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Effect of zinc on vegetative growth, chlorophyll and nutrient uptake of karonda (*Carissa carandas*) seedling under sand culture*

BALJEET KAUR[1] and K K MISRA[2]

Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand 263 145

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The continuing pressure on agricultural land is making the solution difficult for effective harvesting of nutrient management to step up fruit production. Determination of nutritional needs of fruit trees must be made prior to the renewed growth for determination of the potential yield. However, the reliable information is needed to decide how much fertilizers should be applied to the fruit crops for an economic response (Bhargava and Singh 2001). Though karonda (*Carissa carandas* L.) is an important crop, its production and productivity are not satisfactory due to some constraints in its cultivation. One of the major important factors which hamper the production is nutrition. The effect of deficiency of zinc on the vegetative growth of karonda seedlings in sand culture, uptake and consequently the leaf status of other nutrients.

The present investigation was carried out at the Department of Horticulture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during September 2005–July 2006. Two-month old karonda seedlings grown in soil were transplanted in plastic pots filled with thoroughly washed quality sand free from any nutrient and pots kept in polyhouse with a day temperature of 28–32°C and a night temperature of 18–20°C and relative humidity was generally above 70%. The experiment was laid out in completely randomized design and replicated thrice.

Plants were supplied with nine different types of solution, viz solution without zinc (T_{-1}), solution containing 1/4 of total zinc (T_2), solution containing ½ of total zinc (T_3), solution containing 3/4 of total zinc (T_4), solution containing full dose of zinc (control) (T_5), solution containing 1.25 times of total zinc (T_6), solution containing 1.50 times of total zinc (T_7), solution containing 1.75 times of total zinc (T_8) and solution containing 2.00 times of total zinc (T_9).

In each treatment, 18 karonda seedlings were transplanted in three plastic pots (each pot containing six seedlings). Fifty ml nutrient solution was supplied to each pot on alternate days throughout the experimental period. Leaching was done to avoid accumulation of excess salts at the bottom and *p*H of leachetes measured frequently which varied between 6.4 and 7.0. The data on height of seedling, number of leaves, size of leaf (length and breadth), fresh and dry weight of leaf, leaf area, stem girth, length of primary root, chlorophyll 'a', 'b' and total chlorophyll content of the leaves were recorded by standard methods. The experimental data were subjected to analysis of variance of completely randomized design.

Leaf sampling was done at the time when deficiency symptoms of zinc become just noticeable. Leaves from the middle portion of the shoot were taken for the nutrient analysis. Leaves were washed in detergent solution and rinsed in 0.1N HCl. Thereafter, giving 5–6 successive rinsing in distilled water and dried in the oven at 60±2°C till the constant dry weight. The leaf samples were subjected for analysis of N, P, K, Ca, Mg, S, Cu, Fe, Mn, Zn and B. Total nitrogen content was determined by micro-kjeldahl method (AOAC 1975). Phosphorus content of leaf sample was determined by vandomolybdophosphoric, yellow colour in the leaf sample was determined by flame photometery method (Chapman and Pratt 1961). Calcium and magnesium content of the leaves were determined by spectrophotometer (Jackson 1973). Leaf copper, iron, manganese and zinc content were determined by atomic absorption spectrophotometer. Boron content in leaves was measured by using Azomethin-H reagent method (Bingham *et al.* 1958).

An increase in zinc supply increased the number of growth flushes/plant (Table 1). Maximum height of seedling was obtained with T_5 (control) and minimum with T_1 (without zinc). Highest numbers of leaves/seedling were recorded with T_6. Maximum length (2.57 cm) and breadth (1.69 cm) of

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[1]Ph D Scholar (e mail: kaurbaljeet19@gmail.com), [2] Professor and Head (email: misrakk_hort@rediffmail.com), Department of Horticulture

Table 1 Effect of variable zinc supply on growth attributes of karonda seedlings under sand culture

Treatment	Height of seedling (cm)	Number of leaves	Length of leaf (cm)	Breadth of leaf (cm)	Fresh weight of leaf (g)	Dry weight of leaf (g)	Leaf area (cm^2)	Stem girth (cm)	Length of primary root (cm)	Chlorophyll 'a' content	Chlorophyll 'b' content	Total chlorophyll content
T_1, without zinc	12.83	16.00	2.25	1.35	0.054	0.0126	2.77	0.178	12.83	0.673	0.339	0.694
T_2, 1/4 of total zinc	16.01	18.33	2.30	1.38	0.058	0.0128	2.79	0.207	13.00	0.775	0.361	1.597
T_3, 1/2 of total zinc	16.31	19.83	2.39	1.50	0.058	0.0130	2.81	0.236	13.60	0.675	0.373	1.689
T_4, 3/4 of total zinc	18.95	23.33	2.42	1.52	0.067	0.0173	2.84	0.249	17.26	0.678	0.514	1.666
T_5, full amount of zinc	28.44	26.33	2.57	1.67	0.077	0.0247	2.93	0.307	19.83	0.951	0.596	1.813
T_6, 1.25 times of total zinc	26.03	26.66	2.57	1.69	0.063	0.0246	2.92	0.290	19.29	0.953	0.600	1.816
T_7, 1.5 times of total zinc	24.38	24.33	2.40	1.63	0.067	0.0134	2.90	0.269	18.48	0.952	0.600	1.817
T_8, 1.75 times of total zinc	22.87	22.70	2.37	1.64	0.066	0.0129	2.88	0.264	17.58	0.955	0.600	1.818
T_9, 2 times of total zinc	20.33	21.33	2.36	1.59	0.063	0.0126	2.80	0.260	16.51	0.954	0.597	1.813
S Em±	0.2608	0.4695	0.102	0.0142	0.0004	0.00005	0.0021	0.0011	2.84	0.0332	0.0026	0.0069
CD (*P*=0.05)	0.7751	1.395	0.0303	0.0422	0.0012	0.0001	0.0062	0.0032	9.01	0.0987	0.0079	0.205

Table 2 Effect of variable zinc supply on uptake of nutrient in karonda seedling under sand culture

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
T_1, without zinc	1.23	0.44	1.08	2.23	0.60	0.68	54	139.33	84.33	97.66
T_2, 1/4 of total zinc	1.25	0.43	1.05	2.23	0.62	0.68	52	138.00	85.00	100.33
T_3, 1/2 of total zinc	1.28	0.34	1.03	2.24	0.61	0.71	49	134.00	83.66	116.66
T_4, 3/4 of total zinc	1.31	0.31	1.02	2.25	0.62	0.70	45	134.66	80.33	124.00
T_5, full amount of zinc	1.34	0.30	1.09	2.25	0.64	0.22	41	134.33	82.00	126.33
T_6, 1.25 times of total zinc	1.34	0.27	1.10	2.27	0.64	0.71	40	133.33	78.66	127.33
T_7, 1.5 times of total zinc	1.32	0.24	1.08	2.26	0.65	0.72	40	132.00	75.00	129.00
T_8, 1.75 times of total zinc	1.29	0.24	1.06	2.26	0.65	0.71	37	126.00	7766	139.33
T_9, 2 times of total zinc	1.27	0.20	1.05	2.26	0.65	0.71	35	121.00	77.00	141.00
S Em±	0.0064	0.0031	0.0047	0.019	0.0187	0.066	0.693	0.618	0.684	1.677
CD (*P* = 0.05)	0.0192	0.0093	0.140	NS	NS	NS	2.061	1.838	NS	4.98

leaf were registered with T_6 which was at par with T_5. Reduction in leaf size may be due to limitation of cell division and expansion under condition of deficient zinc supply and consequent reduction in size of morphological parts, especially leaves are results of decreased protein and RNA synthesis.

Differential supply of zinc influenced the fresh and dry weight of leaf significantly. Maximum fresh weight (0.077 g) and dry weight (0.0247 g) of leaves of karonda seedlings were found when complete nutrient solution (T_5) was applied (Table 1). Leaf area/seedling, stem girth of seedling and length of primary root increased with increase in substrate zinc supply up to the control (T_5). A further increase in the levels of zinc, slightly reduced leaf area, stem girth and length of primary root were observed (Table 1). Maximum leaf area (2.93 cm^2) was recorded in T_5. A possible cause of increased and reduced leaf area may be due to increased and reduced leaf size. Maximum girth of seedling (0.307 cm) was recorded when normal zinc level was maintained (T_5), whereas, minimum (0.178 cm) was noticed with T_1 (without zinc). The data are in accordance with the findings of Banik and Sen (1997) in mandarin. Chlorophyll content in the leaves of karonda seedlings were significantly affected when differential zinc levels were applied. Maximum chlorophyll 'a' (0.955 mg/g fresh weight) was recorded with T_8 which was at par with T_9, while minimum (0.673 mg/g fresh weight) with T_1 (Table 1). Chlorophyll 'b' content was recorded maximum (0.600 mg/g fresh weight) with treatment T_8 which was at par with T_6, T_7 and T_9.Total chlorophyll content was found highest (1.818 mg/g fresh weight) with T_8 treatment. The loss of chlorophyll might be due to chloroplast disorganization.

Various levels of zinc supply greatly influenced the concentration of nitrogen, phosphorus and potassium content. Maximum nitrogen content (1.34%) was recorded with T_5 and minimum (1.23%) with T_1. The phosphorus content decreased with the increase in zinc levels. Higher value of phosphorus content (0.44%) was recorded with T_1 and minimum (0.20%) in T_9. It is due to the fact that added P precipitates zinc in the soil as insoluble zinc phosphate, thus

causing zinc deficiency in the plants. The leaf potassium content was recorded maximum (1.10%) in T_6 and minimum (1.05%) was recorded with T_9.The values of leaf calcium, magnesium, sulphur and manganese contents showed non-significant differences when various levels of zinc were applied. As the zinc levels increased, the copper content decreased significantly. It is due to the antagonistic effect of zinc on copper uptake (Havlin *et al.* 2003). Maximum iron content (139.33 ppm) was recorded with T_1 (without zinc) and minimum iron content (121.00 ppm) in T_9. As the level of zinc increased, the iron content decreased significantly. Similar results are obtained in navel orange that excessive zinc in the rooting medium caused iron chlorosis due to root injury. Thereby, reduced uptake of iron by the plant. Maximum value of zinc (141 ppm) was recorded with T_9 and minimum leaf zinc content (97.66 ppm) with T_1.

It was concluded that variable zinc supply affected the plant growth attributes and nutrient uptake of karonda. To get the optimum vegetative growth and production of karonda fruit, the leaf zinc levels must be maintained in the range of 126–127 ppm.

SUMMARY

Symptoms of zinc deficiency were induced in sand culture under polyhouse conditions. Deficiency of zinc resulted in stunted height of seedling, reduced number, size of leaf, fresh and dry weight of leaf, leaf area/seedling, stem girth of seedling and length of primary root of karonda seedling. Chlorophyll 'a', 'b' and total chlorophyll content of leaves reduced significantly when zinc levels were deficient in the nutrient solution. Leaf nitrogen, phosphorus and potassium contents were affected significantly by different zinc levels, whereas, leaf calcium, magnesium and sulphur content did not show significant variation when various doses of zinc were applied under sand culture. There was significant influence on leaf copper, iron and zinc content when varying doses of zinc were applied. Deficiency of zinc resulted in smaller leaf size which become narrow and distorted with interveinal chlorosis. In the acute stage rossetting occur as a result of shorter internodal length and small leaf size and critical level of zinc was 123 ppm under sand culture.

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