Research Article

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Optimisation of foliar application of zinc and boron in small cardamom (*Elettaria cardamomum* Maton)

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Abstract

A field experiment was conducted at Indian Cardamom Research Institute, Spices Board, Myladumpara, Idukki district, Kerala during 2006-09 to study the response of foliar application of zinc and boron on growth, yield and its content in index leaves in small cardamom. The experiment was laid out in randomized block design with twelve treatments replicated thrice. The treatments were various levels of zinc (0.1, 0.25, 0.5, 0.75 and 0.9 %) as zinc sulphate and boron (0.2, 0.4, 0.6, 0.8, 1.0 and 1.2 %) as borax with a control. The zinc content in the leaves of zinc treated plants ranged from 53.79 mg kg^{-1} to 116.67 mg kg^{-1}. The boron content in leaves of the boron treated plants ranged from 20.62 mg kg^{-1} to 34.37 mg kg^{-1}. The DTPA extractable zinc in soil was 0.756 to 0.917 mg kg^{-1} in zinc treatments and 0.93 mg kg^{-1} in control plot. Hot water extractable boron in soil ranged between 0.90 mg kg^{-1} to 2.2 mg kg^{-1} in boron treatments and 0.850 mg kg^{-1} in control plot. Application of boron at 0.6 and 0.8 % significantly improved the yield of cardamom compared to control. A significant quadratic relationship was established between yield and various levels of zinc and the quadratic curve gives the zinc optimum dose as 0.38 %. The yield attributing characters like number of panicles per clump and number of racemes per panicle were positively influenced by the foliar application of zinc and boron.

Keywords: Boron, cardamom, foliar application, nutrient content, yield, zinc

Introduction

The role of micronutrients in agricultural production has been viewed with great importance in recent years as a limiting factor for sustained crop productivity. Without application of micronutrients like zinc, boron etc. it is not possible to get the maximum benefit of NPK fertilizers from high yielding varieties (Sudipta *et al.*, 1997). A random survey conducted on the status of micronutrients in cardamom growing soils of south India showed that 70 percentage of the area sampled were deficient in available zinc and 30 percentage of area deficient in boron (Srinivasan *et al.*, 1993). Positive response of cardamom to application of zinc has been reported (Sivadasan *et al.*, 1991). Seventy four percentage of leaf samples collected from various cardamom fields in south India were analysed for zinc concentration and was found to be below the critical level of 33 mg kg^{-1} (Hamza *et al*., 2009). Thomas and Kuruvilla (2008) have reported decreasing sustainability of cardamom gardens due to widespread zinc and boron deficiencies. In the present scenario of intensive farming with high input responsive cultivars, deficiencies of micronutrients have become common. With this background, the present experiment was undertaken to study the response of foliar application of zinc and boron and to work out the optimum foliar spray doses of these micro nutrients for improving productivity in small cardamom.

Materials and Methods

A field experiment was conducted at Indian Cardamom Research Institute (ICRI), Spices Board, Myladumpara, Idukki District, Kerala during 2006-2009. The experimental site is situated at 9° 53' N latitude, 77° 9' E longitude and 1068 m above mean sea level. The soil of the experimental site was clayey, mixed, isohyperthermic, ustic, kandi and humult with moderate permeability. The experiment was laid out with twelve treatments in randomized block design and replicated thrice. The treatments were imposed on three year old yielding cardamom variety ICRI accession MCC 260 planted at a spacing of 3 x 3 m. The recommended dose of chemical fertilizers @ 75:75:150 kg N, P, K ha^{-1} was applied uniformly to all treatments. Similarly organic manure at the rate of 5 kg /plant was applied in the month of May (pre monsoon period). The experiment consisted of five levels of zinc (0.1, 0.25, 0.5, 0.75 and 0.9 % as zinc sulphate), six levels of boron (0.2, 0.4, 0.6, 0.8, 1.0 and 1.2 % as sodium tetra borate [borax]) with a control. The micronutrients were applied as pre and post monsoon sprays to the foliage and panicles in the month of May and September respectively for three consecutive years. The youngest mature leaf from terminals of newly emerged panicle bearing tillers were collected as index leaves (Korikanthimath, 1994) and analysed for Zn and B content before and 48 h after each micronutrient application. Prior to the imposition of the treatments, the index leaves from each treatment plot were collected, washed in distilled water and analysed for B and Zn contents as per standard procedures (Jackson, 1967) and these values for the micronutrients were taken as the bench mark for each treatment. Leaving the bench mark, the content of Zn and B in leaves (before and 48 h after application of micronutrients) for three years were added together and its average was computed to obtain the content of Zn and B for varying levels of their application. Soil nutrient status was assessed prior to the start and thirty days after the imposition of the treatments during each year of the experiment. Initially, the experimental soil had a pH value of 4.13, organic carbon 2.05 %, Brays P- 19.3 mg/100 g and exchangeable potassium 50 mg/ 100g. The DTPA extractable Zn was 0.643 mg kg^{-1} and available B in soil was 0.755 mg kg^{-1}. The DTPA extractable Zn was 0.756 to 0.917 mg kg^{-1} in zinc treatments and 0.598 to 1.038 mg kg^{-1} in boron treatments. Hot water extractable B in soil ranged between 0.90 mg kg^{-1} to 2.2 mg kg^{-1} among the various levels of boron treatments while in zinc treatments, it ranged from 1.09 to 1.202 mg kg^{-1}. The control treatments recorded 0.930 and 0.955 mg kg^{-1} of available Zn and B, respectively.

Important yield attributing characters like number of bearing tillers per clump, number of panicles per clump and number of racemes per panicle were recorded prior to and thirty days after the imposition of the treatments during each year of the experiment. The yield from each picking of cardamom was recorded during the experiment period. From the thirteen rounds of harvest (picking) during the experiment period, fresh yield and dry yield of capsules were recorded. The annual dry yield of first, second and third year were pooled. The litter weight of dried cardamom capsules was measured for each picking and average was computed for each year. The litter weight of the first, second and third year were pooled. The supply response equation was worked out to find out the economic optimum foliar dose of Zn and B. All the data were subjected to statistical analysis.

Results and Discussion

Zinc content in leaves as influenced by the foliar application of zinc

With the application of increasing levels of Zn, there was a corresponding increase in its content in the index leaves of the plant upto 0.75 % and then it declined at 0.9 % (Fig. 1). For 0.25 % zinc treatment, the corresponding Zn content was 65.68 mg kg^{-1}. The Zn content in leaves was 86 mg $kg^{-1}$with the application of 0.5 % of zinc as foliar dose, whereas, it was 116.67 mg kg^{-1} with 0.75 % of Zn application. At this level of Zn in leaves, the yield declined by 22 % when compared to 0.25 % Zn applied plants. At 0.9 % Zn application, the Zn content in the index leaves declined to 78.37 mg kg^{-1}. Sadanandan *et al.* (2000) reported 46 - 60 mg kg^{-1} as sufficient level of zinc under DRIS norms in the index leaves of cardamom. Cengiz and Higgs (2002) reported that foliar application of zinc can overcome the negative effects of zinc deficiency of plant growth when it is applied at optimal range in tomato.

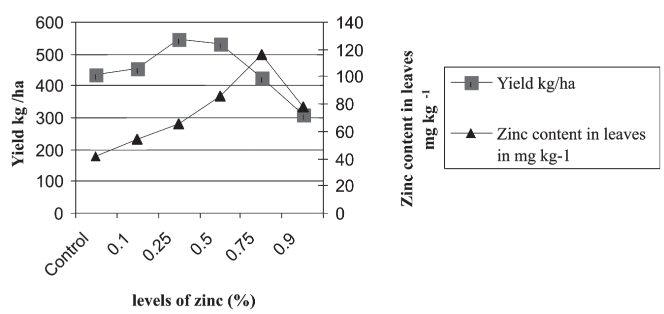

Fig. 1. Effect of foliar application of zinc on yield

Boron content in leaves as influenced by the foliar application of boron

Foliar application of B at 0.8 % recorded the highest pooled yield of 665 kg ha^{-1} over three years and corresponding B content in leaves was 29.88 mg kg^{-1} (Fig. 2). The pooled yield recorded with 0.2 % B was 529 kg ha^{-1} and corresponding B content in leaves was 24.04 mg kg^{-1}. With the increasing levels of B application, there was a corresponding increase in its content in the index leaves with a maximum of 34.37 mg kg^{-1} for 1.2 % boron application.

Effect of boron and zinc on yield attributing characters in cardamom

The variations among treatments for the number of bearing tillers per clump before the imposition of any treatment in the first year of the experiment could not be

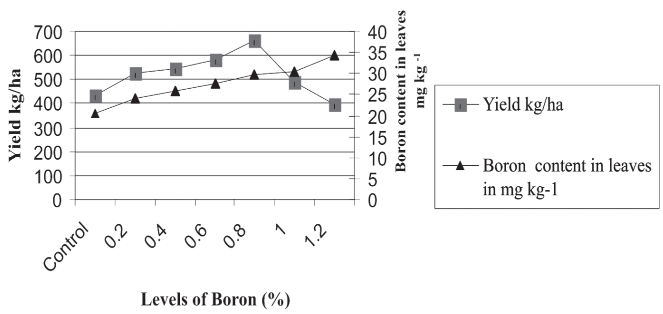

Fig. 2. Effect of foliar application of Boron on yield

attributed to treatment effect. The other parameters like number of panicles per clump and number of racemes per panicle were not significant between treatments before the imposition of the treatments.

In the pre treatment data, 0.2 and 0.8 % B, 0.75 % Zn and Control were on par and superior compared to all other treatments for number of bearing tillers per clump. In the post treatment, levels of B from 0.2 to 1.0% and all levels of Zn had higher number of bearing tillers per clump compared to control. However, the difference between treatments for the number of bearing tillers per clump after the treatment imposition was statistically not significant (Table 1).

Boron and Zn have positive influence on the number of panicles per clump after the imposition of respective treatments. (Table 1). Application of B upto 0.8 % recorded numerically higher number of panicles per clump compared to control. However, B treatment upto 0.8% was on par with control statistically. Srinivasan *et al*. (2000) have reported that 0.4 % B application as borax is beneficial for plant growth performance in cardamom in Kerala. There was considerable increase in the number of panicles per clump with levels of zinc from 0.1 to 0.5 %. Zinc at 0.5 % was statistically significant compared to control. Zinc at 0.25 and 0.5 % as well as B at 0.2,0.4 and 0.8 % were on par.

The number of racemes per panicle after treatment imposition was positively influenced by the application of B and Zn (Table 1). The Zn application upto 0.5 % increased the number of racemes per panicle and the treatment difference was significant for 0.25 and 0.5% Zn application compared to control. Sivadasan *et al.* (1991) have reported the yield increase in cardamom with the foliar application of zinc sulphate as attributable to over all growth improvement of the crop. The number of racemes per panicle was numerically higher for B treatments upto 0.8 %, but on par with control.

Effect of zinc and boron on yield in cardamom

The dry yield data of all the pickings in each year were added to obtain total dry yield for the year and statistically analysed. The results of the data on dry capsule yield of the plants for first year, second year and third years are presented in Table 2. Statistically significant difference in yield among the treatments was noticed during the first year. In the first year of treatment, the highest yield of 994.2 kg ha $^{-1}$ was obtained for 0.8 % B which was statistically superior compared to control plants which recorded 612.8 kg ha $^{-1}$. Application of B at 0.8 % was on par with 0.6 % but superior to control and applications at 0.2, 0.4 and 1.2 %. Boron treatment generally improved the yield when compared to control. Boron at 0.2, 0.4, 0.6,1.0 and 1.2 % with all levels of Zn were on par with control. Among the various levels of Zn, 0.25 % Zn treated plants recorded the highest yield of 794.4 kg ha^{-1} followed by 0.5 % Zn with a yield of 674.2 kg ha$^{-1,}$ whereas 0.75 and 0.9 % Zn recorded lower yields compared to control but were on par.

Table 1. Effect of boron and zinc on yield attributing characters

Dose of B and Zn (%)		No. of bearing tillers		No. of panicles/clump		No. of racemes/panicle	
		Pre*	Post**	Pre	Post	Pre	Post
	Control	24.67	29.19	48.58	63.15	22.22	23.02
Boron	0.2	26.83	30.69	46.75	68.93	25.55	24.02
	0.4	16.58	31.01	41.58	65.39	17.45	23.59
	0.6	21.00	31.10	39.08	67.67	20.44	23.99
	0.8	22.50	31.05	38.00	66.12	20.17	23.44
	1.0	20.80	31.85	40.83	60.26	20.27	22.08
	1.2	20.30	28.63	40.70	59.42	19.93	23.21
Zinc	0.1	21.90	30.77	45.27	60.86	20.03	24.47
	0.25	21.83	32.11	46.08	71.01	21.78	24.83
	0.5	26.67	30.91	51.5	77.17	21.22	25.58
	0.75	21.33	30.28	41.92	63.16	19.22	23.39
	0.9	20.95	30.55	42.85	58.20	19.27	21.52
CD (P=0.05)		4.206	NS	NS	10.49	NS	1.528

*Pre-pretreatment & **Post-post treatment NS = Not significant

Table 2. Yield of cardamom as influenced by different doses of boron and zinc over three years

Dose of B and Zn (%)		Dry yield (kg ha $^{-1}$) First year	Second year	Third year	Pooled mean
	Control	612.8	302.3	385.6	433.6
Boron	0.2	722.6	390.6	473.6	529.0
	0.4	747.5	400.8	490	546.1
	0.6	813.4	416.7	513.9	581.3
	0.8	994.2	454.2	548.3	665.6
	1.0	790.3	304.2	366.3	487.1
	1.2	647.8	219.4	251.7	397.0
Zinc	0.1	658.2	309.2	391.7	453.0
	0.25	794.4	393.1	455	547.5
	0.5	674.2	460	466.4	533.5
	0.75	595.6	278.3	407.5	427.2
	0.9	430.6	202.2	298.9	310.6
CD (P=0.05)		245	NS	NS	146

NS = Not significant

During the second and third years, significant differences were not obtained between various doses of zinc and boron for dry yield of cardamom (Table 2).

Split plot design was used with year as subplots and treatment as main plot to study the interaction effect between treatment and years as per standard procedures. Interaction between year and treatments was non significant. Hence, yield data over three years were pooled and statistically analysed. Pooled analysis of dry yield indicates that there was increase in yield of cardamom upto 0.8 % B application. Application of B at 0.6 % (581.3 kg ha^{-1}) and 0.8 % (665.6 kg ha^{-1}) are statistically superior compared to control (433.6 kg ha^{-1}). Application of B at 1.2 % and Zn at 0.75 and 0.9 % have resulted in lower yield compared to control, but were on par (Table 2).

Results indicate that there is a positive response with respect to yield on application of B at levels upto 0.8 %, and the yield started declining from 1.0% (487.1 kg ha^{-1}). With application of B at 1.2 %, the yield (397.0 kg ha^{-1}) declined by 8 % compared to control. In the case of Zn, maximum response with respect to yield was obtained at 0.25 % (547.5 kg ha^{-1}). Application done at 0.5 % recorded higher yield (533 kg ha^{-1}) compared to control. There was 26 % increase in yield for 0.25 % Zn application compared to control. Beyond 0.5 % level of zinc, yield declined compared to control. The economic optimum dose for foliar application of Zn for yield maximization was worked out to be 0.38 % and details are described elsewhere. Sharma *et al.* (1991) reported that maximum fruit set, fruit retention and yield were obtained in Guava by foliar application of 0.6 % zinc sulphate.

Effect of zinc and boron on litre weight of the capsule

The variation between treatments on litre weight was not significant (Table 3). Pooled mean data over three years on litre weight also showed a similar trend. The statistical analysis of the data reveals that micronutrients like Zn and B may not have any influence on litre weight of the cardamom capsules.

Supply response equation and its critical limit

In order to derive the critical level of Zn, a quadratic curve was fitted to the pooled yield data over three years obtained for Zn treatment (Fig. 3). A significant quadratic relationship between Zn application as foliar doses and yield was obtained. From the response curve, the optimum dose of Zn for obtaining maximum yield was found to be 0.38 % with R^2 value of 0.972. The quadratic relationship was explained by the following mathematical equation, $Y = 420.72+667.21x-877.3\ x^2$. Dwivedi *et al.* (2002) reported the optimum Zn fertilizer dose for maximum grain yield of maize as 7.1 kg ha^{-1}.

Response equation was not found to be good fit for yield data obtained from various levels of B treated plants.

Table 3. Effect of zinc and boron on litre weight of cardamom capsules

Dose of B and Zn (%)		Litre weight (in kg) First year	Second year	Third year	Pooled mean
	Control	444.71	401.97	405.44	417.38
Boron	0.2	438.66	396.02	407.70	414.15
	0.4	441.84	388.64	406.89	412.46
	0.6	436.42	383.82	423.19	414.47
	0.8	436.35	389.46	396.16	407.33
	1.0	436.63	377.27	412.43	408.78
	1.2	430.43	377.47	397.45	401.78
Zinc	0.1	439.01	398.13	407.76	414.97
	0.25	438.36	401.25	410.97	416.86
	0.5	439.43	389.81	404.89	411.38
	0.75	442.41	399.13	412.68	418.07
0.9	432.82	385.91	398.16	405.63	
CD (P=0.05)		NS	NS	NS	NS

NS = Not significant

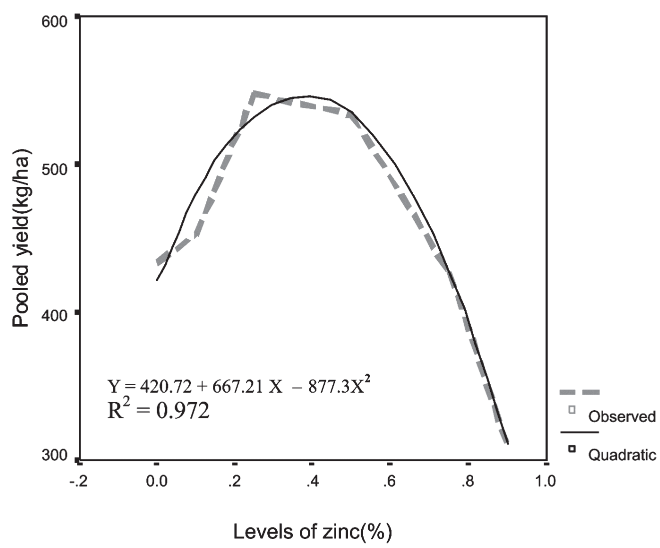

Fig. 3. An estimated quadratic relationship between various levels of zinc and pooled yield

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References

Cengiz, K.and Higgs, D.2002. Response of tomato cultivars to foliar application of zinc when grown in sand culture at low zinc. *Science Horticulture* **93**: 53-64.

Dwivedia, S.K., Singh, R.S.and Dwivedia, K.N. 2002.Effect of Sulphur and Zinc nutrition on yield and quality of maize in Typic Ustochrept soil of Kanpur. *Journal of Indian Society of Soil Science* **50**: 70-74.

Hamza, S., Srinivasan, V.and Dinesh, R. 2009. Nutrient diagnosis of cardamom gardens in South India. *Indian Journal of Agricultural Sciences* **79**: 429-432.

Jackson, M.L. 1967. *Soil Chemical Analysis*. pp. 372-375. Prentice hall of India Pvt. Ltd., New Delhi.

Korikanthimath, V.S. 1994. Nutrition of cardamom. pp. 467- 476. In : *Advances in Horticulture. (*Eds.) Chadda, K.L. and Rethinam, P. Malhothra Publishing House, New Delhi.

Roy, A., Chatterjee, R., Hassan, A. and Mitra, S.K.1992. Effect of Zinc, Iron, and Boron on growth, yield and nutrient content in leaves of ginger. *Indian Cocoa Arecanut and Spices Journal* **15**: 99-101**.**

Sadanandan, A.K., Hamza, S and Srinivasan, V. 2000. Foliar nutrient norms for optimizing cardamom production. pp. 101-106. In: *Proceedings of centennial conference on spices and aromatic plants*. (Eds.) Ramana, K.V., Eapen, J.S., Babu, K.N., Krishnamoorthy, K.S. and Kumar, A. held during 20-23, September 2000 at IISR, Calicut.

Sharma, R.K., Kumar Ram, and Thakur, S. 1991. Effect of foliar application of potassium, calcium, and zinc on yield and quality of guava. *Indian Journal of Horticulture* **48** (4): 61-65.

Sivadasan, C.R., Nair, C.K., Srinivasan, K. and Mathews, K.1991. Zinc requirement of cardamom. *J. Plantn.Crops* **18**:171-173.

Srinivasan, K., Vadiraj, B.A., Krishankumar, V. and Naidu, R.1993. Micronutrient status of cardamom growing soils of South India. *J.Plantn.Crops* **21**: 67 -74.

Srinivasan, K., Krishnakumar, V., and Potty, S.N., 2000.Effect of boron on growth and yield of cardamom. pp. 206-208. (In): *Recent Advances in Plantation Crops Research.* (Eds). Muraleedharan, N., Rajkumar, R. Allied Publishers Limited, New Delhi.

Sudipta K. Ghosh, S.K. and Hassan, M.A. 1997. Effect of boron on growth and yield of cauliflower. *Annals of Agricultural Research* **18**: 391-392**.**

Thomas, J. and Kuruvilla, K.M. 2008.The Indian Cardamom Research Institute- Gearing up for the challenges in cardamom industry. pp. 40-46, In: *PLACROSYM XVIII*. (Eds.) Nagaraj, K.V., and. Shivarama Bhat, P., Indian Society for Plantation Crops, Kasaragod.