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Effect of zinc and boron on nutrient uptake pattern in mango ginger (*Curcuma amada* Roxb.)

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Abstract
The present experiment on mango ginger was carried out in randomized complete block design with three replications during 2018-19 in College of Horticulture, Mudigere. The experiment consisted of nine different treatment combinations which comprises two micronutrients (Zn and B) at 3 levels (0, 5 and 10 kg / ha) in all possible combinations. The experimental findings evident that the treatment T9 (ZnSO4 10 kg / ha + Borax 10 kg / ha) was found better with respect to uptake of N, P, K, Zn and B by leaves and rhizomes. However, least nutrient content in leaves and rhizome was recorded in T1 (Control).

Keywords: zinc and boron, nutrient uptake pattern, mango ginger (Curcuma amada Roxb.)

Introduction

Curcuma amada Roxb. is an important minor spice cum medicinal plant grown for mature rhizomes. Origin of this crop is Indo-Malayan region and is widely distributed in the tropics from Asia to Africa and Australia (Sasikumar, 2005) [16].

The species is a member of zingiberaceae family and has morphological resemblance with turmeric but the rhizomes look like that of ginger. The rhizomes are flavoured like that of raw mango (*Mangifera indica* L.) and hence the crop is commonly called as mango ginger. The plant grows up to a height of one meter. Each plant bears 5 to 6 pairs of leaves. The rhizomes are branched and the branching is sympodial. The plant grows luxuriantly in well-drained, fertile soil. Hot humid tropical climate with high rainfall is congenial for good stand of the crop.

Rhizomes yield one per cent essential oil which contains 68 volatile compounds like, mangiferin, car-3-ene, myrcene, cis-ocimene, d-a–pinene, ocimene, linalool, linalyl acetate, safrole etc. Among these compounds presence of car-3-ene, myrcene, cis-ocimene and d-a-pinene are mainly responsible for raw mango flavour of the rhizomes (Srivastava *et al*., 2001) [17]

Essential oil extracted from rhizomes has several applications in food, beverages, cosmetics and in medical sectors. The mango ginger rhizome has been extensively used as an appetizer, alexteric, antipyretic, aphrodisiac and laxative.

Mango ginger appears to be highly potential, but the agronomic information on requirements such as nutrition, irrigation, plant density *etc.*is much less. Hence, development of suitable production technology to boost the crop yield is essential where nutrition plays a vital role in crop production. As no works has been done on the effects of nutrition in mango ginger, the present investigation was carried out at College of Horticulture, Mudigere during 2018-2019.

Materials and methods

A field experiment was conducted at College of Horticulture, Mudigere during the period from May 2018 to November 2018. The experiment was designed to study the influence micronutrients on growth and yield of mango ginger (*Curcuma amada* Roxb.). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Size of each plot was 3 m × 1. 2 m. The spacing followed was 30 cm between rows and 30 cm between plants. There were totally 40 plants in each plot.

The experiment consists of two micronutrients (Zn and B) with 3 levels (0, 5 and 10 kg/ ha). The zinc was applied in the form of zinc sulphate and boron as borax as per the treatment at the time of planting. The plots were kept weed-free by hand weeding at an interval of 40-50 days. The plots were irrigated at an interval of 2-3 days in initial growth period. Later the irrigation requirement was met by rain. Earthing up was done to keep the plant base covered. Totally four weedings, two earthing up and four irrigations were taken up during the entire crop growth period. Various observations related to quality of the mango ginger were recorded at periodic growth intervals. Five plants per plot were selected randomly and tagged for recording various observations.

Plant sampling and processing

The third leaf from the top of the plant was taken from five tagged plants in each treatment (at 90, 120 and 150 DAP), dried at 50º C and then finely powdered those leaves by using pestle and mortar. Likewise, dried rhizomes were also powdered. Powdered samples (5 g) were stored in air tight box for further analysis. Both plant and rhizome samples were digested in diacid and analysed for total N, P, K, S, Zn and B content. The methods used for plant analysis are presented in Table 1.

Table 1: Methodologies for plant analysis

SL. No.	Parameter	Procedure	Method and Reference
1	Total plant Nitrogen	Plant sample digested in concentrated sulphuric acid and digestion mixture (K2SO4: CuSO4: Selenium in 100:20:1 proportion). The digested sample was distilled by micro Kjeldhal distillation method. The liberated ammonia was trapped in boric acid and estimated by titration against standard sulphuric acid.	Piper (1966) [14]
2	Total plant Phosphorus	Phosphorus in diacid digested plant sample estimated by forming yellow colour phosphovanadomolybdate complex using spectrophotometer at 430 nm.	Phosphovanadomolybdate complex method, Baruah and Bar Thakur (1997) [2]
3	Total plant Potassium	Potassium in diacid digested plant sample was estimated with flame photometer	Flame photometry, Jackson (1967) [6]
4	Total sulphur	Sulphur in diacid digested plant sample was estimated by precipitating with BaCl2, and the turbidity was measured at 420 nm.	Turbidometry, Bradsley and Lancester (1965) [3]
5	Zinc	Micronutrients in diacid digested plant samples were determined using Atomic Absorption Spectrophotometer	Lindsay and Norwell (1978) [11]
6	Boron	The diacid digested plant samples were treated with Azomethane–H reagent and colour was measured at 420 nm using Spectrophotometer	Azomethane–H method, Jones and Case (1990) [9]

Soil sampling and processing

A composite soil sample from the experimental site was collected before planting to know the nutrient status of the soil before the application of fertilizer. After the crop was harvested, surface composite soil samples were collected (0-30 cm depth) from each treatment plot. Soil samples were mixed and spread on a sheet for air drying and kept in shade. Then the samples were subjected for analysis for available Nitrogen, Phosphorus, Potassium, Sulphur, Zinc and Boron content of the soil by adopting standard methods of analysis. The methods used for soil analysis are furnished in Table 2.

Table 2: Methodologies for soil analysis

SL. No.	Parameter	Procedure	Method and Reference
Soil analysis			
1	Available Nitrogen	Soil was oxidized and distilled with alkaline potassium permanganate and then titrated against standard acid using mixed indicator.	Subbaiah and Asija (1956) [18]
2	Available phosphorus	Soil was extracted with Brays-1 and estimated by Ammonium molybdate acid method using spectrophotometer and intensity of blue colour was measured at 660 nm.	Brays –I method, Brays and Kurtz (1945) [4]
3	Available potassium	Extracted the soil with 1 N (pH 7) ammonium acetate and estimated with flame photometer.	Flame photometry, Jackson (1967) [6]
4	Available Sulphur	Extract the soil with 0.15 % CaCl2 then Sulphur was precipitated with BaCl2, and the turbidity was measured at 420 nm.	Turbidometry, Jackson (1967) [6]
5	DTPA extractable Zn	Extracted the soil with DTPA and estimated with atomic absorption spectrophotometer	Lindsay and Norwell (1978) [11]
6	Available boron	Azomethane–H reagent method	Guptha (1979) [8]

Analysis of variance (ANOVA) for RCBD

Analysis of variance for all characters in Randomized Complete Block Design (RCBD) was carried out following Cochran and Cox (1957) [5] procedure. The statistical significance was tested by applying 'F' test at 0.05 level of probability and critical differences were calculated for those parameters which turned significant ($P < 0.05$) to compare the effects of different treatments.

Results and discussion Nutrient content in plants

The perusal of data (Table 3.) on nitrogen, phosphorous and potassium content (%) in leaves and rhizomes as influenced by the soil application of zinc and boron indicated that the treatment T9 (ZnSO410 kg / ha + Borax 10 kg / ha) performed better in uptake of N content in leaves (3.00 %) and rhizome (2.52%) whereas minimum N content in leaves (1.21%) was recorded in T1 (Control) and in rhizome (1.09 %) was recorded in T3. With respect to P, the treatment T9 recorded maximum uptake of P content in leaves (1.13%) and T8 recorded maximum P content in rhizome (0.94%) whereas minimum P content in leaves (0.52%) was recorded in T2 and minimum P content in rhizome (0.51%) was recorded in T1 (Control). In case of potassium, the treatment T9 recorded maximum K content in leaves (3.15 %) and rhizome (2.71 %) whereas minimum N content in leaves (1.27 %) and in rhizomes (1.05) was recorded in T1 (Control). The beneficial role of zinc and boron in increasing CEC of roots might have helped in increasing absorption of nutrient from the soil. Further, the beneficial role of Zn in chlorophyll formation, regulating auxin concentration and its stimulatory effect on most of the physiological and metabolic process of plant, also might have helped plants in absorption of greater amount of nutrients from the soil. The results were in close conformity with Roy *et al.* (1992) [15] in ginger, Yadav *et al.,* (2006) [19] in onion, Paliyal *et al.* (2008) [13] in ginger and Khatemenla *et al.* (2018) [10] in onion The perusal of data in Table 4. represented that, the maximum sulphur content (0.50 % and 0.58 % in leaves and rhizome, respectively), zinc (98.22 ppm and 116.37 ppm in leaves and rhizome, respectively) and boron (22.19 ppm and 27.10 ppm in leaves and rhizomes, respectively) was recorded in treatment T9. Whereas, minimum sulphur content (0.12 % and 0.12 % in leaves and rhizome, respectively), zinc (30.07 ppm and 42.55 ppm in leaves and rhizome, respectively) and boron (9.13 ppm and 10.14 ppm in leaves and rhizomes, respectively) was recorded in treatment T1 (Control). The variations and contradiction in nutrient content of plant may be attributed due to strong acidic soil pH, which affects the nutrient uptake pattern (Gudade *et al.*, 2016) [7]. The external application of zinc and boron to plants increased their availability to plants and hence improved the uptake of these nutrients by the plants. The results were in close conformity with Yadav *et al.,* (2006) [19] in onion, Ali *et al* (2013) [1], Murma *et al.* (2014) [12] in potato and with Khatemenla *et al.* (2018) [10].

Soil nutrient status after the harvest of crop

The nutrient status *viz.,* available N, P2O5, K2O and S, micronutrients such as DTPA extractable zinc and hot water soluble boron of the soil after harvest of crop are presented in Table 20.

The available nutrients (N, P and K) in the soils after harvest were significantly differed with different treatments. The maximum available N (295.55 kg / ha) and available K (292.28 kg / ha) were recorded in treatment T1 (Control). The maximum available P (159.35 kg /ha) was found to be highest in T2 and it was on par with T1 (Control).

Maximum available S (18.07 mg/kg) in soil was recorded in T4 and it was on par with T1 (Control). As the application of Zn and B increases the Availability of N, P, K and S was decreases. This may be due to increase in uptake of nutrients with increased application of micro nutrients. But in case of Zn and B even though the uptake increased with increased application, availability in the soil was also increased. The maximum Zn (0.94 mg/kg) and B mg/kg) were recorded in T8 and it was on par with T9. This might be due to higher external application of Zn and B to the soil.

Table 3: Effect of zinc and boron nutrition on N, P and K content in leaves (at different growth stages) and in rhizome (after harvest) of mango ginger (*Curcuma amada* Roxb.)

Treatments	Nitrogen content (%)		Phosphorous content (%)		Potassium content (%)	
	In leaves	In rhizomes	In leaves	In rhizomes	In leaves	In rhizomes
T1 (ZnSO4 0 kg/ha + Borax 0 kg/ha) (Control)	1.21	1.11	0.55	0.51	1.27	1.05
T2 (ZnSO4 0 kg/ha + Borax 5 kg/ha)	1.70	1.38	0.52	0.60	1.68	1.38
T3 (ZnSO4 0 kg/ha + Borax 10 kg/ha)	1.50	1.09	0.61	0.79	1.99	1.64
T4 (ZnSO4 5 kg/ha + Borax 0 kg/ha)	1.94	1.71	0.72	0.73	2.11	1.82
T5 (ZnSO4 5 kg/ha + Borax 5 kg/ha)	2.03	1.80	0.80	0.89	2.08	2.14
T6 (ZnSO4 5 kg/ha + Borax 10 kg/ha)	2.27	2.04	0.89	0.92	3.03	2.31
T7 (ZnSO4 10 kg/ha + Borax 0 kg/ha)	2.44	2.08	0.75	0.85	2.54	1.76
T8 (ZnSO4 10 kg/ha + Borax 5 kg/ha)	3.00	2.24	1.02	0.94	3.11	2.56
T9 (ZnSO4 10 kg/ha + Borax 10 kg/ha)	2.96	2.52	1.13	0.90	3.15	2.71
S Em ±	0.17	0.12	0.05	0.04	0.10	0.15
CD (5%)	0.506	0.38	0.16	0.12	0.30	0.45

- DAP- Days after planting

Table 4: Effect of zinc and boron nutrition on S, Zn and B content in leaves (at different growth stages) and in rhizome (after harvest) of mango ginger (*Curcuma amada* Roxb.)

Treatments	Sulphur content (%)		Zinc content (%)		Boron content (%)	
	In leaves	In rhizomes	In leaves	In rhizomes	In leaves	In rhizomes
T1 (ZnSO4 0 kg/ha + Borax 0 kg/ha) (Control)	0.12	0.12	30.07	42.55	9.13	10.14
T2 (ZnSO4 0 kg/ha + Borax 5 kg/ha)	0.17	0.18	34.58	52.07	12.53	13.27
T3 (ZnSO4 0 kg/ha + Borax 10 kg/ha)	0.21	0.12	35.61	54.18	16.48	17.51
T4 (ZnSO4 5 kg/ha + Borax 0 kg/ha)	0.24	0.26	56.81	68.17	9.90	11.50
T5 (ZnSO4 5 kg/ha + Borax 5 kg/ha)	0.32	0.32	61.87	78.37	15.87	16.17
T6 (ZnSO4 5 kg/ha + Borax 10 kg/ha)	0.43	0.46	69.30	83.49	21.83	23.60
T7 (ZnSO4 10 kg/ha + Borax 0 kg/ha)	0.41	0.41	85.82	96.93	11.95	13.27
T8 (ZnSO4 10 kg/ha + Borax 5 kg/ha)	0.46	0.52	88.57	102.91	19.22	20.40
T9 (ZnSO4 10 kg/ha + Borax 10 kg/ha)	0.50	0.58	93.93	116.37	22.19	27.10
S Em ±	0.016	0.02	2.49	2.72	0.93	0.63
CD (5%)	0.05	0.05	7.46	8.15	2.80	1.90

DAP- Days after planting

Table 5: Effect of zinc and boron nutrition on availability of nutrients in the soil after harvesting of mango ginger (*Curcuma amada* Roxb.)

Treatments	Availability of nutrients in soil after harvesting					
	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (mg/kg)	Zn (mg/kg)	B (mg/kg)
T1 (ZnSO4 0 kg/ha + Borax 0 kg/ha) (Control)	295.55	151.67	292.28	17.38	0.44	0.15
T2 (ZnSO4 0 kg/ha + Borax 5 kg/ha)	288.47	159.35	285.18	16.95	0.39	0.41
T3 (ZnSO4 0 kg/ha + Borax 10 kg/ha)	267.17	139.86	271.91	16.18	0.36	0.37
T4 (ZnSO4 5 kg/ha + Borax 0 kg/ha)	271.20	130.70	267.97	18.07	0.72	0.29
T5 (ZnSO4 5 kg/ha + Borax 5 kg/ha)	266.29	123.37	262.87	14.97	0.61	0.46
T6 (ZnSO4 5 kg/ha + Borax 10 kg/ha)	213.68	113.31	258.06	13.57	0.50	0.37
T7 (ZnSO4 10 kg/ha + Borax 0 kg/ha)	256.10	108.60	252.85	10.60	0.91	0.13
T8 (ZnSO4 10 kg/ha + Borax 5 kg/ha)	245.77	95.83	242.55	12.07	0.94	0.44
T9 (ZnSO4 10 kg/ha + Borax 10 kg/ha)	230.53	97.80	227.11	11.45	0.88	0.40
S Em ±	7.95	6.55	8.20	0.75	0.03	0.02
CD (5%)	23.85	19.64	24.58	2.27	0.09	0.05

Conclusion

From the data it is evident that the treatment T9 (ZnSO4 10 kg / ha + Borax 10 kg / ha) found to be better in terms of improving the uptake of nutrients from both leaves and rhizome over the control (T_1).

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