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Effect of plant growth regulators on yield and quality of sapota (*Achras zapota* l.) through crop regulation under hill zone of Karnataka

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ABSTRACT

An experiment was conducted in the 35 year old sapota orchard at Mudigere (Karnataka) during 2014-15 to know the Effect of plant growth regulators on yield and quality of sapota (Achras zapota L.) through crop regulation under hill zone of Karnataka. Three growth regulators viz., NAA (250, 300 and 350 ppm), 2, 4-D (40, 50 and 60 ppm) and Ethephon (350, 400 and 450 ppm) at varied concentrations were sprayed at pea nut stage. The results of the experiment showed that, the foliar application of NAA at 350 ppm gave significantly maximum fruit weight (110.23 g), fruit length (6.07 cm), fruit diameter (58.30 mm), volume of fruit (106.87 ml), yield per tree (108.47 kg), yield per hectare (10.85 t) and extended shelf life (10.58 days) with minimum physiological loss in weight (6.10 %, 8.11 % and 10.22 % at 3, 6 and 9 days during storage respectively) compared to all other treatments tried. The foliar application of Ethephon 450 ppm showed significantly decrease in number of mummified fruits (40.10) with maximum per cent of thinning (35.30 %), total soluble solids (19.75 ÚBrix), reducing sugars (9.12%), non reducing sugar (6.96%) and total sugars (15.97%).

***Keywords**: Sapota, Growth Regulators, Ethephon, Crop Regulation, Mummified Fruits.*

INTRODUCTION

Sapota (*Achras zapota* L.) is a native of Mexico belongs to the family Sapotaceae. India is the largest producer of sapota in the world with a production of 14.95 lakh metric tonnes. Karnataka is one of the major sapota growing states with an area of 31,700 hectares with a production of 3,73,000 metric tonnes and productivity of 11.80 metric tons per hectare (Anon, 2013). The ripe fruit is rich in sugar (12-14 %) and contains fairly large amount of minerals like calcium, phosphorous, iron and sodium besides vitamins A, B_1, B_2, B_6 and C (Joshi *et al.*, 1993). Crop regulation plays an important role in influencing the yield and quality of fruits. Among the crop regulation methods, application of chemical is cheaper than the manual thinning. Consequently, many substances like phenols, cresols, NAA, 2,4-D, MCPA, Ethephon, Carbamate, MH *etc.*, were used to regulate some of the flowers or fruitlets in different fruit crops (Auchter and Roberts, 1935). As sapota is a heavy bearing fruit crop, it suffers with the problems like enormous flowering, flower drop, less fruit set, small sized fruits with low quality and fetches less price in the market. Especially in wasteland and marginal lands, this crop suffers from a malady called mummification or stone fruit, which has been described as a nutritional or physiological disorder. This is very severe in old orchards in certain areas of hill zones. The severity leads to a loss of crop to the tune of more than 70 per cent. To overcome these problems one of the easily practicable cultural operations is crop regulation. NAA and 2,4-D enhances the early fruit drop by decreasing competition between fruits and increasing production of abscission inducing ethylene, both encouraging greater physiological drop (Mitra, 1995). Ethephon induces the biosynthesis of plant hormone ethylene which stimulates abscission (Wertheim, 1997). Keeping the above aspects in view, the present study was undertaken to know the effect of plant growth regulators on size, yield, quality, thinning per cent and incidence of mummification in sapota through crop regulation under hill zone of Karnataka.

MATERIALS AND METHODS

The present investigation was carried out at existing 35 year old sapota orchard, Zonal Agricultural and Horticultural Research Station (ZAHRS), Mudigere, Chikamagalur district, Karnataka state during 2014-2015. The plants having uniform size were selected for the study. The treatments consisted of three different plant growth regulators with three concentrations of each namely, NAA (250, 300 and 350 ppm), 2, 4-D (40, 50 and 60 ppm), Ethephon (350, 400 and 450 ppm) and the plain distilled water sprayed on the control plants. There were ten treatments along with a control and each treatment was replicated thrice in a complete Randomized Block Design (RBD). All the treatments were applied at pea nut stage through foliar spray. The observations on physical parameters like fruit length (cm), diameter of fruit (mm), and weight of fruit (g) were recorded; further, the volume of fruit (ml) was determined by water displacement method. Yield attributes like, number of fruits per tree was physically counted when they were harvested; yield per plant (kg), yield per hectare (t), fruit thinning per cent and number of mummified fruits was also recorded. The observations on quality parameters like physiological loss in weight (%), shelf life (days), total soluble solids (ÚBrix), reducing sugar (%), non-reducing sugar (%) and total sugars (%) were recorded after harvest. Here Sugars present in the sapota fruit samples were estimated by Anthrone reagent method (Ranganna, 1977) and total soluble solids was recorded with the extracted juice using a hand refractometer at room temperature. The data obtained were statistically analysed by the analysis of variance method as suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The various physical parameters were significantly influenced by application of different growth regulators (Table1). The maximum fruit volume (106.87 ml), fruit diameter (58.30 mm) and fruit length (6.07 cm) were recorded when NAA at 350 ppm was applied at pea nut stage. Application of NAA and Ethephon decreases the fruit number resulting higher accumulation and translocation of extra metabolites from other parts of the plant towards developing fruits and also due to NAA there will be a cell elongation by enlargement of vacuoles and loosening of cell wall after increasing its plasticity. This might have lead to increase in size of fruit. Similar findings were reported by Reyes *et al*. (2008), Kaur *et al.* (2005) and Taghipour *et al.* (2011).

The data revealed that the different treatments had significant effect on yield parameters of the tree (Table 2). The maximum value of fruit weight (110.23g in T_4) and reduced number of fruits per tree (964.13 in T_{10}) might be due to the elevated concentrations of Ethephon and also NAA mediated synthesis of polygalacturonase enzymes which has initiated the abscission zone, resulting in the fruit dropping, as the number of fruit decreases, the individual weight of the fruit increases due to less competition for carbohydrates. These results were in conformity with the findings of Abbas *et al.* (2014), Kaur *et al.* (2005) and Taghipour *et al.* (2011). NAA has a positive effect on yield of fruit. As a result of fruit thinning the tree did not become exhausted due to use of energy in fruit development and ripening, the prepared food remain reserved which might have helped to increase yield per tree (108.47 kg in T_4) and yield per hectare(10.85 t in T_4). These results are relevant to Abbas *et al.* (2014).

The minimum number of mummified fruit (40.10) was recorded under ethephon 450 ppm which was reduced by 1.04 per cent over the control (Table 3) and maximum number of mummified fruit (60.09) was recorded in control. This might be due to application of different concentration of ethephon, NAA and 2, 4-D decrease the fruitlet number which results in increasing the sink strength in smaller sized fruits, which leads to the more mobilization of photosynthates, moisture and mineral nutrients to the fruits and this result in proper balance of nutrients. These results were meagerly relevant to the study of Ugalat *et al.* (2013) in sapota.

There were significant differences on thinning per cent among the treatments. The maximum per cent of thinning (35.30%) was recorded in ethephon 450 ppm and minimum thinning per cent (17.63%) was recorded in control (Table 3). The result may be due to the use of ethephon enhanced the fruitlet thinning which increased the endogenous level of ethylene production leading to the abscission induction by increasing the cellulose activity in the abscission zone. The results were conformity with Moreira *et al.* (2011) in Ponkan mandarin and Sing *et al.* (2000) in Kinnow mandarin and Taghipour *et al.* (2011) in Apricot.

Table 1. Effect of foliar spray of different plant growth regulators on fruit characters of sapota

Treatment details	Fruit Volume (ml)	Fruit length (cm)	Fruit diameter (mm)
T_1 - Control	59.27	4.56	43.78
T_2 - NAA 250 ppm	84.40	5.18	48.97
T_3 - NAA 300 ppm	88.10	5.38	51.67
T_4 - NAA 350 ppm	106.87	6.07	58.30
T_5 - 2,4-D 40 ppm	70.77	5.08	48.72
T_6 - 2,4-D 50 ppm	74.33	5.03	48.58
T_7 - 2,4-D 60 ppm	78.40	5.01	48.47
T_8 - Ethephon 350 ppm	89.23	5.41	52.44
T_9 - Ethephon 400 ppm	94.77	5.65	54.51
T_{10} - Ethephon 450 ppm	97.40	5.82	55.74
S. Em ±	4.21	0.18	1.60
CD @ 5%	12.51	0.53	4.75

Table 2. Effect of foliar spray of different plant growth regulators on yield parameters of sapota

Treatment details	Fruit weight (g)	Number of fruits per tree	Fruit Yield	
			kg/tree	t/ha
T_1 - Control	62.59	1208.32	75.63	7.56
T_2 - NAA 250 ppm	87.17	1131.99	98.23	9.82
T_3 - NAA 300 ppm	91.53	1122.52	102.98	10.30
T_4 - NAA 350 ppm	110.23	1108.57	108.47	10.85
T_5 - 2,4-D 40ppm	74.40	1173.47	96.58	9.66
T_6 - 2,4-D 50ppm	77.20	1190.19	91.90	9.19
T_7 - 2,4-D 60ppm	81.87	1179.31	85.02	8.50
T_8 - Ethephon 350ppm	92.50	1098.22	101.68	10.17
T_9 - Ethephon 400ppm	97.74	1053.50	103.18	10.32
T_{10} - Ethephon 450ppm	99.40	964.13	94.61	9.46
S. Em ±	4.36	20.58	1.83	0.18
CD @ 5%	12.94	61.13	5.45	0.54

Table 3. Effect of foliar spray of plant growth regulators on number of mummified fruits and percent of fruit-let thinning in sapota.

Treatment details	Number of mummified fruits per tree	Fruit-let thinning (%)
T_1 - Control	60.09 (4.73 %)	17.63 (24.82)
T_2 - NAA 250 ppm	46.57 (3.95 %)	22.83 (28.54)
T_3 - NAA 300 ppm	45.07 (3.87 %)	23.50 (28.99)
T_4 - NAA 350 ppm	44.57 (3.86 %)	24.43 (29.62)
T_5 - 2,4-D 40ppm	51.03 (4.30 %)	20.01 (26.57)
T_6 - 2,4-D 50ppm	48.27 (3.99 %)	18.87 (25.74)
T_7 - 2,4-D 60ppm	45.30 (3.89 %)	19.61 (26.68)
T_8 - Ethephon 350ppm	44.07 (3.85 %)	26.14 (30.74)
T_9 - Ethephon 400ppm	41.73 (3.81 %)	29.19 (32.70)
T_{10} - Ethephon 450ppm	40.10 (3.69 %)	35.30 (36.45)
S. Em ±	1.86	1.22
CD @ 5%	5.53	3.63

Table 4. Effect of foliar spray of different plant growth regulators on physiological loss in weight and shelf life of sapota fruits

Treatment details	Physiological loss in weight (days)			Shelf life
	3rd Days	6th Days	9th Days	(Days)
T_1 - Control	9.64	11.80	14.16	7.89
T_2 - NAA 250 ppm	6.29	8.69	11.16	10.43
T_3 - NAA 300 ppm	6.12	8.40	10.49	10.54
T_4 - NAA 350 ppm	6.01	8.11	10.22	10.58
T_5 - 2,4-D 40 ppm	7.64	9.87	11.99	9.68
T_6 - 2,4-D 50 ppm	7.61	9.72	11.80	9.63
T_7 - 2,4-D 60 ppm	7.49	9.55	11.66	9.26
T_8 - Ethephon 350 ppm	8.22	10.37	12.49	9.18
T_9 - Ethephon 400 ppm	8.71	10.90	13.16	8.47
T_{10} - Ethephon 450 ppm	8.88	11.12	13.39	8.02
S. Em ±	0.24	0.26	0.26	0.16
CD @ 5%	0.71	0.79	0.78	0.49

Table 5. Effect of foliar spray of different plant growth regulators on quality parameters of sapota fruit

Treatment details	TSS (^{0}B)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)
T_1 - Control	14.07	7.78	4.91	13.50
T_2 - NAA 250 ppm	16.00	8.50	6.11	14.25
T_3 - NAA 300 ppm	16.13	8.53	6.17	14.53
T_4 - NAA 350 ppm	16.20	8.59	6.46	14.64
T_5 - 2,4-D 40 ppm	14.73	8.36	5.86	14.08
T_6 - 2,4-D 50 ppm	17.13	8.82	6.47	15.30
T_7 - 2,4-D 60 ppm	17.87	8.93	6.49	15.38
T_8 - Ethephon 350 ppm	18.73	9.01	6.52	15.53
T_9 - Ethephon 400 ppm	19.00	9.03	6.58	15.60
T_{10} - Ethephon 450 ppm	19.75	9.12	6.96	15.97
S. Em ±	0.35	0.10	0.16	0.13
CD @ 5%	1.04	0.29	0.46	0.40

The physiological loss in weight increased with the advancement of storage period as can be observed from Table 4. In the present investigation, the Minimum physiological loss in weight (6.01, 8.11 and 10.22%) at 3, 6 and 9 days after storage respectively with maximum shelf life of 10.58 days was recorded with NAA 350 ppm. The possible reason might be due to cause of some chemical changes within the fruits, resulting in retention of more water against the rate of evaporation, which resulted in increasing shelf life of the fruits. Further, it may be possibly due to the alteration of some proteinous constituents of the cell and thus increase in affinity towards water which resulted in lowest physiological loss in weight. Similar response was reported by Kher and Bhat (2005) in guava.

The data (Table 5) indicate that application of various plant growth regulators significantly improved the fruit quality of sapota in terms of T.S.S and sugars. The increase in total soluble solids (19.75 ÚB), reducing sugars (9.12%), non-reducing sugar (6.96%) and total sugars (15.97%) due to application of ethephon (at 450 ppm) in the present investigation might be due to its action of converting complex substances (starch) into simpler ones (sugars) through higher respiration and carbon assimilation activity. Similar findings were observed in guava by Yadav *et al*. (2001), Jain and Dashora (2010) and also ethylene acts as a thinning agent and thinning variants, which was normal because the trees fed a smaller number of fruits, which got larger with higher amount of sugars. These results were relevant to Sarkadi (2012) in peach.

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