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Effect of foliar application of Ca, Zn, Fe and B on growth, yield and quality of papaya var. Taiwan Red Lady

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ABSTRACT

A study was undertaken to assess the effect of foliar application of Ca, Zn, Fe and B on growth, yield and quality of papaya (*Carica papaya* L.) var. Taiwan Red Lady. Results revealed that the foliar application of calcium nitrate 1000 mg/l + borax 30 mg/l + zinc sulphate 200 mg/l + ferrous sulphate 200 mg/l (T_{10}) at 60, 90 and 120 days after planting were found to be best with respect to plant height (136.20 cm), stem girth (36.50 cm) as well as leaf area (1089.53 cm^2) with total yield and quality parameters as compared to other treatments. However, foliar application of borax 30 mg/l resulted in earliness in initiation of flowering (93.40 days) of papaya var. Taiwan Red Lady.

Key words: Flowering, growth, micro-nutrients, papaya, quality, yield.

INTRODUCTION

Papaya (*Carica papaya* Linn.) is an important fruit crop of tropical world and has long been known as wonder fruit of the tropics. It gives higher production of fruits per hectare and an income next to banana. In Gujarat, it is cultivated on an estimated area of 15.3 thousand hectares with 832.9 thousand mt of production and average productivity is 54.3 mt per ha (Anon, 1). Micro-nutrients are key elements in plant growth and development. Deficiencies of Ca, Zn, Fe and B have been increasing in some fruit crops. Some reasons are higher crop yields, which increase plant nutrient demands, use of high analyses NPK fertilizers containing lower quantities of micro-nutrient contaminants and decreased use of farmyard manure on many agricultural soils. Micro-nutrient deficiencies have been verified in many soils through increased use of soil testing and plant analyses. The Ca, Zn, Fe and B are not only essential but they are equally important like other micro- and macro-nutrients. These elements play important role in various enzymatic activities and synthesis. These micro-nutrients also helps in uptake of major nutrients and play an active role in the plant metabolism process starting from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity, hormone synthesis, nitrogen fixation and reduction *etc*. (Das, 3). Presently, farmers of Gujarat state are much interested in cultivation of Taiwan Red Lady variety due its gynodioecious nature and also ease and convenient in its raising. Though production technology of papaya is known and farmers are harvesting higher fruit yield. However, the main problem lies in their nutrients deficiencies, which need to be standardized through systematic experimentation that will generate useful information on recovery of deficiency symptoms on papaya plant as well as fruit. Therefore, this study was carried out in order to know the effect of foliar application of Ca, Zn, Fe and B on papaya var. Taiwan Red Lady.

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MATERIALS AND METHODS

The present experiment was carried out at the Regional Horticultural Research Station, Navsari Agricultural University, Navsari during the year 2008-2009 and 2009-2010. The seeds of papaya (var. Taiwan Red Lady) were sown in small polythene bags. Forty-five day-old seedlings of uniform size and vigour were planted within field during last week of August during evening in the pits of 30 × 30 × 30 cm dimension at a distance of 2 m in both directions. Soil application of fertilizers (200 g N, 200 g P and 250 g K per plant) were done in four equal split doses at two months interval starting from transplanting of seedlings. The experiment was laid out in Randomized Block Design (RBD) with 11 treatments, which were replicated three times. The treatments were, T_1 = calcium nitrate 500 mg/l, T_2 = calcium nitrate 1000 mg/l, T_3 = borax 15 mg/l, T_4 = borax 30 mg/l, T_5 = zinc sulphate 100 mg/l, T_6 = zinc sulphate 200 mg/l, T_7 = ferrous sulphate 100 mg/l, T_8 = ferrous sulphate 200 mg/l, T_9 = calcium nitrate 500 mg/l + borax 15 mg/l + zinc sulphate 100 mg/l + ferrous sulphate 100 mg/l, T_{10} = calcium nitrate

1000 mg/l + borax 30 mg/l + zinc sulphate 200 mg/l + ferrous sulphate 200 mg/l and T_{11} = control (water spray). The time of spray of nutrients were done at 60, 90 and 120 days after planting. The observations were made on different growth characters, *viz.*, plant growth and stem girth (90, 120 and 150 DAP) and leaf area as recorded at day one and fifteen days before and after of first and third sprays. In case of yield attributes and quality parameters, the observations were made at ripening stage during both the years. Total sugars and acidity contents of fruits were estimated as per the procedures (AOAC, 2). The data of both years pooled and were analyzed separately adopting analysis of variance method as suggested by Panse and Shukhatme (8).

RESULTS AND DISCUSSION

Plant height and stem girth are considered to be an important factors to judge the vigour in papaya crop. The robust vegetative growth is an essential prerequisite for higher yield. The total numbers of functional leaves are major function of total leaf area so, almost leaves are identical in all the treatments except T_{11}, and it has been only due to the size of individual leaf area. Therefore, the treatment favorable affecting vegetative growth showed higher leaf area. The foliar sprays of calcium nitrate 1000 mg/l + borax 30 mg/l + zinc sulphate 200 mg/l + ferrous sulphate 200 mg/l (T_{10}) resulted in maximum plant height, stem girth as well as leaf area of papaya plants. Results pertaining to above growth attributes could be due to improved photosynthetic activity and respiration of plants as influenced by Ca, Zn, Fe and B. Calcium is a critical part of the cell wall that produces strong structural rigidity by forming cross-links within the pectin-polysaccharide matrix. With rapid plant growth, the structural integrity of stems that hold flowers and fruit as well as the quality of the fruit produced, is strongly coupled to calcium availability (Easterwood, 4). The effect of zinc sulphate on enhancing the vegetative growth may be ascribed to the presence of zinc in structure of tryptophan, which is the precursor of auxin. Thus, the combinations of boron and zinc increased metabolic activities, which lead to increase plant metabolites responsible for cell division, cell elongation and plant growth. Fe is also necessary for vital plant metabolic functions such as chlorophyll synthesis, enzymatic reactions, respiration and photosynthesis. Boron regulates metabolism involved in translocation of carbohydrates, cell wall development and RNA synthesis. These findings are in conformity with above mentioned growth parameters have also been reported by Singh *et al.* (10) in papaya. On the contrary, the initiation of flowering (days) (Table 1) was utmost advanced (required minimum days) under the treatment receiving borax @ 30 mg/l (T_4 - 93.40 days). Second best treatment T_6 (zinc sulphate @ 200 mg/l) also took minimum days (97.60 days) for flowering in papaya. The earliness in flowering might be due to the boron, which regulates metabolism involved in translocation of carbohydrates, cell wall development and RNA synthesis and it also increased the phenolic compounds thereby regulating polar auxin transport (Ram and Bose, 9). These results are in conformity with the findings of Singh *et al.* (10), and Modi (7) on papaya.

From the Table 2, it is revealed that the increase in size (diameter and length) of fruit with maximum yield was obtained from papaya plants when sprayed with calcium nitrate 1000 mg/l + borax 30 mg/l + zinc sulphate 200 mg/l + ferrous sulphate 200 mg/l (T_{10}). Size of fruits and yield of plant are the cumulative effect of various attributes as affected by micro-nutrients through higher rate of cell division and enlargement, photosynthesis and increase in enzymatic activities as well as involvement of zinc in biosynthesis of auxin. In the present study, the foliar sprays of calcium nitrate 1000 mg/l + borax 30 mg/l + zinc sulphate 200 mg/l + ferrous sulphate 200 mg/l thrice at one month interval intervals from 60 DAP, significantly increased the number of fruits per plant resulting into higher yield. Further, boron application might have enhanced the translocation of metabolism from source (leaf) to sink (fruit) and increased accumulation of dry matter within the fruits resulting into higher yield. Zinc, regulating the semi-permeability of cell walls, thus mobilizing more water into fruits resulting increase in fruit size. Similar findings were also observed by Kavitha *et al.* (5) and Singh *et al.* (10) on papaya.

The physiological loss in weight (PLW) was reduce in foliar application of calcium nitrate 1000 mg/l + borax 30 mg/l + zinc sulphate 200 mg/l + ferrous sulphate 200 mg/l (T_{10}), which helps to higher firmness of papaya fruit (Table 3). Similar findings were previously noted by Kavitha *et al.* (6). Moreover, higher fruit firmness, which results to increase the shelf-life, maximum sugar percentage and ascorbic acid with minimum titrable acidity were significantly influenced by combine foliar application of calcium nitrate 1000 mg/l + borax 30 mg/l + zinc sulphate 200 mg/l + ferrous sulphate 200 mg/l (T_{10}) on papaya var. Taiwan Red Lady. It might be due to the adequate amount of zinc improves the auxin content and it also acts as a catalyst in oxidation-reduction processes in plants. Besides, it also helps in other enzymatic actions like transformation of

Table 1. Effect of Ca, Zn, Fe and B on growth attributes of papaya var. Taiwan Red Lady (data pooled over two years).

Treatment	Plant height (cm)			Stem girth (cm)			Leaf area (cm^2)				Initiation of flowering (days)
	90 DAP	120 DAP	150 DAP	90 DAP	120 DAP	150 DAP	One day before first spray	Fifteen days after first spray	One day before third spray	Fifteen days after third spray	
T_1	79.71	94.84	102.84	18.80	26.02	31.77	430.10	595.25	887.44	987.01	123.10
T_2	82.16	96.70	104.68	19.12	26.56	32.90	464.77	659.14	929.37	1061.12	121.10
T_3	84.14	102.37	111.51	20.51	29.23	34.80	420.59	627.54	898.23	1014.56	100.25
T_4	85.31	106.55	114.10	21.31	29.84	35.36	529.15	719.68	1018.50	1200.99	93.40
T_5	84.55	104.33	112.12	21.05	29.56	35.03	448.60	641.27	913.17	1040.14	110.80
T_6	92.56	117.70	132.41	22.74	31.88	37.96	498.27	697.30	976.03	1156.88	97.60
T_7	82.83	99.74	108.11	19.24	27.43	33.81	482.71	674.44	930.16	1099.57	118.50
T_8	83.24	100.68	109.50	19.57	27.72	34.53	572.31	678.00	949.55	1117.50	113.40
T_9 - T_1 + T_3 + T_5 + T_7	90.73	112.23	121.94	21.98	30.43	36.50	476.99	666.03	921.80	1089.53	107.90
T_{10} - T_2 + T_4 + T_6 + T_8	98.58	123.40	136.20	23.85	33.18	39.46	491.95	785.95	1090.89	1248.10	103.40
T_{11} - (control)	68.40	82.46	94.41	18.64	23.02	29.05	438.38	580.78	873.09	971.31	128.40
CD at 5%	7.81	10.23	12.38	1.59	2.16	2.61	NS	65.56	72.57	90.32	8.59

T_1 = calcium nitrate 500 mg/l, T_2 = calcium nitrate 1000 mg/l, T_3 = borax 15 mg/l, T_4 = borax 30 mg/l, T_5 = zinc sulphate 100 mg/l, T_6 = zinc sulphate 200 mg/l, T_7 = ferrous sulphate 100 mg/l, T_8 = ferrous sulphate 200 mg/l, T_9 = calcium nitrate 500 mg/l + borax 15 mg/l + zinc sulphate 100 mg/l + ferrous sulphate 100 mg/l, T_{10} = calcium nitrate 1000 mg/l + borax 30 mg/l + zinc sulphate 200 mg/l + ferrous sulphate 200 mg/l and T_1 = control (water spray).

Table 2. Effect of Ca, Zn, Fe and B on yield and quality of papaya var. Taiwan Red Lady (data pooled over two years).

Treatment	No. of fruits/ plant	Fruit wt. (kg)	Fruit yield/ plant (kg)	Fruit yield/ ha (t)	Fruit dia. (cm)	Fruit length (cm)	PLW (%)	Fruit firmness (kg/cm^2)	Shelf-life (days)	Total sugars (%)	Reducing sugar (%)	Titrable acidity (%)	Ascorbic acid (mg/100 g)
T_1	19.32	1.07	20.73	51.83	18.51	20.60	19.31	5.67	5.12	6.12	4.26	0.035	20.19
T_2	20.17	1.09	22.15	55.38	19.06	20.77	15.56	6.76	6.06	6.30	4.77	0.021	21.04
T_3	21.27	1.19	25.37	63.44	19.66	21.56	17.77	6.56	5.86	6.66	4.57	0.027	20.41
T_4	22.36	1.29	28.91	72.28	20.61	22.93	11.75	6.98	6.71	6.83	5.01	0.015	22.00
T_5	21.75	1.22	26.59	66.48	19.82	21.95	18.20	5.95	5.67	6.91	4.48	0.031	20.28
T_6	22.99	1.32	30.57	76.42	21.09	23.64	14.97	6.86	6.25	7.10	4.85	0.020	21.72
T_7	20.03	1.11	22.44	56.10	20.17	22.54	18.80	5.88	5.40	6.46	4.31	0.032	20.22
T_8	21.14	1.15	24.39	60.97	19.46	21.36	13.83	6.86	6.41	6.65	4.89	0.017	21.77
T_9 - T_1 + T_3 + T_5 + T_7	21.81	1.26	27.65	69.14	19.95	22.29	16.01	6.62	5.96	7.00	4.74	0.027	20.53
T_{10} - T_2 + T_4 + T_6 + T_8	23.45	1.37	32.31	80.76	21.86	25.39	10.63	7.17	6.95	7.49	5.27	0.014	23.23
T_{11} - (control)	18.89	1.03	19.63	49.07	17.30	19.12	20.37	4.02	3.86	5.69	4.07	0.038	19.89
CD at 5%	1.87	0.10	4.03	10.08	1.42	1.86	1.67	0.53	0.50	0.48	0.38	0.0036	1.21

T_1 = calcium nitrate 500 mg/l, T_2 = calcium nitrate 1000 mg/l, T_3 = borax 15 mg/l, T_4 = borax 30 mg/l, T_5 = zinc sulphate 100 mg/l, T_6 = zinc sulphate 200 mg/l, T_7 = ferrous sulphate 100 mg/l, T_8 = ferrous sulphate 200 mg/l, T_9 = calcium nitrate 500 mg/l + borax 15 mg/l + zinc sulphate 100 mg/l + ferrous sulphate 100 mg/l, T_{10} = calcium nitrate 1000 mg/l + borax 30 mg/l + zinc sulphate 200 mg/l + ferrous sulphate 200 mg/l and T_1 = control (water spray).

carbohydrates, activity of hexokinase and formation of cellulose and change in sugar are considered due to its action on zymohexose. The reduction of titrable acidity of papaya fruits through application of different levels of calcium, zinc, ferrous, boron and their different combinations might be due to the positive influence of boron and zinc in conversion of acids into sugars and their derivatives by the reaction involving glycolytic path way or be used in respiration both (Singh *et al.*, 10). Kavitha *et al.* (5) also reported the increase of ascorbic acid content after application of zinc, boron and ferrous which might be due to conversion of sugars into ascorbic acid in papaya.

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