These underline the findings of Sadanandan (2000) and De Ward (1969) who reported that for black pepper, highly fertile soil with good drainage is very essential. Sivaraman *et al.* (1999) also reported that due to heavy rainfall and unsustainable soil management practices, soil is becoming poor and balanced manuring is essential for good growth and production of black pepper vines.

It may be concluded that soils of high yielding black pepper gardens have high sand fraction, with pH ranging acidic to near neutral, high exchangeable bases, CEC, organic carbon, major, secondary and micronutrients especially Zn, compared to low yielding gardens and these properties are significantly higher in gardens at higher altitudes.

References

Brennan R F 1992 The effectiveness of zinc fertilizers measured by DTPA soil extractable zinc, dry matter production and zinc uptake of a range of Australian soils. Australian J. Soil Res. 30 : 45–53.

Broadbent F E 1986 Effects of organic matter of nitrogen and phosphorus supply to plants. In: Chen & Avmimelech (Eds.) The Role of Organic Matter in Modern Agriculture, Martinus Nijhoff Publishers, Dordrecht, Netherlands.

Chattopadhyay T, Sahoo A K, Singh R S & Shyampura R L 1996 Available micronutrient status in the soils of Vindhyan Scarplants of Rajasthan in relation to soil characteristics. J. Indian Soc. Soil Sci. 44 : 678–681.

De Ward P W F 1969 Foliar diagnosis, nutrition and yield stability of black pepper (*Piper nigrum* L.) in Sarawak. Comm. No. 58, Royal Tropical Institute, Amsterdam.

Jackson M L 1973 Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Mathew P G, Wahid P A & Nair G S 1995 Soil fertility and nutrient requirement in relation to productivity in black pepper. J. Plantn. Crops 23: 109–115.

Nair H & Koshy M M 1983 Chemical and physicochemical characteristic of red soils of Kerala. Agric. Res. J. Kerala, 21: 39–46.

Sadanandan A K 2000 Agronomy and nutrition of black pepper. In: Ravindran P N (Ed.) Black Pepper, *Piper nigrum* (pp. 163–223). Harwood Academic Publishers, Amsterdam.

Sadanandan A K & Hamza S 1993 Nutrition management of red and lateritic soils for sustainable spices production in India. In: Proceedings, International Seminar on Red and Lateritic Soils for Sustainable Agriculture, September 24–28, 1993, Bangalore (pp. 114–115). Indian Society of Soil Survey and Land Use Planning, Nagpur.

Siddiqui M, Ghonsikar C P, Malewar G V & Chalvade P B 1993 Effect of soil properties on zinc adsorption in some soil series of Marathwada region. Indian. J. Agric. Chem. 26 : 133–139.

Sivaraman K, Kandiannan K, Peter K V & Thankamani C K 1999 Agronomy of black pepper (*Piper nigrum* L.): a review. J. Spices Aromatic Crops 8 : 1–18.