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RESPONSE OF SOIL AND FOLIAR APPLICATION OF MICRONUTRIENTS ON FLOWERING AND FRUITING OF SAPOTA CV. KALIPATTI UNDER HDP SYSTEM

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ABSTRACT
The present experiment was carried out to find out the response of soil and foliar application of micronutrients on flowering and fruit characteristics of sapota cv. Kalipatti under HDP system at KRCCH, Arabhavi UHS Bagalkot, during 2015-2016. Here three micro-nutrients (namely zinc, iron and boron) were used under this experimentation and the micro-nutrients are applied through soil and foliar spray, for soil and foliar application Zinc and iron sulphates were used,, where as boron sodium tetraborate (Jai bore) for soil application and solubor for foliar application are used. The results indicated that, the foliar application of 0.5% ZnSO4 + 0.5% FeSO4 + 0.3% B tree-1 (*i.e.* 1st at 50 per cent flowering and another at fruits at pea size) along with recommended dose of macro-nutrients *i.e.* 100: 40: 150 g NPK and FYM 50 kg tree^{-1} for four to six years plants was shown less number of days (29 days) taken for flower initiation, flower opening to fruit set (29.50 days), days taken to reach harvestable stage (195.88 days) and the maximum number of flowers ((17.15) and fruits (2.95) shoot^{-1}, maximum fruit set percentage (23.56%) and fruit retention (85.91%) were recorded. Also it gave superior fruit characters like fruit weight (113.33 g), fruit length (6.10 cm), fruit girth (5.84 cm) and fruit volume (101.50 ml), where as the lowest values were noticed in control.

INTRODUCTION

Among the different sapota cultivars the Cv. Kalipatti is one of the most popular variety around, in South India especially in Northern Districts of Karnataka. This variety is known for its prolific bearer and fruits contain high sugar content (18-24%). Here the problem with Sapota Cv. Kalipatti is poor fruit setting and long flowering (62 days from flower initiation to flower opening) and medium sized fruits. It bears 8-10 flowers per shoot during the peak flowering periods *i.e.*, November-December and February-April. Even though, it has the tendency of low fruit set (10-12%) and heavy shedding of during different stages of fruit development. It was noticed that, from the total flowers and only few fruits retains until maturity. Maximum fruit-drop occurs immediately after fruit setting due to various factors among these micronutrients play an important role. Increasing of fruit set and retention is possible by spraying of boron (B), Iron (Fe) promotes formation of chlorophyll pigments, which will acts as an oxygen carrier and reactions involving cell division and growth. Zinc (Zn) aids in regulating plant growth hormones and enzyme system, necessary for chlorophyll production, carbohydrate and starch formation. Zinc is an important for the formation and activity of chlorophyll and in the functioning of several enzymes and the growth hormone, auxin (Sundar *et al.*, 1972)

The successful commercial cultivation of sapota crop will depends on many factors such as climate, soil, irrigation, fertilizer, spacing and season of fruiting etc. Among the different management practices, the nutrient management practices will plays an important role in growth, yield and quality fruits under high density planting (HDP) system. To perform sustainable yield and quality it need high amount of nutrients (Mishra, 2014). The intensive and exploitative agriculture practices like high inputs and high yielding varieties and improved technologies which were helped in increase fruit production in sapota. But under high density planting competition for water and nutrients are the major, the nutrients usually supplied through straight fertilizers or mixture in an aggressive manner it lead to the depletion of micronutrients by maximum utilization it will ultimately resulting in to the indeed application of micronutrients. To sustain the production of fruit sapota maintenance of micro and secondary nutrients becomes very pertinent to foresee the emerging nutrient deficiencies and to evolve suitable ameliorating technologies. Therefore, based on the possible benefits of micro nutrients, the present study was carried out to study the response of soil and foliar application of micronutrients application on flowering and fruit characters of sapota Cv. Kalipatti under high density planting system.

MATERIALS AND METHODS

Experiment area was located at K. R. C. College of Horticulture, Arabhavi (University of Horticultural Sciences, Bagalkot,). The experiment was carried out during May 2015 to April 2016. Arabhavi is situated in northern dry zone of Karnataka State at 16°15' North latitude, 74° 45′ East longitude and at an altitude of 612.05 m above themean sea level.

Experimental details

A field experiments was conducted at Kittur Rani Chennamma College of Horticulture, Arabhavi, UHS, Bagalkot, during the

year 2015-2016, the plants were selected are uniform in size and planted under high density planting with a spacing of 3x3 m. Experiments were laid out in Randomized Complete Block Design with eleven treatments *viz*., T1: control-recommended dose of fertilizers [RDF-recommended dose of macro-nutrients *i.e*. 100: 40: 150 g NPK and FYM 50 kg tree-1 for four to six years plants]; T2- water foliar along with RDF; T3- ZnSO4 (50 g plant-1 as soil application) + RDF; T4-FeSO4 (40 g plant-1 as soil application) + RDF; T5- Boron (Jai bore 25 g plant-1 through soil application) + RDF; T6- ZnSO4 (as foliar application 0.5 %) + RDF; T7- FeSO4 (as foliar application 0.5 %) + RDF; T8: boron (Solubor for foliar application 0.3 %) + RDF; T9- ZnSO4 @ 50 g + FeSO4 @ 40 g + boron 25 g plant-1 through soil application + RDF; T10- ZnSO4 (0.5%) + FeSO4 (0.5%) + boron (0.3%) for foliar application + RDF; and T11-combination of T9 + T10. These nutrients are applied in two times through foliar *i.e*. 1st at 50 per cent flowering and another at fruits at pea size. Whereas for soil application micronutrients applied along with RDF. It was recorded by manual counting the flowers on newly emerged shoots in four direction of plant and in each direction five shoots has tagged. It was recorded by counting calendar days from flower initiation to fruit set *i.e*., pea size fruits.

Statistical analysis of experimental data

The experimental data collected relating to different parameters were statistically analyzed as described by Sundar *et al*. (1972) and the results were tested at 5 per cent level of significance by Fischer method of analysis of variance.

RESULTS AND DISCUSSION

The effect of micronutrients on number of days taken for flower initiation of sapota

The present research results was indicated that, the minimum number of days taken for flower initiation in T4 (28.50) and T10 (29.50) whereas, the maximum number of days (37.70) in T2 and T1 [Table-1]. It might be due to Zn, Fe and boron has improved the N and S metabolism, chlorophyll synthesis these metabolic activities will helps in production of good amount of biomass that leads to early flower initiation (Elico *et al*., 2013) and in other hand Zinc will play the important role in the synthesis of auxin, Iron (Fe) is credited with a definite role in the synthesis of chlorophyll molecules. Similarly, boron regulates metabolism and translocation of carbohydrates which would needed for active cell wall development and RNA synthesis (Ram and Bose 2000). It was conformed that the combined effect of Zn, Fe and B has played a vital role in increase of physiological activities leading to early initiation of flowering (Tulsu *et al*., 2015).

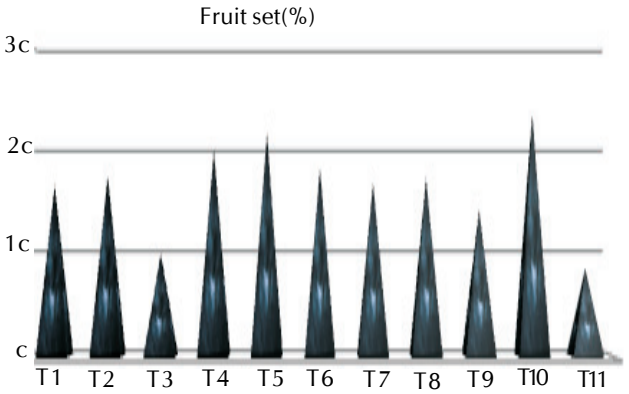


Figure 1: Effect of micronutrients on fruit set (%) of sapota.

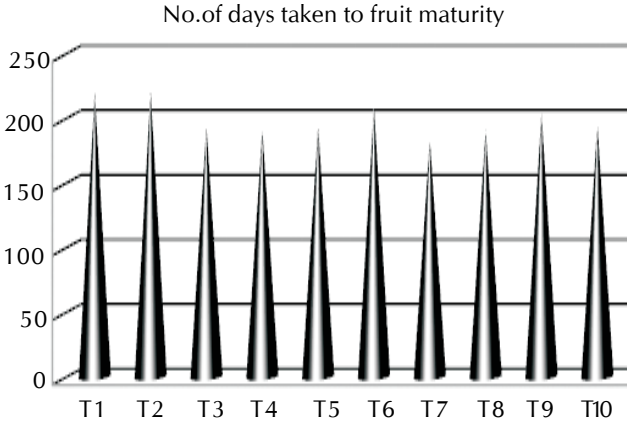


Figure 3: Effect of micronutrients on days taken for fruit maturity of sapota Cv. Kalipatti

Table 1: Effect of micronutrients on days taken to flower initiation, number of flowers shoot-1 and days to flowering to fruit set of sapota Cv. Kalipatti.

Treatments	Flowering parameters		
	Days taken to flower initiation	No. of flowers shoot-1	Days to flowering to fruit set
T1- Control (RDF)	37.76	9.5	33.05
T2- RDF + Water spray	37.31	9.48	31.2
T3- RDF + 50 g ZnSO4 per tree (SA)	33.9	11.25	30.43
T4- RDF + 40 g FeSO4 per tree (SA)	28.5	16.8	31.5
T5- RDF + 25 g B per tree (SA)	35.5	14.5	31.9
T6- RDF + 0.5% ZnSO4 per tree (FA)	34.83	16.75	31.97
T7- RDF + 0.5% FeSO4 per tree (FA)	34.93	12.8	29.85
T8- RDF + 0.3% B per tree (FA)	36.5	17.25	32.75
T9- RDF + 50 g ZnSO4 + 40 g FeSO4 + 25 g B per tree (SA)	32.51	10.5	30.5
T10- RDF + 0.5% ZnSO4 + 0.5% FeSO4 + 0.3% B per tree (FA)	29.5	17.15	29.75
T11- T9 + T10	31.73	11.45	32.25
S. Em ±	0.23	0.88	0.24
C. D. at 5%	0.67	2.59	0.71

SA = soil application; FA: foliar application

Table 2 : Effect of micronutrients on fruit set (%), No. of fruits shoot-1, per cent fruit reached to final harvest and no. of days taken to fruit maturity of sapota Cv. Kalipatti.

Treatments	Fruit set (%)	No. of fruits shoot-1	Per cent fruit reached to final harvest	No. of days taken to fruit maturity
T1- Control (RDF)	16.52	1.00	60.20	220.15
T2- RDF + Water spray	17.51	1.01	62.31	221.70
T3- RDF + 50 g ZnSO4 per tree (SA)	9.90	1.35	72.30	194.20
T4- RDF + 40 g FeSO4 per tree (SA)	19.97	2.80	71.32	191.60
T5- RDF + 25 g B per tree (SA)	21.66	2.50	74.90	193.97
T6- RDF + 0.5% ZnSO4 per tree (FA)	18.27	1.20	78.20	209.33
T7- RDF + 0.5% FeSO4 per tree (FA)	16.83	2.12	63.36	183.80
T8- RDF + 0.3% B per tree (FA)	17.26	2.90	74.98	191.85
T9- RDF + 50 g ZnSO4+40 g FeSO4+ 25 g B per tree (SA)	14.21	1.80	56.97	204.86
T10- RDF + 0.5% ZnSO4 + 0.5% FeSO4 + 0.3% B per tree (FA)	23.50	2.95	85.95	195.88
T11- T9 + T10	8.43	0.55	50.25	220.06
S. Em ±	0.66	0.05	3.36	1.16
C. D. at 5%	1.95	0.14	9.93	3.43

Table 3: Effect of micronutrients on fruit weight (g), fruits girth (cm), fruit length (cm) and fruit volume (ml) of sapota Cv. Kalipatti.

Treatments	Fruit characters			
	Fruit weight (g)	fruits girth (cm)	Fruit length (cm)	Fruit volume (ml)
T1- Control (RDF)	83.56	4.9	6.01	86.2
T2- RDF + Water spray	82.16	5	5.8	86.33
T3- RDF + 50 g ZnSO4 per tree (SA)	85.3	4.98	5.95	86.83
T4- RDF + 40 g FeSO4 per tree (SA)	102.5	5.8	6.25	99.2
T5- RDF + 25 g B per tree (SA)	109.4	5.9	6.3	99.45
T6- RDF + 0.5% ZnSO4 per tree (FA)	62.5	4.8	6.45	80.85
T7- RDF + 0.5% FeSO4 per tree (FA)	111.5	5.12	6.21	90.1
T8- RDF + 0.3% B per tree (FA)	90.3	6	6.5	100.2
T9- RDF + 50 g ZnSO4+40 g FeSO4+ 25 g B per tree (SA)	89.2	5.55	6.85	99.31
T10- RDF + 0.5% ZnSO4 + 0.5% FeSO4 + 0.3% B per tree (FA)	113.1	5.9	6.4	101.5
T11- T9 + T10	82.5	5.01	5.85	81.5
S. Em ±	0.48	0.22	0.5	0.45
C. D. at 5%	1.41	0.64	NS	1.33

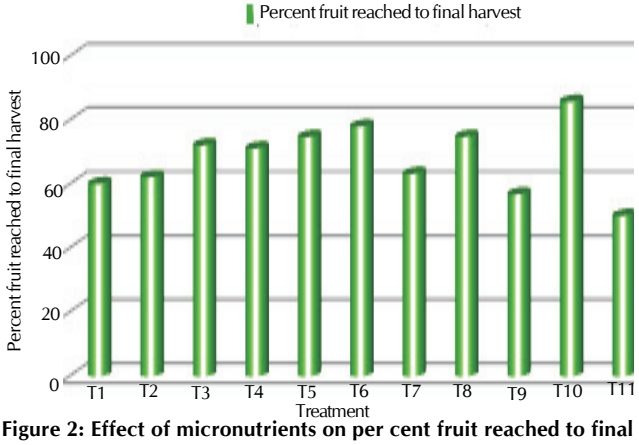


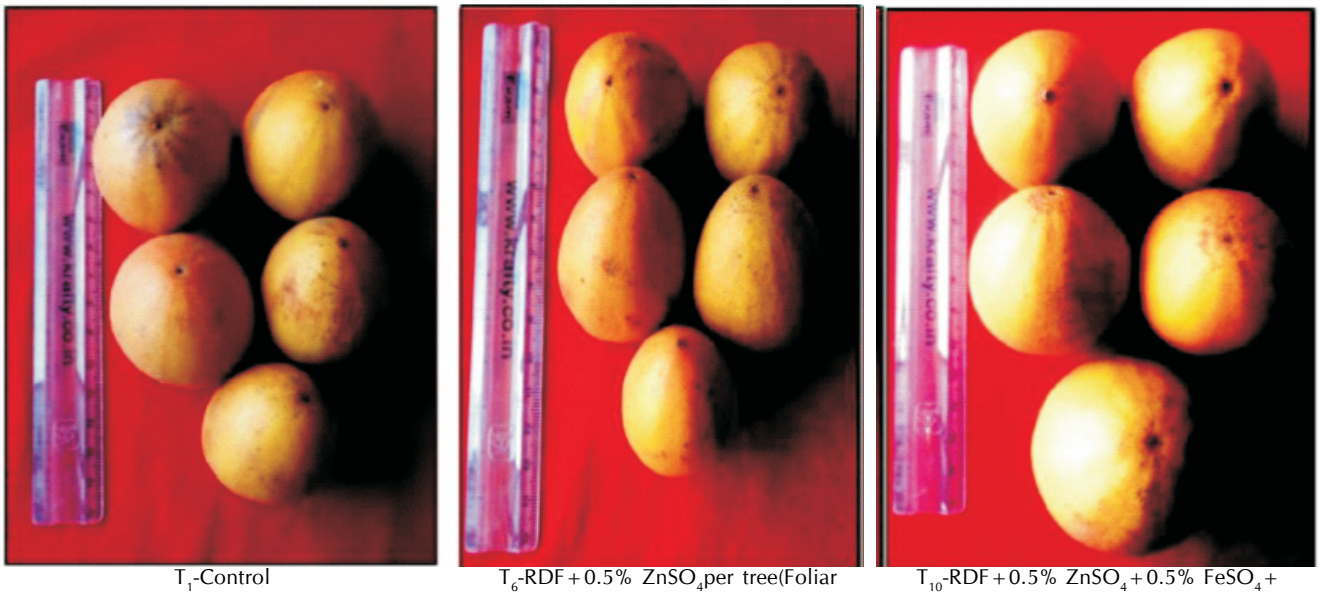
Figure 2: Effect of micronutrients on per cent fruit reached to final harvested of sapota.

Number of flowers per shoot

The maximum number of flowers was noticed with the foliar application of boron @ 0.3 per cent (T8), foliar spray of 0.5 ZnSO4 + 0.5 FeSO4 + 0.3 B per cent (T10), Soil application of 40 g FeSO4 tree^{-1} (T4), Foliar spray of 0.5 per cent ZnSO4 (T6) and (T5) Soil application of 25 g B per tree (17.25, 17.15, 16.80, 16.80 and 14.50 respectively), and the minimum number of flowers or flower buds (9.50 and 9.48) was recorded in T1 and in T2 respectively [Table-1]. It is because boron play important role in sugar translocation. It will helps in flower production, Fe play major role in N and S metabolism, chlorophyll synthesis these metabolic activities may helps in production of good amount of biomass it helps in increased number of flower production and zinc (Zn) essential for auxin synthesis it helps in high number of flower production. This might be due to adequate amount of boron present in foliage which is used for development and growth of new cell in the plant meristem (Rashid *et al*., 2004).

Number of days taken to flowering to fruit set

The results indicated that, the minimum days taken for fruit set in T10 and T8 (29.75 and 29.85 days) which was on par with T4 (30.43) which might be due to micronutrients play an essential role in the major nutrients metabolism and it promotes the enzymatic activity in the cell wall [Table-1]. The earliness in fruit set was attributed to encourage the fertilizing process of plants and also enhance the premature rapture of pollen tubes and thus to promotes their growth and whole process of pollination (Ramesh and Singh2015). The maximum days to fruit set was taken in T1 (33.05) in control. It was found that zinc has enhanced the synthesis of auxin and iron is credited with a definite role in the synthesis of chlorophyll molecules. Similarly, boron regulates metabolism and translocation of carbohydrates, there by cell wall development and RNA synthesis was increased. It was conformed that the combined



T_1-Control | T_6-RDF + 0.5% $ZnSO_4$ per tree(Foliar application | T_{10}-RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + 0.3% B per tree(Foliar application)

effect of different micronutrients might have played a vital role in increasing of physiological activities leading to early fruit set in sapota cv. Kalipatti [Table-1].

Number of fruits per shoot

In the present study number of fruits shoot-1 has shown significant different among the different treatments and the maximum number of fruits (2.95 fruits shoot-1) was recorded in the treatment T10 (Foliar application of 0.5% ZnSO4 + 0.5% FeSO4 + 0.3% B per tree), T8 (2.90 fruits shoot-1) which was significance with T4 (2.80 fruits shoot-1), followed by T5 (2.50 fruits shoot-1), minimum number of fruits per shoot (0.55) was recorded in T11 (T9 + T10) [Table-2].This might due to better photosynthesis, greater accumulation of starch in fruits and the zinc involvement in auxin synthesis and boron in translocation of starch from source to sink (fruits). The balance of auxin in plant regulates the fruit drop or retention in plants, which will helps in control of fruit drop and increased the total number of fruits per tree (Dutta, 2004; Jeyabaskaran and Pandey, 2008; Kavitha *et al*., 2000; Sarolia *et al*., 2007 and Singh and Murya 2004). The reduce number of fruits was due to high concentration of Zn and Fe, low concentration of boron.

Per cent fruit set and per cent fruits reached to final harvest

The soil and foliar application of micronutrients had significant influence on per cent fruit set among the different treatments [Table-2] and [Fig-1]. The results was found to the maximum fruit set percentage was recorded in T10 (23.50 %) followed by T5 (21.46) which is might be due to the combine application micronutrients (Zn, Fe and B) has play major role in photosynthetes allocation by Fe, auxin synthesis enhanced by Zn and pollen germination and sugars translocation by boron resulted in to increased fruit set (Ahmed *et al*., 2012; Callan *et al*., 1978; Gujar *et al*., 2015; Rajput *et al*., 1979; Ashish *et al*., 2016 and Shivanadan *et al*., 2007). The application of micronutrients also had significant influence on per cent fruits reached to final harvest [Table-2] and [Fig-2]. The results reveal that maximum number of fruits retained at final harvest (85.95 %) was recorded in T10 which was on par with T6 (77.92%) this may be due to the zinc play important role in auxin synthesis which might helped in maximum fruit retention (Lenny and Patrick 2008; Nilesh and Banik 2011; Rajput *et al*., 1976; Vikas *et al*., 2013 and Yadav *et al*., 2013).

Number of days taken to fruit maturity

The results reveals that the significance reduced (Table-2 and Fig-3) crop cycle days in T7 (183.80) followed by T4 (191.60) which is on par with T8, T5, and T3 (191.85, 193.97 and 194.20) and the maximum number of days taken with T2 (221.70). This might have resulted into better photosynthesis, greater accumulation of photosynthates in fruits by increasing the amount of chlorophyll and zinc involved in auxin synthesis and boron helps in translocation of sugars source to sink (fruits) and also boron regulates metabolism and translocation of carbohydrates, cell wall development and RNA synthesis (Banik and Sen 1997). These metabolic activities might be helped in early crop maturation.

The effect of micronutrients on fruit characters of sapota.

The results of present research observations recorded on fruit characters *viz*., fruit weight (g), fruit length (cm), fruit girth (cm) and fruit volume (ml) due to the effect of application micronutrients during the crop growth are discussed [Table-3] and (Plate-1). The maximum fruit weight (113.10 g) was recorded in treatment T10 (foliar spray of ZnSO4 (0.5%) + FeSO4 (0.5%) + B (0.3%) per tree). However, the lowest fruit weight recorded in T2 (82.16 g) and T11 (81.50 g).The maximum fruit length (6.85 cm) was recorded in T9 which was statistically on par with other treatments. The minimum fruit length (5.80 cm and 5.85) was recorded in T2 and T11. The maximum fruit diameter in (6.00 cm) was recorded in the treatment T8, which was on par with T10, T5, and T4 (5.90, 5.90 and 5.80 respectively). However, treatment T6 recorded the minimum diameter of fruit (4.80 cm). The maximum fruit volume (101.50 ml) recorded in T10 followed by T8 (100.20) and the minimum volume of fruit (81.50 ml) was recorded in treatment T11. The increase in fruit weight in sapota with the

spray of borax was might be due to the involvement in harmonal metabolism, increase in cell division and expansion of cell. Boron is also known to stimulate rapid mobilization of water and sugar in the fruit and zinc play role in tryptophan metabolism and iron is essential for the chlorophyll synthesis. Ferritin, which stores and releases Fe, makes up about 75 % of the content of chloroplasts in leaf cells. Moreover, iron participates in the electron transport in the process of reduction via cytochromes and ferredoxin (Khayyat *et al*., 2007; Marschner, 1986; Rani and Brahmachari 2001; Razzaq *et al*., 2013 and Saraswathy *et al*., 204). The decreased fruit weight, length and volume in T11 due higher concentration of micronutrients and in T6 decreased fruit weight, girth and volume due to toxic effect of Zn at 0.5% foliar spray it had shown adverse effect on boron. The boron regulates metabolism and translocation of carbohydrates, cell wall development and RNA synthesis (Mlik *et al*., 2011, Jitendra *et al*., 2015).

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