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Research Article

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Impact of Zinc and Boron on Growth and Qualitative Parameters of Papaya (*Carica papaya* L.) cv. Red Lady

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Abstract

A field experiment was carried out to study the impact of foliar application of zinc and boron on growth and quality parameters of papaya cv. Red Lady conducted at V.P.O. Maheru, Tehsil Phagwara, District Kapurthala, Punjab under the Department of Horticulture, Lovely Professional University, Phagwara, Jalandhar, Punjab during the year 2019-20. The experiment was conducted by using micronutrients viz., boron (B) and zinc (Zn) at different concentrations in Randomized Block Design layout. The outcome of investigation is very significant from sustainability point of view as with treatment $ZnSO_4$ at 0.25% + Borax at 0.50% improved the growth factors like plant girth (40.20 cm), height (209.78 cm), and leaves/plant (39.10) at 270 DAP (Days after planting) and other characters like fruit weight (1.45 kg), fruit length (19.10 cm), yield per plant (92.82 kg) were observed. Increased production will help to meet feeding requirements of increased population. As far as food chemistry is concerned, fruit characteristics like improved total soluble sugars (TSS) (16.18 B) and the lower acidity (0.120%) were observed when the plants sprayed with $ZnSO_4$ at 0.50% + B at 0.50%.

Keywords

Boron, Zinc, Papaya, Red lady, Foliar spray

Introduction

Papaya is a major fruit crop in subtropical and tropical constituencies of the world have its place in genus *Carica* (family Caricaceae), its place of origin is probably in South Mexico and Costa Rica. This crop was initially grown as a backyard crop but with time it became an important commercial fruit crop due to its nutritional and pharmaceutical values, besides its quick and continuous yielding habit generating early income to the growers. Among the fruits, papaya (2020 IU) is the 2nd richest fruit in Vitamin A. Papaya crop is produced in many countries like Hawaii, Malaysia, Burma, Sri Lanka, India, Queensland, South Africa, Tanzania, Kenya, and other subtropical and tropical countries of the world. In India it is widely available and cultivated in almost all parts of the country. It is estimated that in India, papaya is commercially grown in Telangana, Gujarat, Karnataka, Chhattisgarh, Madhya Pradesh, and Maharashtra, Uttar Pradesh, Bihar, Assam, Tamil Nadu, Orissa, Manipur, and Meghalaya. In India, papaya is cultivated in area of 146,000 Ha with production of 5540,000 HT [1].

India is one of the prominent countries in fruit production which produces large varieties of fruits including papaya. Subsequently in the last fifty years lot of scientific efforts have been done in this direction at various locations on different aspects of the crop like development of varieties fertigation, weed management, post-harvest practices, etc., for improvement in quality and yield of papaya. Unlike all fruit crops papaya also needs 16 essential elements viz., hydrogen, oxygen and carbon are derived from the atmosphere, soil, and water. The left over 13 essential elements (potash, nitrogen, calcium, phosphorus, magnesium, iron, sulfur, zinc, boron, manganese, copper, chlorine, and molybdenum) are derived from soil minerals and organic matter present in the soil or by inorganic fertilizers. These 13 essential elements are further classified as micronutrients and macronutrients. Macronutrients like nitrogen, potash, calcium, phosphorous, magnesium and sulfur play significant role in promoting plant production and vigor. Micronutrients (Chlorine, iron, boron, zinc, copper, and molybdenum) are an important component of metabolism process, respiration, chlorophyll formation, enzyme activity, photosynthesis, etc.

For various physiological processes in plants, such as biosynthesis of protein and carbohydrate including nucleic acid, photosynthesis, sugar production, metabolism processes, zinc is necessary at modest but crucial concentrations [2]. Various scientists supported this fact for other locations that for appropriate development, output, and fruit quality in sweet oranges grown in Pakistan's climate, micronutrients like Zn and B are crucial [3]. It was also supported that application of borax @ 0.4% and GA_3 @ 100 ppm at the full bloom stage during rainy season improved fruit set in Lalit cultivar guava [4]. Moreover, these beneficial benefits could be attributed to the abundance of Zn in plants, which fosters nucleic acid and protein synthesis in addition to photosynthesis [5] proved that in Sweet orange Cv. "Blood Red," foliar applications of Zn and B at full bloom, fruit set, and premature stage led to maximum yield of high-quality fruits [6]. Application of borax at a rate of 0.4%, improved fruit set with little fruit drop and cracking, decreased seed weight, and improved fruit length, width, weight (weight of pulp, pulp: seed ratio), and fruit production [7].

Moreover, plantation provided the most fruit retention under the plains of central Uttar Pradesh because they were high in total soluble solids and total sugars with a low proportion of titratable acidity. Micronutrients are generally provided by the organic matter present in the soil to the plants, but due to the greater use of inorganic fertilizers, the micronutrients supply has been depleted.

Materials and Methods

The preparation of the field started in the second week of March and afterward planting is done. Papaya plants are planted on the raised nine beds and transplanting was done in the last week of March. The spacing between plants was kept 2 m X 2 m. Total 27 plants were included in this experiment with 9 treatments (named as T_1- Borax at 0.25%, T_2- Borax at 0.50%, T_3- Zinc sulphate at 0.25%, T_4- Zinc sulphate at 0.50%, T_5- Borax at 0.25% + Zinc sulphate at 0.25%, T_6- Borax at 0.25% + Zinc sulphate at 0.50%, T_7- Borax at 0.50% + Zinc sulphate at 0.25%, T_8- Borax at 0.50% + Zinc sulphate at 0.50%, T_9- Control (water spray) and 3 replications. Various plant observations recorded show that mean plant height, girth and number of leaves/plant were documented at intervals of 90 days and days taken from transplant to development of first fruit were recorded by visual observation. The yield observations recorded viz. average number of fruits/plants, fruit length (cm), weight (kg), including weight of the total fruits and yield per plant (kg), harvested in various intervals from the experimental plants in each treatment was observed. To study quality parameters like TSS (°Brix) were determined with help of hand refractometer of 0-32 range (Erma make, Japan) and expressed as degree brix, titratable acidity (%) was calculated and expressed as per cent citric acid using the factor that 1 ml of 0.1 M NaOH neutralizes 0.0064 g of citric acid [8]. Obtained data was analyzed through Randomized Block Design. The overall significance of differences in the treatments was tested by using critical differences (CD) at 5% level of significance.

Results and Discussion

Plant height

Data accessible in table 1 reveals that treatment with $ZnSO_4$ at 0.25% + borax at 0.50% (foliar spray) has shown significantly improved plant height after 90 DAP, 180 DAP and 270 DAP was recorded as 60.10 cm, 120.15 cm, and 207.33 cm, respectively. It was interesting to note that after planting of 90, 180 and 370 days the plant height was minimum (39.33 cm, 75.50 cm, and 147.33 cm) in control treatment. Significant differences were observed in all treatments regarding height of the papaya plant. This increase in plant height might be accredited because of better respiration of plants and photo-

Table 1: Effect of micronutrients on plant height, girth (cm), no. of leaves/plant of papaya.

Treatment	Plant height (cm)			Plant girth (cm)			Average no. of leaves/plant		
	90 DAP	180 DAP	270 DAP	90 DAP	180 DAP	270 DAP	90 DAP	180 DAP	270 DAP
T1	42.25	88.68	177.8	10.33	18.33	22.23	19.28	24.9	29.8
T2	48.22	91.42	189.62	11.25	20.5	33.58	20.2	27.52	33.8
T3	48.07	96.56	193.33	11.8	20.8	34.1	21.47	31.6	36.7
T4	53.07	116.45	209.78	12.5	23.33	37.2	25.2	30.8	37.3
T5	45.3	89.78	181.5	11.73	21.73	36.03	20.58	25.6	33.92
T6	45.5	91.48	183.83	11.83	21.93	38.07	20.1	27.3	33
T7	60.1	120.15	207.33	13	25.5	40.2	27.4	33.23	39.1
T8	50	99.29	201.2	11.17	21.56	33.88	20.33	28.18	34
T9	39.33	75.5	147.33	7.7	16.67	26.1	11.33	16.68	21.52
Mean	47.98	96.59	187.96	11.25	21.15	33.48	20.65	27.31	33.23
S. Em (±)	0.61	0.14	0.31	0.21	0.32	0.19	0.22	0.24	0.35
CD (P = 0.05)	0.2	0.05	0.1	0.07	0.1	0.06	0.07	0.08	0.12

synthetic activity as subjected to B and Zn elements. Zn plays an important role in metabolism of nitrogen and synthesis of auxin in the plant, and it was supposed to involve in various activities of the cell like division and cell enlargement along with improvement in the plant growth and development. Arshad and Ali. [9] reported that the plant height was recorded maximum under application of Zn in guava [6] proved that application of Zn and B has also dramatically improved vegetative and reproductive characteristics, such as tree height and spread along with other characteristics.

Plant girth (cm)

Concerning plant girth, significant differences were recorded at 90 DAP, 180 DAP and 270 DAP as the data explains (Table 1). Maximum plant girth (13.00 cm) was observed with the spray of borax at 0.50% + $ZnSO_4$ at 0.25% which was found statistically significant at 90 DAP and it was at par with treatment of borax at 0.25% + $ZnSO_4$ at 0.50% (13 cm) while $ZnSO_4$ at 0.50% (12.50 cm). At 180 DAP, the plants applied with borax at 0.50% + $ZnSO_4$ at 0.25% have significantly shown the highest plant girth (25.50 cm). At 270 DAP, the plants applied with borax at 0.50% + $ZnSO_4$ at 0.25% have significantly shown the highest plant girth (40.20 cm). While in the control treatment has recorded minimum plant girth (7.70 cm, 16.67 cm, and 26.10 cm respectively). Guava (*Psidium guajava* L.) cultivar Allahabad Safeda that was treated with a mixture of ($ZnSO_4$ @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4%) showed decent increase in plant height, shoot growth, stem girth, flowering including fruit set, yield, and lessening in fruit drop [10].

Total no. of leaves in plant

Total no. of leaves per plant was significantly influenced at each crop stage by different treatments at 90 DAP, 180 DAP and 270 DAP. It was recorded that at 90 DAP plants supplied with $ZnSO_4$ at 0.25% + borax at 0.50% have put forth significantly maximum leaves per plant (27.40) while at 180 DAP and 270 DAP, same application (borax at 0.50% + $ZnSO_4$ at 0.25%) have shown expressively higher number of leaves/plant (33.23 and 39.10, respectively). However, the treatment control has produced significantly lesser number of leaves per plant (11.33, 16.68 and 21.52 respectively) on 90, 180, and 270 DAP.

Days to first fruit formation

Significant variation was observed among the treatments with respect to days to fruit formation (Table 2). While treatment with borax at 0.50% has significantly taken a smaller number of days to first fruit formation (162.10 days) followed by $ZnSO_4$ at 0.50% (164.14 days). Maximum number of days to fruit formation (187.60 days) was recorded in control. It is apparent from the results that a smaller number of days to fruit formation was taken by the plants received high concentration of B and a combination of low concentration of B and high concentration of Zn as compared to untreated plants in control. Noteworthy effects of Zn and B may be responsible for higher synthesis of metabolites. Micronutrients increase the size, color, flavor, and freshness of fruits as well as NPK and water input use efficiency, improve their quality. Increase disease resistance, which lessens the need for defense, extend post-harvest life by reducing waste, prevent physiological disorders, and increase marketable yield [11].

No. of fruits per plant

No. of fruits per plant significantly varies with treatments (Table 2). The highest number of fruits per plant (49.70) was obtained with foliar treatment borax at 0.50% + $ZnSO_4$ at 0.50% followed by borax at 0.50% + $ZnSO_4$ at 0.25% (47.52) and shows significance. Least fruits/plant (26.07 number) were observed in control treatment. All the concentrations of Zn, B and their combinations increased no. of fruits per plant significantly over control. Zn and B have several encouraging effects towards fruit setting, retention and related activities which ultimately results in more fruits/plant. B and Zn are involved in involved in hormonal metabolism and photosyn-

Table 2: Effect of micronutrients on days require to form first fruit, number of fruits per plant, yield per plant (kg), weight of total fruits (kg), fruit length (cm), and chemical properties of papaya.

Treatment	Days require to form first fruit	Number of fruits per plant	Yield per plant (kg)	Weight of total fruits (kg)	Fruit length (cm)	TSS (°Brix)	Acidity %
T1	177.25	33.53	47.4	1	16.03	11.22	0.18
T2	162.1	43.46	83.33	1.4	18.22	13.68	0.15
T3	180.1	38.1	56.56	1.1	17.05	12.1	0.16
T4	164.14	44.8	86.26	1.43	18.4	14.3	0.14
T5	183	37.92	60.54	1.16	18.1	11.42	0.17
T6	171.08	39.6	66.56	1.22	17.4	14.12	0.14
T7	181.48	47.52	92.82	1.45	19.1	15.55	0.13
T8	174.33	49.7	75.55	1.42	17.01	16.18	0.12
T9	187.6	26.07	28.7	0.86	10.8	10.9	0.19
Mean	175.67	40.07	66.41	1.22	16.9	13.27	0.15
S. Em (±)	0.24	0.26	0.22	0.27	0.24	0.27	0.02
CD (P = 0.05)	0.08	0.08	0.07	0.09	0.08	0.09	0.01

thetic activities which promotes the synthesis of auxin, a prerequisite for improved growth processes and fruit set. Foliar application of 1% urea + 0.45% $ZnSO_4$ to immature mango leaves increased yield and resulted in the production of more fruits [12].

Yield per plant (kg)

Perusal of data reveals that foliar treatment with B and Zn had substantial influence on yield. Significantly improved yields were obtained with foliar treatment of $ZnSO_4$+ borax at 0.50 % (92.82 kg) followed by $ZnSO_4$ at 0.50 % (86.26 kg) lowest fruit yield per plant (28.70 kg) was perceived in control. This incline in plant yield might be accredited due to enhanced fruits/plant, increased fruit size and weight by treating the plant with B and Zn. Improvement in yield because of B treatment resulted in increased rate of RNA and carbohydrates metabolism. Foliar application of Zn gradually affected the productivity and fruit quality of grapes, red peppers, sweet oranges, and Kinnow mandarins [13]. Nutritional requirements of fruit crops are met through plant bio-regulators and micronutrients, and they play a crucial role in controlling various physiological phenomena, boosting yield and quality, and increasing plant productivity [7].

Fruit weight (kg)

Different treatments have substantial effects on fruit weight. Data revealed that significantly improved weight was recorded by treating it with borax at 0.50% + $ZnSO_4$ at 0.25% (1.45 kg) followed by $ZnSO_4$ at 0.50% (1.43 kg). The plants in the control treatment yielded fruits with less weight (0.860 kg). Foliar sprays of borax and $ZnSO_4$ resulted in improved fruit weight which might be due to contribution of B and Zn in hormonal metabolism, enhanced cell partition or development of cell walls. Physical traits of the fruit were also improved due to the application of Zn. B application at the pre-bloom and fruit set stage resulted in maximum fruit production/plant, improved fruit weight, size, flesh %, and minimum fruit stone percentage in olive (*Olea europea* L.) [14].

Fruit length (cm)

Significant variations were recorded concerning fruit length among different treatments. Treatment with $ZnSO_4$ at 0.25% + borax at 0.50% showed improved fruit length to the tune of 19.10 cm and it was found at par with borax at 0.50% (18.22 cm), borax at 0.25% + $ZnSO_4$ at 0.25% (18.10 cm), $ZnSO_4$ at 0.25% (17.05 cm), $ZnSO_4$ at 0.50% (18.40 cm) and $ZnSO_4$ at 0.50% (17.01 cm). On the contrary, plants in control have shown less fruit length (10.80 cm). Custard apple cv. "Sindhan" had improved flower number/shoot, fruit set, less fruit drop, improved retention, and physical parameters of the fruit (weight, girth, length, and pulp weight) as well as yield with applied with combined treatment of B + $ZnSO_4$ or $ZnSO_4$ (alone) [15].

Total soluble solids (%)

The foliar application of both the elements viz. Zn and B (alone or in combination) showed significant influence on TSS in papaya plants. The maximum accumulation of TSS content in papaya fruits was observed with the foliar treatment of borax at 0.50% + $ZnSO_4$ at 0.50% (16.18 °Brix) and it was on par with $ZnSO_4$ at 0.25% + borax at 0.50% (15.55 °Brix), $ZnSO_4$ at 0.50% (14.30 °Brix) and borax at 0.25% + $ZnSO_4$ at 0.50% (14.12 °Brix) treatments. The TSS content was significantly less (10.90 °Brix) in fruits obtained from the plants in treatment control. The increased accumulation of TSS could be due to catalytic action of micronutrients (Zn and B) and their mutual synergetic influence particularly at advanced concentrations. The increase in TSS by B might have happened due to rapid translocation of sugars from leaves to emerging fruits. Ethrel may lead to increased TSS of the fruit by more accumulation of metabolites and fast translation of starch into sugars in response to plant growth regulators during fruit development. Additionally, fruit quality characteristics like TSS, flavonoids, total sugar and ascorbic acid content of the fruit were documented maximum in T_9 with at par effect in T_6. To acquire the highest yield with improved fruit quality from mosambi orchards with calcareous and alkaline soil, three foliar sprays of B @ 0.3% + Fe @ 0.2% + Zn @ 0.5% + Cu @ 0.1% from May-July led to better results [16].

Titratable acidity

The acidity of fruits was expressively influenced by various treatments. The data publicized that acid content in fruits reduced under all treatments in comparison to control. Among the treatments meaningfully minimum acidity per cent (0.120 %) was chronicled by the applying $ZnSO_4$ at 0.50% + borax at 0.50% followed by $ZnSO_4$ at 0.25% + borax at 0.50% (0.125 %). Maximum titratable acidity was found under control treatment (0.189%). Decline of acidity in fruits due to treatment with various concentrations of Zb, B, or combination of both might because of promising impact of Zn and B in rapid conversion of acids, by the reactions which includes the reverse glycolic pathway or might be consumed in the respiration or both. Additionally, spraying the Picual cultivar with nano-Zn at 200 ppm + nano-B at 20 ppm was considered as most effective technique for maximizing fruit set, which in turn led to the harvest of the highest number of fruits with high seed oil proportion and low acidity in *O. europaea* [17].

Conclusion

From the findings of the present research work, it could be established that plants treated with $ZnSO_4$ at 0.25% + borax at 0.50% have shown noteworthy increase in the vegetative characters of plants at dissimilar stages of plant, its fruit yield. Papaya plants treated with $ZnSO_4$ at 0.50% + borax at 0.50% have shown significant increase in quality of the fruits like TSS and titratable acidity. Thus, it has been observed that B and Zn play vital roles in overall growth and quality of papaya plants and fruits.

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None.

Conflict of Interest

None.

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