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Effect of Foliar Application of Plant Growth Regulators and Nutrients on Quality of Kinnow Mandarin

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A B S T R A C T

The present study was undertaken to observe the response of Kinnow Mandarin to different forms of growth regulators and nutrients. The result of investigation indicates that fruit length and diameter were found maximum with the foliar application of K_2SO_4 2%, shape index and ascorbic acid were found maximum with the foliar application of 2, 4-D 20 ppm, peel thickness, acidity, peel content were recorded minimum and juice content and TSS were recorded maximum with the foliar application 2, 4-D 10 ppm, while rag content was found maximum with the application of GA_3 20 ppm. The total sugar was found maximum in fruits treated with treatment K_2SO_4 2% while reducing sugar was found maximum under the treatment K_2SO_4 1.5%.

Introduction

In India, citrus fruits rank third in production after banana and mango. Among citrus crops**,** mandarin (Kinnow mandarin, Nagpur, Khasi and Darjling) covers largest area followed by sweet orange (Musambi, Pineapple, Blood Red and Jaffa) and Acid lime. Among these, Kinnow mandarin bears highest place in production, productivity, juice content and fruit quality. Foliar application of Zn and K improved N, P, K and Zn level in Washington Navel leaves (Hafez and El-Metwally, 2007) and effectively controlled fruit drop, increased yield, juice volume, total soluble solids and vitamin C in Kinnow mandarin (Ashraf *et al.*, 2012). Foliar application of different levels of GA_3 (5, 50,100 and 500 mg L^{-1}) to young fruitlets just after fruit set has been reported to increase fruit weight and to reduce peel thickness and better recovery percentage with improved taste of grapefruit (Berhow, 2000).

As compared to other macronutrients, citrus fruit tree takes up higher amount of potassium (Alva & Tucker, 1999; Ashraf *et al.*, 2010; 2012).

It has a key role in many physiological processes like water relations, opening and closing of stomata, cell division, formation of sugars and starch, neutralization of organic acids, synthesis of proteins, and activation of enzymes(Liu *et al.*, 2000; Srivastava & Singh, 2006).

By enhancing fruit size, juice contents, color, size and juice flavor potassium improves the fruit quality (Tiwari, 2005; Ashraf *et al.*, 2010).

Materials and Methods

The present study was carried out at Chaudhary Farm House, Village Malapur, Hisar. Thirty-nine trees of uniform size and plant vigour with spacing 6 X 6 m were selected. All the thirteen treatments were replicated three times taking one plant as a single unit. The treatments comprising of 2,4-D ppm,GA_3,$K_2SO_4$and $ZnSO_4$ along with control were laid out in randomized block design.

Sr. no.	Treatments	Concentration of plant growth regulators and nutrients for foliar application
1	**T_1**	2,4-D 10 ppm
2	**T_2**	2,4-D 15 ppm
3	**T_3**	2,4-D 20 ppm
4	**T_4**	GA_3 10 ppm
5	**T_5**	GA_3 15 ppm
6	**T_6**	GA_3 20 ppm
7	**T_7**	K_2SO_4 1.0%
8	**T_8**	K_2SO_4 1.5%
9	**T_9**	K_2SO_4 2.0%
10	**T_{10}**	$ZnSO_4$ 0.25%
11	**T_{11}**	$ZnSO_4$ 0.50%
12	**T_{12}**	$ZnSO_4$ 0.75%
13	**T_{13}**	Control

Fruit length (mm), fruit diameter(mm)and peel thickness (mm)of four randomly selected fruits were measured with the help of digital Vernier Calipers.

Fruit shape index

Fruit shape index can be calculated by dividing fruit diameter with fruit height.

Peel content(%)

For peel content four randomly selected fruits were peeled manually. The percent peel content was calculated by using the formula:

$$\text{Peel content (\%)} = \frac{\text{Peel weight}}{\text{Fruit weight}} \times 100$$

Rag content (%)

$$\text{Rag content (\%)} = \frac{[\text{Fruit weight} - (\text{Peel weight} + \text{Juice weight})]}{\text{Fruit weight}} \times 100$$

Juice content (%)

The percent juice content was calculated by using the formula:

$$\text{Juice content (\%)} = \frac{\text{Total juice weight}}{\text{Total weight of fruits}} \times 100$$

TSS (^{0} brix)

The TSS of the representative fruit juice was determined with the help of digital hand refractometer

Acidity (%)

The acidity was estimated by titrating the juice with 0.1 N NaOH using phenolpthalein as an indicator.

Ascorbic acid(mg/100 ml of juice)

Ascorbic acid was estimated as per the method given by AOAC (1990). Two ml of fruit juice was mixed with 2 ml of 3% metaphosphoric acid as buffer and titrated with 2,6-dichlorophenol indophenol dye until the light pink colour appeared. The results were expressed as mg of ascorbic acid per 100 g of juice.

Results and Discussion

Physical parameters

The data recorded in Table 1 indicate that the application of different concentrations of 2,4-D,GA_3, K_2SO_4 and $ZnSO_4$ influenced the fruit length, fruit diameter and shape index significantly. The maximum fruit length was found in treatment T_9- K_2SO_4 2% (62.85 mm)and minimum fruit length was found in control (54.92 mm). The fruit diameter was observed maximum in treatment T_9- K_2SO_4 2%(71.81 mm) while it was observed minimum in control(63.37 mm). Malik *et al.*, (2000), Ashraf *et al.*, (2012) and Razzaq *et al.*, (2013) observed maximum fruit size in Kinnow mandarin with foliar application of SA + Zn + K.

The shape index was found maximum under the treatment T_3- 2, 4-D 20 ppm (0.87). The shape index was found minimum under control (0.81).

The data in Table 2 shows the significant influence of different concentrations of 2, 4-D, GA_3, K_2SO_4 and $ZnSO_4$ on juice content, rag content and peel content in Kinnow mandarin fruit. The juice content was observed maximum in treatment T_1- 2, 4-D 10 ppm (49.75%) and minimum juice content was observed in treatment T_9- K_2SO_4 2% (45.65%).

The rag content was obtained minimum in treatment T_{12}- $ZnSO_4$ 0.5%(24.77%) and maximum in treatment T_6- GA_3 20 ppm(27.30%). Sangwan *et al.*, (2008) observed that rag content was found non-significant but it increased with all the potassium treatments.

The treatment T_1- 2, 4-D 10 ppm(25.33%) showed the minimum peel content while the treatment T_9- K_2SO_4 2%(27.93 %) showed the maximum peel content. Kaur *et al.*, (2000) investigated the effect of GA_3 15 and 20 ppm, 2,4-D 20 ppm, NAA 20 ppm and urea 1% on peel content of Kinnow mandarin fruit and found the minimum peel content in fruits under the treatment 2, 4-D 20 ppm (26.3%) and maximum in fruits of control treatment (30.3%). The treatment T_1- 2,4-D 10 ppm

(3.46 mm) showed the minimum peel thickness in Kinnow mandarin while the treatment T_{13}- Control (4.13 mm) showed the maximum peel thickness. The results of present study are in conformity with Sharma *et al.,* (2013) who observed the minimum peel thickness (3.41 mm) in fruits taken from the plants sprayed with 2, 4-D 30 ppm and maximum (5.33 mm) in control fruits.

Chemical parameters

The data in Table 3 shows the significant influence of different concentrations of 2, 4-D, GA_3, K_2SO_4 and $ZnSO_4$ on TSS, acidity and ascorbic acid. The TSS was reported maximum in treatment T_9- K_2SO_4 2%(11.4 ^{0}brix) and minimum in treatment T_1- 2, 4-D 10 ppm(9.8 ^{0} brix). The results of present study are in conformity with the findings of Ashraf *et al.,* (2011) who found an increase in TSS in citrus juice with foliar application of Zn + K. The increase in TSS content with foliar application of K was related with the role of potassium in translocation of sugars from leaves to fruits (Havlin *et al.,* 2007).

The acidity was found minimum in treatment T_1- 2, 4-D 10 ppm(0.75%), whereas maximum acidity was found in treatment T_9- K_2SO_4 2%(0.93%). Saleem *et al.,* (2008) found that the acidity in juice of Blood Red oranges increased significantly with the increase in 2, 4-D concentration.

The maximum ascorbic acid was observed in treatment T_3- 2, 4-D 20 ppm (29.70 mg/100 ml) while minimum in treatment T_5- GA_3 15 ppm (26.8). The results of present study are in conformity with the findings of Maurya *et al.,* (1973) who observed that with the application of 2, 4-D 20 ppm ascorbic acid content increased in Dusehri mango. The data in Table 4 shows the significant influence of different concentrations of 2, 4-D, GA_3, K_2SO_4 and $ZnSO_4$ on total and reducing sugar. The maximum total sugar was found in fruits treated with treatment T_9- K_2SO_4 2% (10.10%), whereas minimum total sugar was found in fruits of control (8.78%).

The increase in the content of total sugars in fruits might be due to degradation of polysaccharides into simple sugars by the enzymes, conversion of organic acids into sugars and loss of moisture from the fruits (Kumar *et al.,* 2011). The results of the present study are in conformity with the findings of Khan *et al.,* (2015) who found that the total sugars could be improved with exogenous application of nutrients (Zn and K) in Kinnow mandarin. The maximum total and reducing sugars increased with all the potassium treatments in Kinnow mandarin (Sangwan *et al.,* 2008).

The reducing sugar was found maximum under the treatment T_8- K_2SO_4 1.5% (4.03%). The reducing sugar was found minimum under T_{10}- $ZnSO_4$ 0.25% (3.31%). However, Ram and Bose (2000) concluded that the foliar application of micronutrients (zinc, boron and Manganese) had no effect on reducing and non-reducing sugars in mandarin and sweet orange, respectively.

The effect of different concentrations of 2, 4-D, GA_3, K_2SO_4 and $ZnSO_4$ was found non-significant on non-reducing sugar. However, the maximum non-reducing sugar was found in treatment T_3- 2, 4-D 20 ppm (5.23%) and minimum non-reducing sugar was found in control (5.54%). The results of the present study are in conformity with the findings of Jadhavar *et al.,* (1991) who recorded a significant increase in non-reducing sugar content of Nagpur Santra fruits with 2, 4-D applied at 15 ppm. Wang *et al.,* (2004) recorded that the sugar content could be increased with the application of 2, 4-D, GA_3 and some other growth regulators in fruits of various mandarin and sweet orange cultivars.

Table.1 Effect of different plant growth regulators and nutrients on length (mm), diameter (mm) and shape index in Kinnow mandarin fruit

Treatments	Fruit size (mm)		
	Fruit length (mm)	Fruit diameter (mm)	Shape index
T_1: 2,4-D 10 ppm	55.12	64.34	0.84
T_2: 2,4-D 15 ppm	57.82	66.71	0.84
T_3: 2,4-D 20 ppm	56.23	65.63	0.87
T_4: GA_3 10 ppm	56.29	65.23	0.83
T_5: GA_3 15 ppm	59.22	68.83	0.82
T_6: GA_3 20 ppm	59.63	68.74	0.84
T_7: K_2SO_4 1.0%	60.04	69.23	0.82
T_8: K_2SO_4 1.5%	60.41	69.88	0.82
T_9: K_2SO_4 2.0%	62.85	71.81	0.82
T_{10}: $ZnSO_4$ 0.25%	55.93	64.78	0.82
T_{11}: $ZnSO_4$ 0.50%	58.43	67.89	0.84
T_{12}: $ZnSO_4$ 0.75%	58.29	67.45	0.84
T_{13}: Control	54.92	63.37	0.81
CD at 5% level of significance	**1.57**	**4.28**	**0.01**

Table.2 Effect of plant growth regulators and nutrients on juice, peel and rag content (%) in Kinnow mandarin fruit

Treatments	Content (%)			Peel thickness (mm)
	Juice	Rag	Peel	
T_1: 2,4-D 10 ppm	49.75	24.92	25.33	3.46
T_2: 2,4-D 15 ppm	48.52	26.05	25.43	3.58
T_3: 2,4-D 20 ppm	48.00	26.13	25.87	3.69
T_4: GA_3 10 ppm	47.83	26.07	26.10	3.74
T_5: GA_3 15 ppm	46.53	27.15	26.32	3.77
T_6: GA_3 20 ppm	45.90	27.30	26.80	3.85
T_7: K_2SO_4 1.0%	47.80	24.92	27.28	3.98
T_8: K_2SO_4 1.5%	47.23	24.89	27.88	4.00
T_9: K_2SO_4 2.0%	45.65	26.42	27.93	4.04
T_{10}: $ZnSO_4$ 0.25%	49.33	25.19	25.48	3.53
T_{11}: $ZnSO_4$ 0.50%	48.15	25.27	26.58	3.63
T_{12}: $ZnSO_4$ 0.75%	47.80	24.77	27.43	3.82
T_{13}: Control	48.56	25.86	25.58	4.13
CD at 5% level of significance	**1.02**	**0.78**	**0.72**	**0.21**

Table.3 Effect of plant growth regulators and nutrients on TSS (^{0}brix), acidity (%) and ascorbic acid (mg/100 ml) in Kinnow mandarin fruit

Treatments	TSS (^{0}brix)	Acidity (%)	Ascorbic acid (mg/100ml juice)
T_1: 2,4-D 10 ppm	9.8	0.75	28.52
T_2: 2,4-D 15 ppm	10.0	0.77	29.00
T_3: 2,4-D 20 ppm	10.2	0.81	29.70
T_4: GA_3 10 ppm	10.2	0.83	27.52
T_5: GA_3 15 ppm	10.6	0.89	26.87
T_6: GA_3 20 ppm	11.0	0.92	28.36
T_7: K_2SO_4 1.0%	10.8	0.90	27.00
T_8: K_2SO_4 1.5%	11.0	0.91	27.41
T_9: K_2SO_4 2.0%	11.4	0.93	28.00
T_{10}: $ZnSO_4$ 0.25%	9.8	0.76	27.92
T_{11}: $ZnSO_4$ 0.50%	10.0	0.79	28.72
T_{12}: $ZnSO_4$ 0.75%	10.4	0.85	29.49
T_{13}: Control	10.0	0.75	27.41
CD at 5% level of significance	**0.80**	**0.11**	**2.00**

Table.4 Effect of plant growth regulators and nutrients on percent sugar in Kinnow mandarin fruit

Treatments	Sugars (%)		
	Reducing	**Non-reducing**	**Total sugar**
T_1: 2,4-D 10 ppm	3.63	5.17	8.80
T_2: 2,4-D 15 ppm	3.73	5.22	8.95
T_3: 2,4-D 20 ppm	3.87	5.23	9.10
T_4: GA_3 10 ppm	3.60	5.58	9.18
T_5: GA_3 15 ppm	3.32	6.45	9.77
T_6: GA_3 20 ppm	3.86	5.84	9.70
T_7: K_2SO_4 1.0%	3.85	5.15	9.00
T_8: K_2SO_4 1.5%	4.03	5.90	9.93
T_9: K_2SO_4 2.0%	3.92	6.18	10.10
T_{10}: $ZnSO_4$ 0.25%	3.31	5.64	8.95
T_{11}: $ZnSO_4$ 0.50%	3.34	5.90	9.24
T_{12}: $ZnSO_4$ 0.75%	3.97	5.61	9.58
T_{13}: Control	3.36	5.44	8.78
CD at 5% level of significance	**0.44**	**N/S**	**1.10**

The present research findings indicate that foliar application of 2,4-D 10 and 20 ppm are effective in improving juice quality by increasing juice volume, Total soluble solids, acidity and ascorbic acid content. Sugar content can be increased with the foliar application of K_2SO_4.

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