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Effect of Foliar Spray of Potassium and Micronutrients on Yield and Quality of Papaya (*Carica papaya* L.) *cv*. Red Lady

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was carried out in Farmer's field at Basur village, Sorab taluk, Shivamogga dist, during the year 2018-2019. The experiment was laid out in randomized complete block design with three replication and eleven treatments. Results of this study reveal that the combined application of T_7 - K_2SO_4at 1% + Borax at 0.25% + $ZnSO_4$at 0.25% recorded significantly maximum yield and yield attributing parameters *i.e.*fruit length (27.20cm),fruit diameter (16.17cm), fruit weight (2438g and 2.43kg), number of fruits per plant (49.67), yield plant^{-1} (90.07kg) and yield (224.96 t ha^{-1}), pulp weight(2343.74g), peel weight(54.98g), seed weight(52.70g) and quality characters like total soluble solids (13.52 ^{o}brix), ascorbic acid (54.42mg 100g^{-1}), total sugar (5.64%), reducing sugar (4.60%) and minimum acidity (0.13%)over control and which was on par with T_8 (K_2SO_4 at 2% + Borax at 0.25% + $ZnSO_4$ at 0.25%) and non-reducing sugar was found to be statistically non-significant among the different treatments. The results revealed that the plants treated with T_7 - K_2SO_4 at 1% + Borax at 0.25% + $ZnSO_4$ at 0.25% were found to be effective to improve the yield and quality of papaya *cv*. Red Lady.

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1. INTRODUCTION

Papaya (*Carica papaya* L.) is an important fruit of tropical and subtropical regions of the world, belonging to the family Caricaceae and also known as “wonder fruit of the tropics” [1]. It is native of Tropical America was introduced to India in the 16th century from Malacca [2]. India is the largest producer of papaya in the world producing 5.83 million MT of fruits from an area of 0.13mha with productivity of 42.3 MT/ ha (NHB, 2019). Karnataka is the third largest producer of papaya in the country. It is commercially cultivated in Andhra Pradesh, Gujarat, Karnataka, West Bengal, Madhya Pradesh, Maharashtra and Tamil Nadu. It has gained tremendous impact on economic and nutritional value. The ripe fruit of papaya is eaten as such throughout the tropics. Ripe fruits also find its extensive uses for several preparations like jam, soft drinks, ice-cream flavouring and crystallized fruit. It is a nutritive fruit containing carbohydrates, protein and minerals mainly iron, calcium and phosphorus. It is rich source of Vitamin ‘A’ having 2020 I.U./100g of fruit [3]. The papaya fruit belongs to the group of low acid content fruit and the pH of pulp ranges from 5.5 to 5.9 [4].

About 40-55% of Indian soils are moderately deficient in Zinc and 25-30% is deficient in Boron. Deficiency of other micronutrients occurs under 15% of soils. Deficiency of micronutrient has become a major constraint to the productivity, stability and sustainability of crops in many Indian soils [5].

Among macro nutrients, potassium regulates photosynthesis and it is also essential for starch synthesis and sugar accumulation by activating enzymes viz., starch synthetase, etc., (Lester et al., 2010). Potassium is excessively required during fruit maturation stage for enhancing the fruit size, colour, soluble solids, ascorbic acid concentration and taste of fruits [6,7]. Among micro nutrients viz., zinc and boron are essential for growth and development of papaya fruits, affecting various biological processes such as photosynthesis, synthesis of nucleic acids, proteins and carbohydrates [8].

Micronutrients can tremendously increase crop yield and get better quality and post-harvest life of produce. They play a significant role in disease resistance, since they function as enzyme activators and also play a function in lignin biosynthesis [1].

Foliar application of micronutrients has gained importance because foliar application is a well-established operation to complete and enrich plant nutrition. Foliar application can meet the expense of nutrients where absorption of nutrients from the soil is unavailable due to plant stress or in adverse soil conditions [9,10]. Foliar sprays with fertilizers including macro element like potassium and microelements such as Zn and B have been shown to be convenient for field use, have a good effectiveness and very rapid plant response [11]. Hence, foliar application of potassium, zinc and boron in specific plant developmental and critical stages improves the yield and quality of papaya [12,13].

2. MATERIALS AND METHODS

An investigation was carried out in Farmer’s field at Basur village, Sorab taluk, Shivamogga dist with the support of Department of Fruit science at College of Horticulture, Bengaluru, University of Horticultural Sciences, Bagalkot during 2018-2019. The place is located at 14^{o}52’ North latitude, 75^{o}07’ East longitude and altitude of 580 meters above mean sea level and it is situated in the Hilly zone of Karnataka The experiment was laid out in randomized block design with three replications and eleven treatments viz., T_1 - K_2SO_4 at 1%, T_2 - K_2SO_4 at 2%, T_3 - Borax at 0.25%, T_4 - Borax at 0.50%, T_5 - $ZnSO_4$ at 0.25%, T_6 - $ZnSO_4$ at 0.50%, T_7 - K_2SO_4 at 1% + Borax at 0.25% + $ZnSO_4$ at 0.25%, T_8 - K_2SO_4 at 2% + Borax at 0.25% + $ZnSO_4$at 0.25%, T_9 - K_2SO_4 at 1% + Borax at 0.50% + $ZnSO_4$ at 0.50%, T_{10} - K_2SO_4 at 2% + Borax at 0.50% + $ZnSO_4$ at 0.50%, T_{11} - Control (water spray) with a spacing 2 x 2 m. Foliar application of potassium, zinc and boron were applied in six split doses with 45 days interval after transplanting. Three plants per replication were randomly selected and tagged in each treatment and in each replication. The fruits were harvested based on their maturity indices *viz.,* change in colour of fruit from dark green to yellowish orange. Observations were recorded and statistically analyzed as per the methods given by Panse and Sukhatme [14].

3. RESULTS AND DISCUSSION

In the present investigation, the data obtained on yield and yield attributing parameters *i.e.* fruit length (cm), fruit diameter (cm), fruit weight (g), number of fruits per plant, fruit yield plant per plant (kg), yield per ha (ton), pulp weight (g), peel weight (g), seed weight (g)and quality characters like total soluble solids, ascorbic acid, total sugar, reducing sugar and acidity were significantly influenced by spraying of different concentrations of potassium, zinc and boron are recorded and presented in Table 1 and Table 2. The data obtained on non-reducing sugar was found to be statistically non-significant among the different treatments.

Among different treatments, the results observed that the fruit length, fruit diameter and fruit weight showed significantly maximum (27.20cm, 16.17cm and 2438.00g, respectively) in treatment T_7 (K_2SO_4 at 1% + Borax at 0.25% + $ZnSO_4$ at 0.25%), which were on par with application of K_2SO_4 at 2% + Borax at 0.25% + $ZnSO_4$ at 0.25% (26.97cm, 15.84cm and 2397.64g, respectively) and were followed by $ZnSO_4$ at 0.25% (24.38cm, 14.53cm and 2148.32g, respectively), Borax at 0.25% (24.05cm, 14.29cm and 2113.55g, respectively). Whereas, minimum fruit length, fruit diameter and fruit weight (20.07cm, 11.98cm and 1802.43g, respectively) were observed in T_{11} (control-water spray). This might be due to combined effect of zinc and boron involved in hormonal metabolism, starch formation, cell division, cell expansion and increased volume of intercellular spaces in the mesocarpic cells and higher mobilization of photosynthates from other parts of the plant towards the developing fruits that are extremely active metabolic sink [15] and [16]. The similar findings were reported by Singh et al. [17], Waskela et al. [18] and Bhalerao et al. [19]. Zinc helps in regulating the semi permeability of cell walls, thus mobilizing more water into fruits increased rate of cell division and cell enlargement leading to more accumulation of metabolites in the fruit resulting increase in fruit length, fruit diameter and fruit weight [20]. Similar results were obtained by Chaitanya [21,22], Singh et al. [23], Yadav et al. [24] and Rajkumar et al. [25]. Boron activates rapid mobilization of water and sugar in the fruit which intern increased in accumulation of dry matter within the fruit (Bhatt et al. 2012) and application of boron might have caused rapid synthesis of protein and translocation of carbohydrate which ultimately led to increase in fruit weight [26].

The results obtained for number of fruits per plant, fruit yield plant per plant (kg) and yield per ha(ton) were significantly maximum (49.67, 90.07 and 224.96, respectively) with foliar application of K_2SO_4 at 1% + Borax at 0.25% + $ZnSO_4$ at 0.25%, which were on par with the application of K_2SO_4 at 2% + Borax at 0.25% + $ZnSO_4$ at 0.25% (47.22, 88.37 and 221.67, respectively) and were followed by $ZnSO_4$ at 0.25% (42.12, 80.79 and 201.95, respectively), Borax at 0.25% (42.07, 80.48 and 201.68, respectively). Whereas, T_7, T_8, T_5 and T_3 was registered significantly superior over all other treatments respectively. Whereas, in T_{11} (control-water spray) was noticed minimum number of fruits per plant, fruit yield plant per plant (kg) and yield per ha(ton) (33.52,71.85 and 178.64, respectively). This might be due to combined effect of foliar application of potassium, zinc and boron directly or indirectly, involved in fruit setting, retention and their activity improved number of fruits per plant associated with photosynthesis, hormone metabolism which promotes synthesis of auxin, necessary for fruit set and fruit growth [25]. Zinc is helpful in chlorophyll synthesis which increases photosynthetic activities of leaves, which leading to development of primary flowers, production of viable flowers with improve pollination and fruit setting [27]. Similar results were also obtained by Ali, [28,29], Babu and Yadav [30] and [31,23,24,32,33]. The application of boron might have caused rapid synthesis of protein and translocation of carbohydrate which ultimately led to increase in fruit weight which is directly correlated with total yield [34] and [30]. Similar results have been reported by Panwar et al. [35] and [20] and [36] who reported that increase in number of fruits probably due to influence of boron which increases pollen grain germination and pollen tube elongation, consequently leads to higher fruit set and finally more number of fruits per plant. The number of fruits produced per plant has significantly reflected on high yield. Higher the fruit number more will be the yield. Similar results were obtained by Kudada and Prasad [37], Singh et al. [38], Singh et al. [23], Sajid et al. [39] and Trivedi et al. [40].

Significantly the maximum pulp weight, peel weight and seed weight (2343.74g, 54.98g and 52.70g, respectively) was obtained with foliar application T_7 (K_2SO_4 at 1% + Borax at 0.25% + $ZnSO_4$ at 0.25%), which was on par (2268.64g, 52.63g and 50.65g, respectively) with T_8 (K_2SO_4 at 2% + Borax at 0.25% + $ZnSO_4$ at 0.25%) and were followed by (2043.56g, 48.07g and 46.18g, respectively) with T_5 ($ZnSO_4$ at 0.25%), (2015.27g, 47.63g and 45.95g, respectively) with T_3 (Borax at 0.25%). Whereas, T_7, T_8, T_5 and T_3 was registered significantly superior over all other treatments respectively.

Table 1. Effect of foliar spray of potassium and micronutrients on yield and yield attributing characters of Papaya *cv.* Red Lady

Treatments	Treatment Details	Yield and yield attributing characters								
		Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Number of fruits per plant	Fruit yield per plant (kg)	Fruit yield per ha (ton)	Pulp weight (g)	Peel weight (g)	Seed weight (g)
T_1	K_2SO_4 at 1%	21.20	12.95	1865.37	36.88	72.92	181.75	1805.65	43.27	41.23
T_2	K_2SO_4 at 2%	20.33	12.05	1812.13	35.84	71.99	179.50	1703.87	41.64	40.28
T_3	Borax at 0.25%	24.05	14.29	2113.55	42.07	80.48	201.68	2015.27	47.83	45.95
T_4	Borax at 0.50%	20.65	12.37	1834.29	36.31	72.54	181.08	1764.13	42.82	40.79
T_5	$ZnSO_4$ at 0.25%	24.38	14.53	2148.32	42.12	80.79	201.95	2043.56	48.07	46.18
T_6	$ZnSO_4$ at 0.50%	20.88	12.68	1850.93	36.57	72.68	181.34	1793.21	43.04	41.00
T_7	K_2SO_4 at 1% + Borax at 0.25% + $ZnSO_4$ at 0.25%	27.20	16.17	2438.00	49.67	90.07	224.96	2343.74	54.98	52.70
T_8	K_2SO_4 at 2% + Borax at 0.25% + $ZnSO_4$ at 0.25%	26.97	15.84	2397.64	47.22	88.37	221.67	2268.64	52.63	50.65
T_9	K_2SO_4 at 1% + Borax at 0.50% + $ZnSO_4$ at 0.50%	20.59	12.21	1822.16	36.18	72.14	180.58	1730.37	42.50	40.63
T_{10}	K_2SO_4 at 2% + Borax at 0.50% + $ZnSO_4$ at 0.50%	20.52	12.13	1819.92	36.01	72.05	179.67	1715.14	41.92	40.42
T_{11}	Control (water spray).	20.07	11.98	1802.43	33.52	67.65	169.65	1692.28	41.34	40.05
S.Em±		**0.62**	**0.40**	**69.75**	**1.66**	**2.48**	**6.41**	**68.08**	**1.32**	**1.37**
C.D @ 5 %		**2.10**	**1.20**	**205.76**	**4.89**	**7.33**	**19.30**	**200.83**	**4.23**	**4.05**

Table 2. Effect of foliar spray of potassium and micronutrients on quality characteristics of Papaya *cv.* Red Lady

Treatments	Treatment Details	Quality characteristics					
		TSS (^{O} brix)	Acidity (%)	Ascorbic acid (mg 100 g^{-1})	Total sugar (%)	Reducing sugar (%)	Non-Reducing sugar (%)
T_1	K_2SO_4 at 1%	13.44	0.14	53.84	5.48	4.43	1.05
T_2	K_2SO_4 at 2%	13.20	0.14	52.95	5.28	4.28	1.09
T_3	Borax at 0.25%	13.28	0.14	53.57	5.34	4.38	1.06
T_4	Borax at 0.50%	13.15	0.15	52.80	5.15	4.15	1.10
T_5	$ZnSO_4$ at 0.25%	12.90	0.15	51.87	5.06	3.90	1.08
T_6	$ZnSO_4$ at 0.50%	12.84	0.16	51.54	4.98	3.86	1.06
T_7	K_2SO_4 at 1% + Borax at 0.25% + $ZnSO_4$ at 0.25%	13.52	0.13	54.42	5.64	4.60	1.04
T_8	K_2SO_4 at 2% + Borax at 0.25% + $ZnSO_4$ at 0.25%	13.50	0.13	54.07	5.56	4.55	1.02
T_9	K_2SO_4 at 1% + Borax at 0.50% + $ZnSO_4$ at 0.50%	13.02	0.15	52.61	5.13	4.01	1.02
T_{10}	K_2SO_4 at 2% + Borax at 0.50% + $ZnSO_4$ at 0.50%	12.98	0.15	52.23	5.10	3.97	1.01
T_{11}	Control (water spray).	12.52	0.16	50.45	4.84	3.82	1.04
S.Em±		**0.42**	**0.01**	**0.27**	**0.23**	**0.14**	**NS**
C.D @ 5 %		**1.22**	**0.03**	**0.80**	**0.56**	**0.42**	**NS**

The treatment T_{11} (control-water spray) were observed minimum pulp weight, peel weight and seed weight (1692.28 g, 41.34 g and 40.05 g, respectively). This increase in fruit pulp weight might be due to minimum fruit cavity index, increased fruit length, diameter, fruit weight and more accumulation of photosynthates in the matured fruits by beneficial effect of boron and zinc. Similar results were reported by Singh et al. [23].

The present study indicates that significantly maximum total soluble solids (13.52 ^{o}brix), ascorbic acid (54.42mg $100g^{-1}$), total sugar (5.64%), reducing sugar (4.60%) and minimum acidity (0.13%) were observed in T_7 (K_2SO_4 at 1% + Borax at 0.25% + $ZnSO_4$ at 0.25%). Whereas, T_{11} (control-water spray) has registered significantly minimum total soluble solids (12.52%), ascorbic acid (50.45mg 100 g^{-1}), total sugars (4.84%), reducing sugar (3.82%) and maximum acidity (0.16). This might be due to influence of potassium which regulates photosynthesis and it is also essential for starch synthesis and sugar accumulation by activating enzymes *viz.,* starch synthetase, *etc*., [41]. Potassium is excessively required during fruit maturation stage for enhancing the fruit size, colour and taste of fruits [7]. Cell elongation accompanied with increase in sugar content [42]. Similar results were obtained by Kaur and Dhillon, [43,1,44]. TSS is directly associated with reducing and non-reducing sugars, the TSS will significantly reflect on more conversion of starch into reducing and non-reducing sugars during ripening process and this also might be due to influenced by zinc and boron application by regulating translocation of photosynthates to fruit pulp and hydrolysis of complex polysaccharides into simple sugars reported by Kavitha [45].

4. CONCLUSION

From this experiment the results revealed that foliar application is an instant effective way of application of nutrients. Among the different treatments, the plants treated with K_2SO_4 at 1% + Borax at 0.25% + $ZnSO_4$ at 0.25% were found to be significantly maximum in yield and quality of papaya *cv*. Red Lady.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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