Annals of Plant and Soil Research 18(4): 401-404 (2016)

EFFECT OF MAGNESIUM AND BORON NUTRITION ON YIELD AND QUALITY OF BLACK PEPPER IN LATERITE SOILS

P.V RAMANA[1*], R GLADIS[2] AND SAINATH NAGULA[3]

Department of Soil Science and Agricultural Chemistry, Kerala Agricultural University, College of Agriculture, Padannakkad, Kasaragod- 671 314

Received: April, 2016; Revised accepted, September, 2016

ABSTRACT

A field experiment was carried out at the College of Agriculture, Padannakkad and Pepper Research Station, Panniyur during 2013-14 to asses the effect of magnesium and boron on available nutrient status of soil, yield and quality of black pepper. The results indicated that the available Mg and B in soil tended to decrease with age of the plant, irrespecting of treatments. The addition of 200g Mg SO_4 + 20g borax per vine increased the status of available Mg abd B in soil at both the stages of growth. Application of 200g $MgSO_4$+ 20g borax per vine proved superior to other treatments with respect to berries, spike length, spike yield, number of spikes m^{-2}. The concentration of boron and magnesium in leaves, in genral, tended to increase up to berry formation stage followed by a reduction at harvest. Application of Mg and B to the soil increased their contents in leaves at all the stages of growth. Quality parameters of black pepper (oleoresin and piperine) improved with increasing levels of Mg and B and maximum values were recorded under 200g Mg SO_4 + 20g borax per vine.

Keywords: Magnesium, boron, yield, quality, black pepper.

INTRODUCTION

Black pepper (*Piper nigrum* L.), the king of spices is mainly cultivated in warm, humid and high rainfall regions. It is an economically important and widely used spice crop indigenous to the Western Ghats of Kerala. The dried berry obtained from the vines has a commercial value as an important spice condiment used all over the world. It is also valued for its oleoresin and medicinal properties.The total area under black pepper in Kerala is 170,250 ha with a production of 31690 tonnes and productivity is only 186 kg ha^{-1}. The low productivity is due to poor genetic potential of the vines, high population of senile and unproductive vines, losses caused by pests, diseases and soil constraints. Among these, soil related stress like acidity and nutrient deficiencies are major ones. Magnesium is an important element required for the growth of pepper plant. The most well known role of Mg^{2+} is its occurrence at the centre of the chlorophyll molecule. It plays an important role in photosynthesis. It increases resistance to harmful environmental influence such as drought and diseases. Magnesium also plays an important role in the cell energy balance, interacting with the pyrophosphate structure of nucleotide tri and di- phosphates. The magnesium reserves in Kerala soils are poor and thus magnesium can be considered as a critical element in the acid soils of Kerala. Magnesium application is required for crops grown in soils with magnesium content below the critical limit of 120 mg kg^{-1}. Boron is an important essential micronutrient required for plant growth and reproduction (Siddiky *et al.,*, 2007). It is unique among the essential mineral elements because it is the only element normally present in soil solution as non-ionized molecule. Boron has a primary role in cell wall biosynthesis, cell division, lignification of cell wall, membrane function, RNA metabolism, indole acetic acid (IAA) production, phenol metabolism, carbohydrate metabolism, sugar transport, nucleotide synthesis, respiration (Sims and Jhonson, 2003) and it is responsible for better pollination, seed setting and grain formation. It is more important during the reproductive stage as compared to vegetative stage of the crop. Boron deficiency symptoms in black pepper are yellowing starting from the centre to the extremities in younger leaves. Malformed terminal buds show reduced development and development of dark spots between veins and leaf margins. Some younger leaves are curved downside with a rosette appearance.These symptoms are widespread in the pepper growing areas of Kerala. Application of B is essential for crops grown in soils with available B below critical limit of 0.5 mg kg^{-1}. Hence the present study was initiated to assess the affect of Mg

* Corresponding author *email:* rvenkat243@gmail.com

and B application on yield and quality of black pepper yield and quality of black pepper.

MATERIALS AND METHODS

The field experiment was laid out in an existing black pepper (Panniyur-1). garden. It is geographically located at 12^{o} 4' N latitude, 75^{0} 23' E longitude and at an altitude of 95 m above mean sea level, having a moderately sloppy terrain and a humid tropical climate. The soil of experimental site was sandy clay loam belonging to the taxonomical order Oxisols. The experiment consisted of nine treatments replicated three times in a randomized block design *viz.,* T_1 –100 g $MgSO_4$ /vine T_2 –100 g $MgSO_4$ + 10 g borax /vine T_3 –100 g $MgSO_4$ + 20 g borax /vine T_4 –200 g $MgSO_4$ /vine T_5 –200 g $MgSO_4$ +10 g borax /vine T_6 –200 g $MgSO_4$ + 20 g borax /vine T_7 – 10 g borax /vine T_8 – 20 g borax /vine T_9 – control. Pepper vines of the same age were selected and treatments were applied to soil. Fertilizers were applied as per package of practice recommendation @ 50:50:200 g N, P_2O_5 and K_2O per vine as urea, rajphos and muriate of potash. Fertilizers were applied in two split doses, the first dose in June and the second dose in September. Other cultural practices were adopted as per standard recommendations. Magnesium sulphate and borax were applied to black pepper as soil application. Leaf samples were collected at flushing, berry formation and harvest stages and analyzed for boron and magnesium content. Calcium in di-acid digest was determined on atomic absorptions spectrophotometer. Boron was analysed by azomethen-H colorimetric method (Bingam, 1982). The oleoresin content of dried berries was estimated using the Soxhlet method of extraction (Horwitz 1980). The piperine content in dried berries of pepper was determined by uv-spectrophotometric method described by Kolhe *et al.,* (2011). Observations *viz.,* branches m^{-2}, spike m^{-2}, spike length, berries spike^{-1}, 100 berry weight and yield, and quality parameters were recorded. The results obtained were statistically analyzed using statistical analysis software (SAS).

RESULTS AND DISCUSSION

Available nutrients

Application of 200g $MgSO_4$ + 20g borax (T_6) recorded the highest available boron content (0.48 mg kg^{-1}) in post harvest soil (Table 1). The available boron content in soil decreased from berry formation stage to harvest stage. At harvest stage T_6 (0.40 mg kg^{-1}) recorded highest available boron content (Table 1). The boron applied to the soil would have dissociated to soluble boric acid form which would have increased the boron availability in soil. The content of boron in plant is also conspicuously high for the above treatments. Therefore after meeting the requirement of the crop, the added boron might have helped to increase the boron status of the soil. These findings are in line with those reported by Su *et al.,* (1994).

At berry formation stage, T_6 (200g $MgSO_4$ + 20g borax) recorded highest amount of available Mg in soil (69.33 mg kg^{-1}). There was a decline in available magnesium content in soil from berry formation stage to harvest stage. At harvest stage again T_6 recorded maximum available magnesium content of 50.33 mg kg^{-1} (Table 1). The magnesium applied to soil raised the available Mg status of soil over control.These findings are in line with those reported by Hardter *et al* (2003).

Table 1: Effect of soil application of Mg and B on their available content in soil

Treatments (Per vine)	Available boron (mg kg^{-1})		Available magnesium (mg kg^{-1})	
	Berry formation stage	Harvest stage	Berry formation stage	Harvest stage
T_1 100g Mg SO_4	0.23	0.20	56.08	52.50
T_2 100g Mg SO_4 + 10g borax	0.38	0.31	57.08	42.50
T_3 100g Mg SO_4+20g borax	0.40	0.36	60.19	45.75
T_4 200g Mg SO_4	0.30	0.23	68.25	51.66
T_5 200g Mg SO_4+10g borax	0.45	0.37	60.75	45.41
T_6 200g Mg SO_4+20g borax	0.48	0.40	69.33	50.33
T_7 10g borax	0.41	0.30	54.16	36.66
T_8 20g borax	0.44	0.36	52.08	34.66
Control	0.19	0.18	50.50	32.91
CD (5%)	0.18	0.10	6.41	5.14

Nutrient content in leaves

At flushing stage the boron content in leaves ranged from 23.00 mg kg^{-1} in control to 35.16 mg kg^{-1} in T_6 (Table 2). There were significant differences among the treatments at flushing stage. The treatment effect was also significant at berry formation stage where T_6 recorded highest boron content in leaves of 30 mg kg^{-1} (Table 2). There was a decrease in boron content in leaf from berry formation stage to harvest stage. At harvest stage highest boron content of 29.39 mg kg^{-1} was also noticed in T_6 treatment. It should be noted that the available boron content of soil was also increased from sub optimal level to the addition of borox to soil resulted in better absorption and higher content of boron in leaves. Similar results were reported by Hanson, (1991).

Table 2: Effect of soil application of Mg and B on their contents in pepper leaves at different stages

Treatment (Per vine)	Boron (mg kg^{-1})			Magnesium (%)		
	Flushing stage	Berry formation stage	Harvesting stage	Flushing stage	Berry formation stage	Harvesting stage
T_1	27.30	23.00	21.66	0.50	0.45	0.30
T_2	30.25	27.50	25.40	0.46	0.41	0.29
T_3	34.27	23.33	31.36	0.48	0.43	0.28
T_4	29.66	25.00	23.31	0.54	0.50	0.34
T_5	31.83	28.00	26.39	0.50	0.51	0.35
T_6	35.16	30.00	29.39	0.51	0.53	0.36
T_7	29.16	25.51	23.40	0.45	0.41	0.30
T_8	31.00	27.55	25.39	0.47	0.42	0.31
T_9	23.00	20.83	14.16	0.46	0.39	0.29
CD (5%)	3.10	2.48	6.24	0.31	0.32	0.13

Magnesium content in leaves

The treatments showed significance effect on magnesium content of leaves at flushing stage. At berry formation stage, T_6 recorded the highest leaf magnesium content of 0.53%. There was a decline in magnesium status in leaves with advancement of the age and lower values of Mg were recorded at harvest (Table 2). At harvest stage also there was significant difference between treatments with respect to magnesium. Highest magnesium content in leaves was obtained in T_6 (0.36%). These results clearly indicate a positive influence of application of Mg and B on the magnesium nutrition of black pepper. These results are in line with those reported by Hardter *et al.,* (2003).

Table 3: Effect of Mg and B application on growth and yield parameters of black pepper

Treatment	Branches m^{-2}	Spikes m^{-2}	Spike length (cm)	Berries $spike^{-1}$	100 berry weight (g) (dry)	Spike yield (kg $plant^{-1}$) (dry)
T_1	26.64	44.66	11.10	95.2	6.26	1.00
T_2	28.66	46.00	12.66	97.7	6.70	1.07
T_3	32.66	48.00	13.44	98.0	6.90	1.10
T_4	30.00	49.33	13.34	97.3	7.76	1.12
T_5	30.32	51.66	14.10	98.5	8.00	1.13
T_6	32.70	53.33	15.12	99.4	9.35	1.13
T_7	26.68	45.66	13.10	93.0	6.49	1.08
T_8	28.66	47.33	14.10.	94.6	7.00	1.10
T_9	24.00	41.33	10.01	90.88	4.16	0.89
CD (5%)	3.10	4.59	1.09	13.9	2.03	0.10

Growth and yield parameters

The data (Table 3) revealed that number of branches m^{-2} (32.70) were maximum in T_6 (200g $MgSO_4$ + 20g borax). It might be due to maximum branching and vegetative growth facilitated by proper nutrient supply and also could be due to positive effect of Mg and B. Similar results were reported by Sood and Sharma (2004) in bell pepper. Application of P.V 200g $MgSO_4$ + 20g borax (T_6) produced highest number of spikes m^{-2} (53.33), spike length (15.12 cm), number of berries $spike^{-1}$(99.4) and spike yield (1.13 $kgvine^{-1}$). The higher 100 berry weight was recorded with T_6 (9.35g) compared to other treatments. Increased yield were also observed due to application of boron. Hardter *et al.,* (2003) showed that magnesium had significant effect on yield of.The fact that the requirement of boron is more for reproductive growth than vegetative growth. Boron increases flower production and retention, pollen tube elongation and germination and seed (Sood and Sharma 2004).

Quality parameters

Data (Table 4) indicated that the concentration of oleoresin and piperine of black pepper ranged from 11.13 to 11.69% and from 5.18 to 6.84% respectively. The application of 200g $MgSO_4$ + 20g borax (T_6) recorded the highest oleoresin content of 11.69% The lowest oleoresin content was obtained in T_1 (10.20%). The highest content of piperine was obtained in T_6 (6.84%) and superior than other treatments. The lowest content was recorded in control. Boron is required for many enzymatic processes, which might have contributed to the improved quality parameters of black pepper. This might also be attributed to the fact that magnesium act as an activator or co-factor of many enzymes in plants and in various metabolic process as reported by Cowan, (2002).

Table 4: Effect of soil application of B and Mg on quality parameters of black pepper

Treatments	Oleoresin (%)	Piperine (%)
T_1	11.20	6.06
T_2	11.46	6.31
T_3	11.50	6.29
T_4	11.62	6.69
T_5	11.63	6.07
T_6	11.69	6.84
T_7	11.20	5.05
T_8	11.23	6.02
T_9	11.13	5.18
CD (5%)	0.70	1.28

It may be concluded that application of 200g $MgSO_4$+ 20g borax proved superior to other treatments with respect to yield attributes and yield quality and (oleoresin and peperine content). It may be recommended for the successful cultivation of black pepper in the area.

REFERENCES

Binghum, F.T. (1982) Boron. In: Page, A.L. (ed.), Methods of soil analysis. American society of Agronomy, Madison, 438p.

Brown, P.H. and Hu, H. (1996) Species variability in boron requirement is correlated with cell wall pectin. *Journal of Experimental Botany* **47:** 227-232.

Cowan, (2002) Structural and calaytic chemistry of magnesium. *Journals of Biometals* **15**: 225-235.

Hanson, K. (1991) Boron requirements and mobility in fruit tree species. *Current topics plant Biochemistry and Physiology* **10**: 271-273.

Hardter, R., Mortin. and Oleovius, K. (2003) Effect of different Mg fertilizers source on the magnesium availability in soils. *Nutrient cycling in Agro ecosystems* **70**: 249-259.

Horwitz, K. (1980) Evalution of oleoresin content from black pepper berries using actone. *Journal of International Academy* **9**: 341-344.

Kolhe, S.R., Priyanka, B. and Urmi, R. (2011) Extraction and evaluation of piperine from Black pepper (*Piper nigrum.* L). *International Journal of Applied Biology and Pharmaceuticals Technology* 2(2): 144-149.

Siddiky, M.A., Halder, N.K., Ahammad, K.U., Anam, K. and Rafiuddin M. (2007) Response of brinjal to zinc and boron fertilization. *International Journal of Sustainable Agricultural Technology* 3(3): **40**-45.

Sims. J.T. and Jhonson, G.V. (2003) Effect of boron application on grain set failure in boron deficient soils. *Indian Journal of Agronomy* **8**: 5-8.

Sood, R. and Sharma, S.K. (2004) Growth and yield of bell pepper (*Capsicum annum var.Grossum*) as influenced by micronutrient sprays. *Indian Journal of Agricultural Sciences* **74(**10): 557-559.

Su, C., Evans, L.J., Bates, T.E. and Spires, G.A. (1994) Extractable soil boron and calcium carbonate effect on acid soil. *Journal of Soil Science Society of America* 58: 1445-1450.

Sun, O.J. and Payn, T.W. (1999) Magnesium nutrition and leaf photosynthesis in *Pinusradiata*: clonal variation and influence of potassium. *Tree physiology* 1**9**: 535-540.