Journal of Spices and Aromatic Crops
Vol. 12 (1) : 15-18 (2003)

Indian Society for Spices

Influence of different phosphorus sources and zinc spray on yield and quality of black pepper (*Piper nigrum* L.) under acid soils

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Received 17 June 2002; Revised 14 November 2002; Accepted 20 June 2003

Abstract

Trials were conducted to identify the suitable form of phosphorus and optimum spray concentration of zinc for increasing yield of black pepper under acid soil conditions of Yercaud (Tamil Nadu, India). The results indicated that soil application of 40 g P_2O_5 vine^{-1} as rock phosphate along with spraying of $ZnSO_4$ (0.5 %) increased dry pepper yield (9.21 kg vine^{-1}) and oleoresin content (12.34%).

Key words: acid soils, black pepper, *Piper nigrum*, rock phosphate, zinc sulphate

Introduction

Black pepper (*Piper nigrum* L.), is widely cultivated in the coffee based multitier cropping system in Shevory hills of Tamil Nadu, India, which is situated at elevations ranging from 1200 to 1500 m above MSL with an annual rainfall ranging from 1300 to 1600 mm. About 86 per cent of the soils are acidic (pH 4.8- 5.3). Under such acidic conditions, the availability of iron and aluminum ions will be high and hence the applied phosphorus is fixed as iron and aluminum phosphates in the soil. Phosphorus is essential for cell division and it affects the root system of plants by encouraging the formation of lateral and fibrous roots (Tandon 1987). Vasudevan *et al.* (1996) reported that two sprays of $ZnSO_4$ (0.5%) increased the yield of coffee over 30 - 40%. In view of this, trials were conducted to identify the suitable form of phosphorus and optimum concentration of $ZnSO_4$ to increase the yield of black pepper in acid soil.

Materials and methods

The study was carried at Horticultural Research Station, Yercaud during 2000 and 2001. The soil was sandy clay loam in texture, with a pH of 5.24 and electrical conductivity of 0.107 d Sm^{-1}. The available N, P and K of the soil were 254, 7.33, 150 kg ha^{-1} and total N, P and K were 1.54%, 0.58% and 1.08%, respectively. The main plot treatments consisted of two phosphorus sources viz. super phosphate, rock phosphate and sub plot treatments are various concentrations of $ZnSO_4$ (0.25%, 0.50% and 0.75%) spray along with a control (water spray). The treatments were replicated thrice in a split plot design. Twelve year old Panniyur-1 vines trailed an silver oak trees having a height of 4 m were selected (10 vines per treatment) and a common fertilizer dose of 100 : 40 : 140 g N, P_2O_5 and K_2O vine^{-1} was applied in two equal splits during June - July and October - November. The required quantity of phosphorus (40 g P_2O_5 vine^{-1}) was applied either using super phosphate or rock phosphate and nitrogen and potassium as

urea and muriate of potash, respectively. In addition to this, farmyard manure (10 kg vine^{-1}) was given to all treatments. Spraying of $ZnSO_4$ was taken up at the time of spike formation (August) and one month after first spraying (September). Soil and plant samples were collected before first and second split application of fertilizers and at the time of harvest. The soil samples were analysed for available nutrients and plant samples for total N, P and K contents (Tandon 1993). Before each spraying of $ZnSO_4$, the leaf samples were collected and analysed for total Zn content. At harvest, the berries were collected, dried and analysed for oleoresin content (AOAC 1975). The yield attributes were also recorded at the time of harvest.

Results and discussion

Yield attributes

Application of different phosphorus sources and $ZnSO_4$ spray had significant effect on yield attributes of pepper (Table 1). Application of rock phosphate in main plots and spraying of $ZnSO_4$ (0.5%) in sub plots recorded the highest values in both the years. In the year 2001 the same treatment registered the highest yield attributes viz. 100 spike weight (683.1, 653.1g), 100 spike berry weight (611.8, 572.4 g), 100 fresh berry weight (14.97, 12.47 g), 100 dry berry weight (5.08, 4.96 g), drying percentage (29.9, 29.9) and number of spikes m^{-2} (81.5, 76.5). The lowest values were observed in control. The better growth of plants may be attributed to the suitable form of phosphorus applied in acid soil which prevents the ill effects due to toxic amount of Fe, Al and Mn, and less activity of micro-organisms (Ananthanarayana & Prabhu 1992). Sadanandan & Rajagopal (1989) observed that the application of phosphorus either in soil or as spray increased the yield potential of black pepper.

Yield and oleoresin content

Significant increases over control were noticed in the yield and oleoresin content of pepper berries in all the treatments during both years of study (Table 2). Application of rock phosphate @ 40 g vine^{-1} in main plots and spraying of $ZnSO_4$ (0.5%) in sub plots recorded the highest dry berry yield of 9.21 and 8.15 kg vine^{-1} and oleoresin content of 12.34 and 11.94%, respectively during 2002. Among the phosphatic fertilizers, application

Table 1. Influence of phosphatic fertilizers and zinc spray on yield attibuting characters of black pepper

Treatment	100 spike weight (g)		100 spike berry weight (g)		100 fresh berry weight (g)		100 dry berry weight (g)		Drying percentage		No. of spikes m^{-2}	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Main plot treatment												
Control	508.2	512.0	408.5	411.3	5.98	6.14	2.74	2.34	28.2	28.5	53.2	52.5
Super phosphate	664.8	669.1	594.1	596.9	11.36	12.01	4.68	4.89	28.5	29.5	71.1	77.2
Rock phosphate	681.6	683.1	611.2	611.8	13.25	14.97	4.79	5.08	29.1	29.9	76.5	81.5
Sub plot treatment												
Water spray	577.1	580.0	497.1	501.3	8.97	9.42	3.48	3.76	27.8	28.9	61.3	63.4
$ZnSO_4$ Spray 0.25%	607.8	611.0	526.1	527.0	10.02	10.73	4.50	4.58	28.4	29.2	65.4	69.3
$ZnSO_4$ Spray 0.50%	650.9	653.1	570.7	572.4	11.60	12.47	4.81	4.96	29.1	29.9	72.7	76.5
$ZnSO_4$ Spray 0.75%	636.8	641.4	557.8	559.3	10.80	11.53	4.77	4.79	28.7	29.6	69.6	72.4
CD(p=0.05)												
Main	3.01	3.74	2.63	2.34	0.03	0.05	0.035	0.041	0.098	0.043	1.86	2.95
Treatments	3.69	1.03	1.65	1.58	0.04	0.06	0.035	0.036	0.132	0.140	1.44	2.03

Table 2. Influence of phosphatic fertilizers and zinc spray on the yield and oleoresin content of black pepper

Treatment	Dry yield vine^{-1} (kg)								Oleoresin content (%)			
	2000				2001							
	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
Water spray	4.32	7.48	8.59	6.67	3.59	7.88	8.23	6.57	9.84	10.89	11.19	10.68
$ZnSO_4$ spray 0.25 %	4.88	8.28	8.98	7.43	5.35	8.25	8.89	7.50	10.12	11.94	11.90	11.24
$ZnSO_4$ spray 0.50 %	5.24	8.78	9.32	7.97	5.27	8.98	10.20	8.15	11.84	11.98	12.00	11.72
$ZnSO_4$ spray 0.75 %	5.08	8.60	9.11	7.68	5.20	8.81	9.38	7.78	10.56	12.07	14.27	11.51
Mean	4.88	8.41	9.00	-	4.85	8.48	9.21	-	10.59	11.72	12.34	-
CD (p=0.05)												
Main				0.106				0.036				0.284
Treatments				0.060				0.034				0.184
Treat At Main				0.104				0.059				0.118
Main At Treat				0.117				0.049				0.086

1. Control, 2. Super phosphate, 3. Rock phosphate

of rock phosphate recorded the highest amount of yield and available phosphorus in soil. This might be due to the slow release of phosphorus from rock phosphate applied in soil which resulted in lower P fixation and there by influenced the transformation of added nutrients into insoluble forms and their increased availability in soil (Mongia *et al.* 1998). Raju & Ramaiah (1986) also reported that the solubility and ultimate availability of P from applied sources depend on the fixation and release of nutrients.

Available and total nutrients

The data on available N, P and K content in soil and total N, P and K content in leaves are presented in Table 3. A significant difference among the treatments was observed in both the soil nutrient status and nutrient content in leaves for both the years. Among the treatments, the application of rock phosphate in main plots and spraying of $ZnSO_4$ @ 0.5% in sub plots recorded the highest soil available N, P and K contents of 330.3, 26.7, 215.0 and 310.9, 22.5 and 198.3 kg ha^{-1}, respectively. The same treatment also recorded the total N, P and K contents of 2.75, 1.23 and 2.19% in main plots and 2.63, 1.22 and 2.06% in sub plots. The increase in available nutrients in soil might have helped the plant to translocate them to different parts of the plant. The increase or decrease of nutrients in plants depends upon the availability of nutrients in soil, which is essential for better yield (Muthumanickam & Balakrishnamurthy 1999).

Zinc content

The data on the Zn content in leaves are also presented in Table 3. A significant difference among the treatments was observed in leaves due to the spraying of $ZnSO_4$ during the time of spike formation and one month after the first spray. Among the treatments, the application of rock phosphate in main plots recorded the highest Zn content of 18.2 and 23.3 ppm before spike formation and one month after the first spray, respectively during 2001. Among the subplot treatments spraying of $ZnSO_4$ @ 0.50% recorded the highest Zn contents at both occasions. The micronutrients zinc is essential for synthesis of auxins and proteins, seed production and maturity (Tandon 1987). Vasudevan *et al.* (1996) reported that spraying of $ZnSO_4$ @ 0.5% in two foliar sprays during preblossom and 15 days interval increased the yield of coffee. Geetha & Sivaramam Nair (1990) observed that spraying of $ZnSO_4$ solution increased the oleoresin content and yield of black pepper and prevented the spike shedding and fruit drop in pepper.

Table 3. Influence of phosphatic fertilizers and zinc spray on available nutrients in soil, total nutrients in plants and zinc content in leaves of black pepper.

Treatment (ppm)	Available nutrients in soil (kg ha^{-1})						Total nutrients in plants (%)						Zinc content in leaves			
	2000			2001			2000			2001			Before spike formation		One month after spray	
	N	P	K	N	P	K	N	P	K	N	P	K	2000	2001	2000	2001
Main plot treatment																
Control	257.3	9.1	160.0	220.1	6.7	139.1	2.10	0.88	1.69	2.23	0.99	1.68	8.5	8.9	8.5	8.4
Super phosphate	319.3	16.7	225.8	308.3	25.0	205.8	2.47	1.53	2.30	2.55	1.16	2.12	20.0	16.0	28.7	20.8
Rock phosphate	347.0	20.6	238.7	330.3	26.7	215.0	2.57	1.62	2.49	2.75	1.23	2.19	21.9	18.2	32.3	23.3
Sub plot treatment																
Water spray	273.3	11.0	177.7	255.1	16.5	174.4	1.95	1.01	1.70	2.40	1.02	1.88	11.4	11.4	11.7	11.9
$ZnSO_4$ spray 0.25 %	291.7	13.8	197.7	277.1	18.6	181.6	2.28	1.39	2.10	2.42	1.09	1.95	16.7	13.2	24.6	17.1
$ZnSO_4$ spray 0.50 %	342.2	19.2	232.7	310.9	22.5	198.3	2.69	1.52	2.45	2.63	1.22	2.06	20.8	17.2	31.1	20.9
$ZnSO_4$ spray 0.75 %	324.2	17.4	224.4	302.0	20.2	192.2	2.38	1.44	2.35	2.60	1.18	2.08	19.2	15.6	28.5	20.8
CD (p=0.05)																
Main	4.59	2.42	2.98	3.19	0.95	1.63	0.52	0.06	0.06	0.04	0.02	0.03	0.46	0.50	0.75	0.75
Treatments	5.36	1.84	5.06	2.57	0.91	2.28	0.21	0.05	0.05	0.05	0.01	0.01	0.45	0.54	0.86	1.34

Based on the above studies, the application of rock phosphate @ 40 g P_2O_5 along with 100: 140 g N and K_2O in two equal splits during June - July and October - November, 10 kg of farmyard manure vine^{-1} and spraying of $ZnSO_4$ @ 0.5% during the time of spike formation (August) and one month after spray (September) can increase the yield and oleoresin content of black pepper under acid soil conditions. However, more studies are required to work out the economic feasibility of the above findings.

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