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Soil application of Mg, Zn and Mn: Effects on Growth, Nutrient Content and Soil Fertility Status of Large Cardamom in North East, India

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ABSTRACT

Field experiment was conducted at Kabi Research Farm, Indian Cardamom Research Institute, RRS, Spices Board Gangtok, India to find out the role of soil application of Mg, Zn and Mn on growth and nutrition in large cardamom. The experiment laid out in randomized block design, consisted eight treatments *viz.* $ZnSO_4$ (5 kg/ha), $ZnSO_4$ (10 kg/ha), $MnSO_4$ (10 kg/ha), $MnSO_4$ (5 kg/ha), $MgSO_4$ (10 kg/ha), $MgSO_4$ (5 kg/ha), $ZnSO_4$ + $MnSO_4$ + $MgSO_4$ (10 kg/ha) and control. Result showed that among the fertility treatments, soil application of $ZnSO_4$+$MnSO_4$+$MgSO_4$@10kg/ha resulted in maximum number of immature tillers (4.10 and 4.80), mature tillers (4.48 and 4.20) during September, 2014 and March, 2015 and vegetative buds (3.05) of large cardamom. With respect to nutrients status in large cardamom, application $ZnSO_4$+$MnSO_4$+$MgSO_4$ @10kg/ha had significantly higher Mg (0.54%), Zn (55.01 ppm) and Mn (493.60) content in leaf over the control. Change in soil fertility status due to treatment application were noticed at the end of experiment, among the different treatments, application of $ZnSO_4$ + $MnSO_4$ + $MgSO_4$ @10 kg/ha proved its superiority over the others and its effect was statistically non-significant on available Fe and B in soil. Soil application of $ZnSO_4$+$MnSO_4$+$MgSO_4$@10kg/ha recorded the significantly higher Mg (49.03 ppm), Zn (4.20 ppm) and Mn (20.10 ppm) content in soil.

1. Introduction

Large cardamom (*Amomum subulatum* Roxburgh) belonging to family Zingiberaceae is an important spice crop of North East India and often referred as currency crop (Gupta and Chhetri, 2013). Now-a-days adjoining countries of India like Nepal, Bhutan and Myanmar has also started cultivation of large cardamom (Deka *et al.,* 2014a). In Sikkim Himalayas it is cultivated since time immemorial and believed to be the native of the state (Vijayan *et al.*, 2013; Gudade *et al*., 2015). Sikkim has the largest area (22755 ha) as well as production (3744 tons) of large cardamom in the globe and act as a big player in the world market (Spices Board, 2014; Gupta *et al*., 2012). It grows well at altitude ranges from 1000 to 2200 m amsl with well distributed rainfall spread around 200 days with a total of about 3000-3500 mm/year (Rao *et al*., 1993; Gudade *et al.,* 2013b; Gudade *et al.*, 2014). Large cardamom is a sciophyte *i.e.* the plant is grown under shade (Gudade *et al*., 2013c; Gudade *et al*., 2013a). Crop prefers humid subtropical, semi evergreen forests hills of eastern sub-Himalayan region (Vijayan *et al*., 2014). It is essentially a cross-pollinated crop due to the heterostylic nature of its flowers though they are self-fertile.

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Bumble bee *(Bombus breviceps)* is the major pollinator in large cardamom due to its high pollination efficiency attributed to its big body size and foraging habit (Deka *et al.,* 2011; Kishore *et al*., 2012). In Sikkim the average productivity of large cardamom ranges from 240 to 260 kg/ha (Gupta *et al.*, 2012). There is ample scope of increasing productivity by use of good agronomic practices as well as proper fertility management. A suitable combination of macro and micro nutrients is the most important single factor that affects the yield and quality of large cardamom. In recent year's productivity of large cardamom declined in Sikkim. There are several factors responsible for declination of the productivity. Among them the role of plant nutrients especially macro and micronutrients is of paramount importance. All plantation crops respond constructively to the application of macro as well as micronutrients. The agriculture in Sikkim is organic by default, crops are grown in traditional way *i.e.* the organic practices on hill slopes and in some places with terraces, however officially the state has been declared organic from 2003 and has to attain fully organic status by end of 2015. In the organic production systems, the main sources of these nutrients are farm yard manure (FYM), goat and sheep manures, compost, and vermicompost made from locally available biomass. However, these manures contents fewer amount of all nutrients in general and micronutrients in particular ranging from few mg/kg to several thousand mg/kg in soils (Wajahat *et al*., 2006). Among the nutrients Zn, Mn and Mg are of special importance because of their role in the growth and development process in crops. At the time of fertilization most of the zinc is diverted to seed only (Jenik and Barton, 2005; Pandey and Gautam, 2009; Reid *et al*., 2011). In most cultivated plants the critical concentration of manganese in leaves is 25 mg/kg dry matter (Mutaftchiev, 2003). Soil application with magnesium increases net assimilation rate, seed yield and crude protein content of plants. The soils of Sikkim are acidic in nature having high organic matter content and no information is available on effect of soil application of Zn, Mn and Mg on growth and nutrient content of large cardamom. Keeping these facts in view the present study was undertaken to find out the effect of soil application of Zn, Mn and Mg on growth and nutrient content of large cardamom at an altitude of 1567 amsl in Sikkim Himalayas of north east India.

2. Materials and Methods

The field experiment was carried out during 2014-2015 on the standing crop (planted in 2012) at Kabi Research Farm, Indian Cardamom Research Institute, Regional Research Station, Spices Board **(**1567 m amsl; latitude 27° 24′ 21.79″ N; longitude 88° 37′ 12.23″ E) North Sikkim. Weather parameters play an important role in crop growth therefore, monthly rainfall, maximum and minimum temperature were recorded during the cropping period and presented in figure 1. Soils of experimental field was clay loam in texture and had soil pH of 4.4 (1:2.5 soil/water ratio), 241.2 kg/ha alkaline permanganate oxidizable N, 29.22 kg/ha Brays P_1, 193.5 kg ammonium acetate exchangeable K and 3.95 per cent organic carbon. The experiment was laid out in three time replicated randomized block design comprises eight treatments *viz.* $ZnSO_4$ @ 5 kg/ha (T_1), $ZnSO_4$ @ 10 kg/ha (T_2), $MnSO_4$ @ 10 kg/ha (T_3), $MnSO_4$ @ 5 kg/ha (T_4), $MgSO_4$ @ 10 kg/ha (T_5), $MgSO_4$ @ 5 kg/ha (T_6), $ZnSO_4$+$MnSO_4$+$MgSO_4$@10 kg/ha (T_7) and Control (T_8). Large cardamom *Sawney* cultivar was planted with the spacing of 1.5 m x1.5 m during July 2012. Treatments of soil application of secondary nutrients (Mg) and micronutrients (Zn and Mn) were imposed once in a year *i.e.* April. The growth parameters were observed as per the standard procedures two times in a year in September 2014 and March 2015. The plant samples collected were ground into fine powder and passed through a 40 mm mesh sieve and used for chemical analysis to find out the nutrient content in plants. Similarly the composite soil samples were collected from 0-15 cm soil profile for analysis of nutrient content. The soil samples were air-dried, ground and passed through 100 mm mesh sieve and analyzed. Standard laboratory methods were followed for analyzing the leaf and soil samples to find out the nutrient content. The soil and leaf samples were analyzed at Division of Agronomy and Soil Science, Indian Cardamom Research Institute, Spices Board, Myladumpara, Kerala.

3. Results and Discussion

Growth parameters of large cardamom

Results showed that, the soil application of Zn, Mn and Mg alone or in combination of all these nutrients had significant effect on growth parameters of large cardamom. Among the treatments imposed to large cardamom, application of $ZnSO_4$+$MnSO_4$+$MgSO_4$@10kg/ha resulted in maximum number of immature tillers (4.10 and 4.80), mature tillers (4.48 and 4.20) during September, 2014 and March, 2015 and vegetative buds (3.05) of large cardamom as compared to control and other treatments (Table 1). It might be due to the vital role of Zn, Mn and Mg in photosynthesis, nitrogen and phosphate metabolism which resulted in better crop performance. Similar results were also reported in large cardamom by (Gudade *et al*., 2015).

Table 1. Effect of soil application of Mg, Zn and Mn on growth of large cardamom.

Treatment	Immature tillers (nos.)		Mature tillers (nos.)		Vegetative buds (nos.)
	Sep 2014	Mar 2015	Sep 2014	Mar 2015	Mar 2015
$ZnSO_4$ @ 5kg/ha	2.80	3.10	2.68	2.80	1.80
$ZnSO_4$ @ 10 kg/ha	3.10	3.32	3.19	3.05	2.15
$MnSO_4$ @10kg/ha	2.90	3.68	3.47	3.38	2.60
$MnSO_4$ @5kg/ha	2.98	3.71	3.79	3.59	2.70
$MgSO_4$ @10kg/ha	3.80	3.38	3.94	3.71	2.65
$MgSO_4$ @5kg/ha	3.98	4.10	3.60	3.89	2.80
$ZnSO_4$+$MnSO_4$+ Mg SO_4@10kg/ha	4.10	4.80	4.48	4.20	3.05
Control	1.01	2.49	2.08	2.20	1.38
Sem±	0.20	0.20	0.19	0.18	0.10
LSD (*P*=0.05)	0.63	0.61	0.59	0.56	0.32

Zn: Zinc; Mn: Manganese; Mg: Magnesium; SO_4: Sulfate; Sep: September; Mar.: March.

Nutrient content in leaf of large cardamom

Leaf samples of the experiment were analyzed to know the impact of applied nutrients on nutrient content in leaf of large cardamom. Critical review of data presented in Table 2 indicates that soil application of Mg, Zn and Mn significantly affects the nutrient acquisition pattern of Mg, Zn and Mn in large cardamom. However, all the treatment had failed to affect the Cu and Fe content in leaf of large cardamom. Among the treatments, soil application of $ZnSO_4$+$MnSO_4$+$MgSO_4$ @10kg/ha recorded the significantly higher values of Mg (0.54%), Zn (55.01 ppm) and Mn (493.60 ppm) in the leaf of large cardamom. This was due the fact that the soil application of Mg, Zn and Mn marginally enhances the availability of these elements in soil which facilitate the easy absorption to the plants.

Change in soil fertility status

Data presented in Table 3 showed that the soil application of Mg, Zn and Mn brought out the significant improvement in its concentration in soil over the control. Among the fertility treatments soil application of $ZnSO_4$ + $MnSO_4$ + $MgSO_4$ @10 kg/ha proved its superiority over the others and recorded significantly higher values of Mg (49.03 ppm), (4.2ppm) and (Mn 20.1 ppm). This improvement was due to the low availability of these nutrients in soil. (Parthasarthy *et al*., 2008) also reported the deficiency of macro and some micro nutrients in north east soil. However, its effect was statistically non-significant on available Fe, Mn and B in soil. Generally, factors which affect availability of Mg and micronutrient to plants include its content, pH, organic matter content, clay content, redox conditions, microbial activity in the rhizosphere, soil moisture status, concentration of other trace elements, concentrations of macro-nutrients, especially phosphorus. Micronutrients (Zn) and Mn) in soil of north east India was a Availability of these nutrients was increased in soil due to the direct application of these elements through the fertilizers sources.

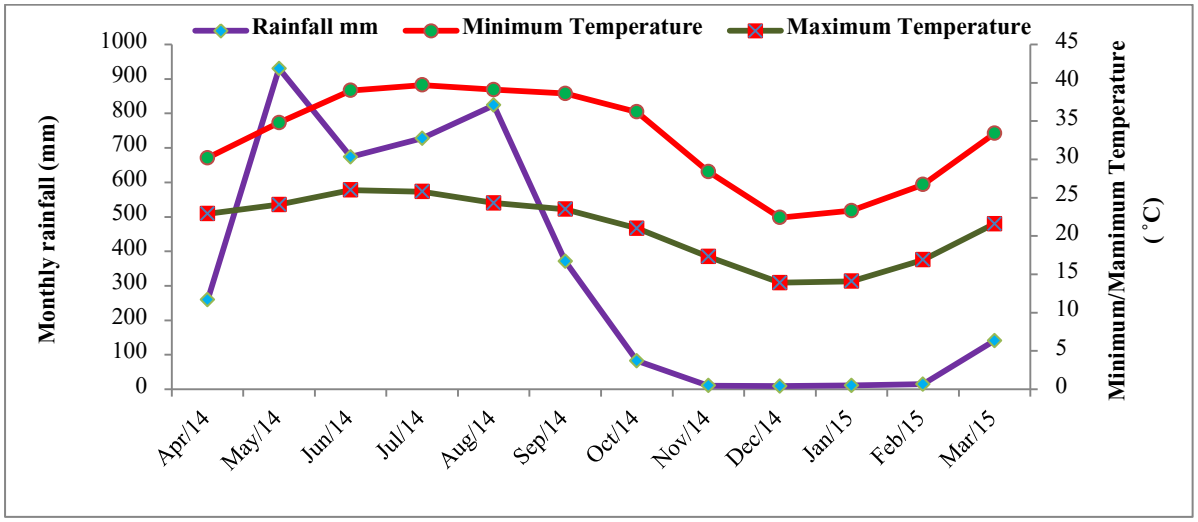

Figure 1. Weather parameters monthly rainfall (m), minimum and maximum temperature (˚C) during the experimental period.

Table 2. Effect of soil application of Mg, Zn and Mn on nutrient content in leaf of large cardamom.

Treatment	Nutrient content				
	Mg (%)	Zn (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)
$ZnSO_4$@5kg/ha	0.37	52.50	5.85	349.50	294.20
$ZnSO_4$@10kg/ha	0.35	48.92	6.03	353.78	338.01
$MnSO_4$@10kg/ha	0.43	47.50	5.97	490.50	299.59
$MnSO_4$@5kg/ha	0.46	46.76	5.93	485.31	305.20
$MgSO_4$@10kg/ha	0.51	45.71	5.45	342.48	328.08
$MgSO_4$@5kg/ha	0.45	44.20	5.47	353.29	349.00
$ZnSO_4$+$MnSO_4$+ $MgSO_4$@10kg/ha	0.54	55.01	6.10	493.60	351.30
Control	0.29	42.50	5.13	349.33	291.30
Sem±	0.038	0.60	0.69	15.30	22.01
LSD (*P*=0.05)	0.010	1.83	NS	48.10	NS

Zn: Zinc; Mn: Manganese; Mg: Magnesium; SO_4: Sulfate; Cu: Copper; Fe: Iron; ppm: Parts per Million.

Table 3. Effect of soil application of Mg, Zn and Mn on soil fertility of large cardamom.

Treatment	Available nutrients (ppm)					
	Mg	Zn	Cu	Mn	Fe	B
$ZnSO_4$ @ 5kg/ha	37.50	3.68	2.04	17.08	186.01	0.160
$ZnSO_4$ @ 10 kg/ha	37.42	4.17	2.07	18.05	188.08	0.172
$MnSO_4$ @10kg/ha	36.00	3.30	2.09	19.60	190.10	0.165
$MnSO_4$ @5kg/ha	36.23	3.28	2.01	19.07	195.07	0.156
$MgSO_4$ @10kg/ha	48.50	3.20	2.10	17.85	183.00	0.151
$MgSO_4$ @5kg/ha	44.07	3.31	2.18	17.41	193.00	0.173
$ZnSO_4$+$MnS0_4$+ Mg SO_4@10kg/ha	49.03	4.20	1.70	20.10	198.00	0.170
Control	35.20	2.81	0.08	16.30	179.00	0.160
Sem±	1.40	0.10	0.39	0.80	3.100	0.008
LSD (*P*=0.05)	4.22	0.32	NS	2.38	NS	NS

Zn: Zinc; Mn: Manganese; Mg: Magnesium; SO_4: Sulfate; Cu: Copper; Fe: Iron; B: Boron; ppm: Parts per Million.

Thus, the present study clearly indicates that soil application of Mg, Zn and Mn is enhances the growth and nutrient contents in leaf of large cardamom besides improving their availability in soil. Among the different treatments, soil application of $ZnSO_4$ + $MnSO_4$ + $MgSO_4$ @10 kg/ha was found superiors over the others and recorded the higher values of growth parameters, nutrients content in plant and soils. Therefore, soil application of $ZnSO_4$ + $MnSO_4$ + $MgSO_4$ @10 kg/ha is strongly recommended for sustainable large cardamom production in Sikkim.

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