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Effect of source and method of application of zinc on yield and quality of black pepper (*Piper nigrum* L.)

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Abstract

Experiments were conducted in the green house at Peruvannamuzhi (Kerala) and also in the field at Madikeri (Karnataka) to compare the effect of zinc sources, zinc sulphate ($ZnSO_4$) and zinc ethylenediaminetetraacetic acid chelate (Zn-EDTA) and methods of application (soil and foliar) to black pepper (*Piper nigrum*) in a zinc deficient soil. The results showed that with regard to soil availability of zinc, application of zinc as Zn-EDTA chelate @ 2.5 mg kg^{-1} soil in green house and 2.5 kg ha^{-1} in field conditions recorded maximum values. Leaf and berry zinc and pepper yield were maximum due to 0.5% $ZnSo_4$ foliar spray. Irrespective of sources and methods, Zinc application significantly increased oleoresin and piperine contents. With regard to benefit : cost ratio, 0.5% foliar spray of $ZnSo_4$ resulted in maximum value in green house, whereas soil application of 2.5 kg Zn ha^{-1} as $ZnSo_4$ resulted in maximum value in field condition.

Key words: black pepper, *Piper nigrum*, quality, yield, zinc, zinc-EDTA chelate.

Introduction

In India, black pepper (*Piper nigrum* L.) is cultivated in warm humid and high rainfall regions, especially on the slopes of Western Ghats of South India. The productivity of black pepper in India is low compared to other black pepper producing countries due to improper management. The soil of Western Ghats is generally shallow in nature and well drained, having high organic matter and medium to high in potassium and low in zinc contents (Sadanandan 2000).

As a component of several dehydrogenases, proteinases and peptidases, zinc is an essential nutrient required for proper growth of plants (Hemantharanjan 1996). Many agricultural soils are incapable of meeting even a small demand of zinc. Consequently, the standard fertilizer recommendation of N, P and K only is generally inadequate for higher crop production. Ethylenediaminetetra acetic acid (EDTA) application is known to significantly increase diethylenetriaminepentaacetic acid (DTPA) extractability of soil zinc (Liz & Shuman 1996; Cunha *et al.* 1996). Maftoun & Karimian (1989) reported greater effectiveness of Zn-EDTA than $ZnSO_4$ as fertilizer due to lower level of soil zinc fixation and greater mobility of chelated zinc. Increased yield and quality of several perennial crops due to foliar zinc application has been reported by many workers (Singh & Ahlawat 1995;

Arulmozhiyan *et al.* 1993). In black pepper, foliar spray of zinc 0.5% reduced spike shedding by 48% (Geetha & Nair 1990) and soil application of zinc increased yield and quality (Hamza & Sadanandan 2002).

It is in this context a green house and field experiment was conducted to compare the efficiency of zinc sources ($ZnSO_4$ and Zinc-EDTA chelate) and methods of application (soil and foliar) on soil availability, plant uptake, yield and quality of black pepper.

Materials and methods

Green house experiment

The green house experiment was conducted at Indian Institute of Spices Research, Experimental Farm, Peruvannamuzhi, during 1996–99 to compare the effect of zinc sources and method of application to black pepper grown as bush. Zinc deficient black pepper growing soils (*Ustic humitropept*) from Peruvannamuzhi (Calicut) having pH 5.26, organic carbon 1.4%, Bray-P 2.5 mg kg^{-1}, exchangeable K, Ca, Mg of 78, 237, 46 mg kg^{-1} respectively, and available S of 61 mg kg^{-1} and DTPA extractable status of Fe, Mn, Zn and Cu of 18, 14, 0.64 and 1.3 mg kg^{-1} respectively, was collected. The soils were sieved and 10 kg each filled in 30 cm diameter earthen pots lined with polyethylene sheet. Three month old bush pepper plants of cv. Karimunda were planted in the pots. The following treatments were super imposed after 3 months: i) Control ii) 1.25 mg zinc kg^{-1} soil as $ZnSO_4$ iii) 2.5 mg zinc kg^{-1} soil as $ZnSO_4$ iv) 2.5 mg EDTA kg^{-1} soil v) 2.5 mg EDTA kg^{-1} soil + 1.25 mg Zn kg^{-1} as $ZnSO_4$ vi) 2.5 mg EDTA kg^{-1} soil + 2.5 mg Zn kg^{-1} soil as $ZnSO_4$ vii) 2.5 mg Zn kg^{-1} as Zn-EDTA chelate viii) 0.25% $ZnSO_4$ foliar spray ix) 0.5% $ZnSO_4$ foliar spray x) 0.1% Zn-EDTA chelate as foliar spray. Foliar spray was given in June and September. A Completely Randomized Design with three replications (2 pots each) was adopted. NPK were applied @ 1.0, 0.5, 2.0 g pot^{-1} at bimonthly intervals to all the pots. The Zn availability in soil and its concentration in leaf and berry were determined as per standard procedures (Jackson 1967). Spiking intensity and yield were recorded. Black pepper quality parameters (oleoresin and piperine contents) were estimated as per standard procedures (ASTA 1968).

Field experiments

The field experiment was conducted during June1996 – 99 in zinc deficient soil (*Haplustult*) at Ashoka Plantation (Pvt.) Ltd, Madikeri, Kodagu District (Karnataka) having an elevation of 1000 m above MSL, rainfall of 2500 to 3000 mm per annum and temperature ranging from 14 to 32^{0}C. The physico-chemical properties of the soil were, pH 5.35, organic carbon 2.3%, Bray P 3 mg kg^{-1}; exchangeable K, Ca, Mg and S 212, 996, 156 and 66 mg kg^{-1}, soil available Fe, Mn, Zn, Cu and Mo 28.0, 29.0, 0.9, 5.8 and 0.5 mg kg^{-1} respectively. The experimental soil was acidic, medium in P and K and low in zinc. Five-year-old black pepper var. Panniyur-1 vines trailed on *Erythrina indica* were used. Six vines were used for each treatment and there were three replications. A Randomized Block Design was followed. To compare the effect of zinc sources and method of applications the following treatments were imposed: i) Control ii) 2.5 kg Zn ha^{-1} as $ZnSO_4$ iii) 2.5 kg EDTA ha^{-1} iv) 2.5 kg EDTA ha^{-1} + 2.5 kg Zn ha^{-1} as $ZnSO_4$ v) 2.5 kg Zn ha^{-1} as Zn-EDTA chelate vi) 0.25 % $ZnSO_4$ foliar spray vii) 0.5% $ZnSO_4$ foliar spray viii) 0.1% Zn-EDTA chelate as foliar spray. Soil application was done in June whereas foliar spray was given in June and September every year.

Soil and plant samples (index leaf and berry) were collected before harvest along with yield during March every year and analyzed for zinc concentrations and quality of the produce as per standard procedures.

Results and discussion

Green house experiment

Application of 2.5 mg Zn kg^{-1} soil as Zn-EDTA chelate resulted in maximum soil availability of zinc. Zinc content in leaf was maximum in case of 0.5% $ZnSO_4$ foliar application that was on par with 0.1% Zn-EDTA chelate foliar application. In the berry, Zn content was maximum in 0.5% $ZnSO_4$ foliar application. With regard to number of spikes, foliar application of 0.5% $ZnSO_4$, 0.25% $ZnSO_4$, 0.1% Zn-EDTA and soil application of 2.5 mg Zn kg^{-1} soil as Zn-EDTA or $ZnSO_4$+ EDTA were on par. The yield was maximum in 0.5% foliar $ZnSO_4$ application, which was on par with 0.1% Zn-EDTA foliar spray. The oleoresin content was maximum in case of soil application of 2.5 mg Zn kg^{-1} as Zn-EDTA and was on par with 0.25% and 0.5% $ZnSO_4$ foliar spray. Piperine content was maximum due to 0.5% $ZnSO_4$ foliar application that was on par with soil application of 2.5 mg Zn as $ZnSO_4$ kg^{-1} soil with 2.5 mg EDTA or 2.5 mg Zn as $ZnSO_4$ kg^{-1} soil. Application of 0.5% $ZnSO_4$ as foliar spray resulted in maximum benefit : cost ratio (Table 1).

Field experiment

Availability of zinc was maximum (2.52 ppm) due to application of 2.5 kg Zn ha^{-1} as Zinc-EDTA chelate. Leaf and berry zinc concentrations were maximum due to application of 0.5% $ZnSO_4$ foliar spray. The yield was maximum (1.68 kg $vine^{-1}$, 27% increase over control) due to foliar application of 0.5% $ZnSO_4$ which was on par with soil application of 2.5 kg Zn ha^{-1} either as $ZnSO_4$ or Zinc-EDTA chelate or $ZnSO_4$ + EDTA. The oleoresin content was maximum due to soil application of 2.5 kg Zn ha^{-1} as Zn-EDTA and was on par with foliar zinc application either as 0.5% $ZnSO_4$ or 0.1% Zn-EDTA chelate. The piperine content was maximum in 2.5 kg Zn ha^{-1} as Zn-EDTA chelate soil application. Among sources and methods, soil application of $ZnSO_4$ @ 2.5 kg Zn ha^{-1} produced maximum benefit : cost ratio (5.27), followed by 0.5% foliar $ZnSO_4$ spray (Table 2).

Response to foliar zinc as 0.5% $ZnSO_4$ or 0.1% Zn-EDTA was reported by many workers in various crops (Arulmozhiyan *et al.* 1993; Moore *et al.* 1991). $ZnSO_4$ is extensively used zinc fertilizer because of its higher water solubility and low cost, as reported by Rattan *et al.* 1997). Increase in the yield of black pepper due to micronutrients was also reported

Table 1. Effect of method and source of zinc application on zinc content, yield and quality of black pepper (green house experiment)**

Treatment	Soil Zn	Leaf Zn	Berry Zn	No. of spikes $bush^{-1}$	Yield (g $bush^{-1}$) (dry)	Oleoresin	Piperine	B : C ratio
		(mg kg^{-1})				(%)		
Control	1.14	13.0	7.4	24	66	8.93	6.10	1.1
1.25 mg Zn kg^{-1} soil as $ZnSO_4$	1.33	14.0	7.4	26	71	9.27	7.13	1.1
2.5 mg Zn kg^{-1} soil as $ZnSO_4$	2.22	15.0	7.6	26	78	9.33	7.60	1.2
2.5 mg EDTA kg^{-1} soil	1.19	12.6	7.4	24	64	10.06	6.90	1.0
2.5 mg EDTA kg^{-1} soil + 1.25 mg Zn kg^{-1}	1.50	13.7	8.0	26	70	11.13	7.23	1.1
2.5 mg EDTA kg^{-1} soil + 2.5 mg Zn kg^{-1} soil	2.49	16.0	9.2	30	84	11.36	7.67	1.3
2.5 mg Zn kg^{-1} soil as Zn-EDTA	2.89	17.0	8.5	32	85	11.83	7.57	1.3
0.25 % Zn SO_4 as foliar spray	2.04	19.7	10.4	31	87	11.53	7.17	1.4
0.5% $ZnSO_4$ as foliar spray	2.22	22.0	11.1	32	92	11.63	7.83	1.5
0.1% Zn-EDTA as foliar spray	2.16	20.3	9.8	30	89	11.37	7.07	1.4
CD (P=0.05)	0.10	1.9	0.62	2.0	4.5	0.32	0.24	

** Mean data of three years

Table 2. Effect of method and source of zinc application on zinc content, yield and quality of black pepper (field experiment)**

Treatment	Soil Zn	Leaf Zn	Berry Zn	Yield ($kg\ vine^{-1}$) (dry)	Oleoresin	Piperine	B : C ratio
	($mg\ kg^{-1}$)				(%)		
Control	0.75	19	6.10	1.32	8.23	6.03	4.23
2.5 kg Zn ha^{-1} as $ZnSO_4$	1.63	25	7.13	1.66	8.35	6.26	5.27
2.5 kg Zn-EDTA chelate ha^{-1}	0.84	22	5.73	1.28	8.21	6.06	4.05
2.5 kg Zn-EDTA chelate ha^{-1} + 2.5 kg Zn ha^{-1} as $ZnSO_4$	2.24	27	6.67	1.59	8.67	6.15	4.94
2.5 kg Zn ha^{-1} as Zn-EDTA chelate	2.52	30	8.2	1.64	8.87	6.42	4.38
0.25% $ZnSO_4$ as foliar spray	1.21	43	8.90	1.56	8.68	6.25	4.95
0.5% $ZnSO_4$ as foliar spray	1.54	50	10.30	1.68	8.81	6.25	5.26
0.1% Zn-EDTA as foliar spray	1.16	37	9.53	1.56	8.80	6.29	4.71
CD 5%	0.09	2.3	0.59	0.11	0.16	0.12	

** Mean data of three years

from Malaysia (Anon, 1990). Soil availability of zinc was maximum due to Zn-EDTA chelate application rather than Zn+EDTA or $ZnSO_4$ alone at the same rate. EDTA increases Zn concentration in exchangeable form by solubilization from organic matter fractions and converting to exchangeable fraction. So in case of zn-EDTA chelate, leaching loss and fixation of zinc in soil will be minimum and hence Zn availability is higher. Modalish (1990) reported that the rates of zinc diffusion and zinc extractability were considerably higher with Zn-EDTA than with $ZnSO_4$ fertilizer. The superiority of Zn-EDTA chelate was also reported by many other workers (Mehdi *et al.* 1990, Ferrandon & Chamel 1988).

The present findings support the need for zinc application for better yield and quality of black pepper either as chelated forms or as $ZnSO_4$. Further, though foliar application can correct zinc deficiency, soil application is more practical for black pepper.

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