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Harpreet Kaur
Department of Fruit Science, Khalsa College, Amritsar, Punjab, India

Navdeep Singh
Department of Fruit Science, Khalsa College, Amritsar, Punjab, India

Dr. Gurpinder Kaur
Department of Fruit Science, Khalsa College, Amritsar, Punjab, India

Corresponding Author:
Harpreet Kaur
Department of Fruit Science, Khalsa College, Amritsar, Punjab, India

Influence of pre-harvest spray of various chemicals on fruiting behaviour and quality of Kinnow Mandarin

Harpreet Kaur, Navdeep Singh and Dr. Gurpinder Kaur

Abstract
The investigation entitled "Influence of pre-harvest spray of various chemicals on fruiting behaviour and quality of Kinnow mandarin" was conducted in the well maintained Kinnow orchard of Department of Horticulture, Khalsa College, Amritsar during the year 2018-19. The healthy and uniform eight years old Kinnow trees were selected and treated with 2,4-D (10, 20 and 30 ppm), NAA (15, 20 and 25 ppm) and SA (10, 20 and 30 ppm) while the trees under control were treated with plain water only. The experiment was laid out in Randomized Block Design (RBD) with ten treatments that replicated thrice. The results of the study revealed that marked variations were recorded among the pre harvest treatments on fruit drop, yield and quality in Kinnow mandarin. Among all the treatments, the trees sprayed with 2,4-D @10 ppm registered maximum fruit set (81.97%), fruit retention (68.57%), fruit yield (75.13 kg per tree) with minimum fruit drop (32.2%) and also having least seed count (19). However, above treatment also found to be at par with 2,4-D @ 20 ppm. The fruit physical parameters in terms of fruit size and weight was found to be maximum under spray of 2,4-D @ 20 ppm and was also closely followed by 2,4-D @10 ppm with fruit size of (10.90 cm x 6.86 cm) and weight of 152.93 g. Whereas fruit biochemical parameters were enhanced significantly with the pre harvest application of SA @ 10 ppm with TSS of 12.3 ºBrix, total sugars of 9.49%, reducing sugars of 4.40% and ascorbic acid of 25.07mg/100g. Hence, it has been suggested that 2,4-D @ 10 ppm proved to be beneficial for increasing fruit yield and fruit retention by checking fruit drop, while SA@ 10 ppm for enhancing fruit quality.

Keywords: Kinnow orchard, 2,4-D, Salicylic acid, Quality, Yield

Introduction
Citrus is subtropical group of evergreen fruits which belongs to family Rutaceae, order Geraniales and sub family Aurantiodae with the chromosome number 2n=18. It has a unique character of having juice sacs instead of pulp and its fruit type is referred to as hesperidium. Citrus is grown in more than 90 countries indicating its adaptability to the varied agro-climactic conditions. It grows successfully in all frost free, tropical and sub-tropical regions of the country. Various species of citrus fruits are widely cultivated in India and among those mandarin, sweet oranges, lemon and lime fruits are commonly grown. Kinnow is one of the important citrus fruit known not only for its beautiful appearance and pleasant flavour but also for its high nutritive value, good yield, fresh consumption, high processing quality and better adaption to agro-environmental conditions (Ahmed *et al.* 2006) [2]. It is a hybrid of 'King' (*Citrus nobilis* Lour) and 'Willow leaf' (*Citrus deliciosa* Tenora) developed at California (USA) by H.B. Frost in 1935 (Rashid *et al.* 2005) [2]. It was introduced by Dr. J.C. Bakhshi at Abohar research station during 1954. Despite so many good qualities of Kinnow, it is, however, be set with the problem of high seed number, alternate bearing and excessive fruit drop. Fruit dropping is one of the main reasons of low fruit yield which is thought to be mainly due to malnutrition, water stress, excessive insect pest attack and most importantly hormonal imbalance. The initial dropping is due to the abscission of weak fruit lets, which appear after anthesis and that abscission layer might be formed due to imbalance of auxins, cytokinins and gibberellins (Lahey *et al.* 2004) [16]. Although fruit drop occurs in different waves but pre-harvest drop is of main concern as it results in direct economic loss to the farmers as fruits are approaching maturity at that time. Fruit drop occurs when the concentration of auxin decreases and the concentration of abscissic acid (ABA) increases. Hence endogenous hormones and their balance play a significant role in mobilization of nutrients to the developing organs.
Inspite of sufficient literature available on the causes and control of fruit drop in kinnow, the problem still remains to be unsolved.

Year to year variations in the extent of drop has been reported in different blocks in an orchard or trees in the same block. This shows that problem is universal in nature and location specific. Although various plant growth regulators have been reported to be effective in controlling fruit drop in citrus but 2,4-D (2,4- Dichlorophenoxyacetic acid) has been found to be more effective in controlling the drop (Khalid *et al.* 2016 and Mollapur *et al.* 2016) [12, 19]. This study was, therefore, conducted to determine the effect of foliar application on preharvest fruit drop and yield of Kinnow mandarin.

Material and Methods

The research work was conducted in a well maintained Kinnow orchard at Department of Horticulture, Khalsa College Amritsar during 2018-2019. Laboratory work was carried out in Postgraduate Laboratory, Department of Horticulture, Khalsa College Amritsar. Eight years old, 30 plants of Kinnow mandarin (*Citrus reticulata* Blanco) of uniform size were selected for this experiment. Three growth regulators 2, 4-Dichlorophenoxyacetic acid ((2,4-D) (10, 20, 30 ppm), Naphthalene acetic acid (NAA) (15, 20 and 25 ppm) and Salicylic acid SA (10, 20 and 30 ppm) were applied at three different stages *viz.*, flower initiation stage (March end), fruit setting stage (Mid May) and before harvesting of fruits to check the effect on preharvest fruit drop and physiochemical properties of the fruit. The experiment consisted of 10 treatments including control, replicated thrice and single tree was taken as an experimental unit. All the experimental trees were maintained under similar agro-climatic condition. Number of fruits per plant at spray time and after spray was counted by tagging 4 branches of one inch diameter on each side of the tree. The per cent fruit drop was calculated on the basis of total number of fruits per tree before the start of the experiment.

$$\text{Fruit drop (\%)} = \frac{\text{Total number of fruit set - Total number of fruits at harvest index}}{\text{Total number of fruit set}} \times 100$$

$$\text{Fruit Set (\%)} = \frac{\text{Number of set fruits}}{\text{Total number of flowers}} \times 100$$

Then per cent fruit retention was calculated as:

$$\text{Fruit retention (\%)} = \frac{\text{Number of fruits retained}}{\text{Total number of fruits set}} \times 100$$

Fruit size was measured by measuring the diameter of 10 fruits per tree randomly with the help of Vernier caliper from each experimental tree. Average fruit weight was calculated by weighing ten fruits per tree on digital UWE–ESP Digital Electric Balance and average weight was calculated. Seeds of each randomly selected fruits were extracted apparently and number of seeds was counted manually and average was expressed as mean number of seeds per fruit. Total Soluble Solids were measured by automatic digital refractometer by placing 1-2 drops of juice on the prism of refractometer.Acidity of juice was determined by taking 10 ml of juice from each sample and diluted with distilled water in a 100 ml beaker; 2-3 drops of phenolphthalein were added for end point. The samples were titrated against N/10 NaOH (Hortwitz, 1960). The results were expressed as percent citric acid.

$$\text{Titratable acidity (\%)} = \frac{0.0064 \times 0.1 \text{ N NaOH used (ml)}}{\text{Volume of juice taken (ml)}} \times 100$$

The sugars were determined by the method suggested by AOAC, 2000. Ascorbic acid was estimated by indophenols dye method.

Results and Discussions

Physical characteristics

Fruit set: Fruit set is the critical phase in the transformation of a flower to obtain good yield and to increase a growers returns (Lovatt 1999). It was noted that treatment T_1 (2,4-D 10 ppm) registered maximum fruit set as presented in Table 1. Whereas the minimum fruit set (40.84%) was recorded under control. The increase in fruit set per cent by an exogenous application of 2, 4-D might be due to the increased availability of nutrients from leaves to the entire tree which increases the initial fruit set (Ullah *et al.* 2014) [24]. The present results of the investigation are in line with the earlier findings of Ashraf *et al.* (2013) [4] in Kinnow mandarin.

Fruit drop: Pre-harvest drop of the fruit is of commercial loss to farmers as the fruit which falls just before harvesting is physiologically mature. The perusal of the Table 1 shows that all the growth regulators treatments significantly reduced the preharvest drop compared to control. The data reveal that 2,4-D controlled the rate of pre-harvest fruit drop effectively than all the other treatments. The minimum pre-harvest fruit drop of 32.20 per cent has been recorded in Kinnow plants sprayed with 10 ppm 2,4-D. However the trees under control exhibited maximum fruit drop (62.46%) as compared to rest of the treatments. The fruit drop in citrus may be attributed due to the formation of abscission layer at the stem point (Lal *et al.* 2015) and the exogenous application of 2, 4-D reducing the fruit drop by maintaining the cells at the zone of abscission by preventing the synthesis of hydrolytic enzymes such as cellulase that known for decomposing the cell walls (Modise *et al.* 2009) [18]. Similar results were reported by Modise *et al.* (2009) and Kaur *et al.* (2000) [18, 11] who reported that 2,4-D significantly reduced fruit drop in Navel orange and Kinnow mandarin respectively.

Fruit retention: Maximum fruit retention has been found in the trees treated with 2,4-D 10 ppm (T_1) i.e. 68.57 per cent than rest of the other treatments.The untreated trees (T_{10}) had occupied least percentage of fruit retention i.e. 42.97 per cent Similar results were also observed by the application of 2,4-D in citrus by Modise *et al.* (2009) [18].

Fruit yield per tree: The presented data revealed that the trees sprayed with 2,4-D 10 ppm (T_1) exhibited higher yield i.e. 75.13 Kg per tree. The increase in yield may be due to the fact that partitioning of assimilates more towards the fruit development and better translocation of assimilates (Jain *et al.*

2015) [10]. However, minimum fruit yield (58.18 Kg per tree) was noted in trees under control (T_{10}). Similar results were also observed by the application of 2,4-D treatment in 'Nova' mandarin and Nagpur mandarin.

Fruit size (l x b): The presented data (Table 2) showed that fruit size was significantly improved as compared to control by the use of growth regulators. The data revealed that the fruits harvested from the trees treated with 2,4-D 20 ppm (T2) attained maximum fruit length and breadth i.e. 11.33 cm and 7.11 cm respectively. While the minimum fruit size was observed in the fruits harvested from untreated plants. Fruit size of Kinnow was significantly affected by the use of various growth regulators. The maximum increment in fruit size was observed with the exogenous application of 2,4-D which might be due to the fact that it accelerates the fruit growth by increasing cell enlargement as the auxins are known to effect the permeability of cell wall leading to the uptake of water and expansion of cells resulting in cell elongation finally. The presented results were also in agreement with that of Nirmaljeet *et al.* (2000) [22] in Kinnow mandarin.

Fruit weight: The results of the fruit weight are presented in table 2 revealed that maximum weight (167.23 g) was exhibited by the fruits harvested from the trees sprayed with 2,4-D @ 20 ppm. The minimum fruit weight i.e 88.03 was observed under NAA@ 20 ppm. The increment in fruit weight is possible due to the fact that the developing fruit is an important metabolic sink into which nutrients and organic substances from leaves and other parts get accumulated thereby resulted in increased fruit weight (Devi *et al.* 2018) [8]. These results are in line with the findings of Jain *et al.* (2014) [9] in sweet orange and Nagpur mandarin respectively.

Seed count: From the data presented in the Table 2, it has been cleared that the fruits harvested from the trees treated with treatment T1 (2,4-D 20 ppm) had least seed count (19), which was found to be statistically at par with SA @ 20 ppm, NAA @ 25 ppm and 2,4-D @ 20 ppm. The presence of lesser seeds might be due to the effect of growth regulators which stimulated parthenocarpic fruit development. Similar results have been found by Agnihotri *et al.* (2013) [1] in guava fruit.

Bio-chemical characteristics

Total Soluble Solids: Total soluble solids measurement is considered to be an important parameter of quality of citrus fruits. From this study it has been found that the fruits harvested from the trees sprayed with SA @ 10 ppm had maximum TSS i.e. 12.3 ºBrix which was also found to be statistically at par with SA @ 20 ppm), SA @ 30 ppm. This may pertain to the effect that application of growth regulators resulted in accumulation of sugars and change in metabolism which eventually resulted in more retention of TSS in fruits (Kumar *et al.* 2011 and 2012) [15, 14]. The results of present study are in accordance with previous findings of Ashraf *et al.* (2012) in Kinnow mandarin.

Titratable acidity: From the précised analysis of given data, the non-significant effect of various chemicals has been noticed on acidic content of Kinnow fruits. However, minimum titratable acidity (0.84%) was recorded in the fruits obtained from trees treated with SA@ 10 ppm and maximum titratable acidity i.e 0.96 per cent was recorded under control.

TSS: acid ratio: The given data revealed that the TSS: acid ratio of Kinnow fruits has increased significantly with the use of salicylic acid as compared to other chemicals. The highest TSS: acid ratio (14.64) was found in fruits harvested from trees treated with SA @ 10 ppm. This increment in TSS: acid ratio might be due to the fact that the application of salicylic acid possibly increase the activity of the hydrolyzing enzyme which results in increased breakdown of polysaccharides into simple sugars that results in increasing the TSS which lead to rise in TSS: acid ratio. The results obtained from the present study also get support from the findings of Nejad *et al.* (2015) [21] in Kinnow.

Reducing sugars: From the evaluation of data presented in Table 3, it was cleared that the growth regulators exert a significant influence on the sugar content of Kinnow mandarin. SA improves the sugar content in fruits significantly as compared to the other treatments. The fruits yielded from the trees treated with SA @ 10 ppm had maximum reducing and non-reducing sugar content i.e. 4.40% and 9.49% respectively. Whereas minimum sugar were recorded under control and was statistically inferior to all the other treatments. The reason for increase in sugar content of Kinnow fruits with the exogenous application of SA may be due to the hydrolysis of starch into sugars whereas decline in sugars may be attributed to the fact that after the completion of hydrolysis of starch, no further increase in sugar content occur and subsequently a decline in sugars is predictable as they along with other organic acids are primary substrates for respiration (Wills *et al.* 1980) [25].

Ascorbic acid: The data revealed that the ascorbic acid of Kinnow fruits did not significantly affected by the pre-harvest application of various chemicals. However, maximum ascorbic acid (25.07 mg/100 g) content was noticed in fruits harvested from Kinnow trees sprayed with SA@ 10 ppm. This increase in ascorbic acid of Kinnow fruits might be due to the fact that the salicylic acid activates ascorbate peroxidase, which increases antioxidant ability that prevents the vitamin C destruction in the fruits (Dat *et al.* 1998) [7]. Whereas the minimum ascorbic acid (20.96 mg/100 g) was recorded in the fruits harvested from untreated trees. The present results are supported by the previous findings of Khan *et al.* (2012) [13] on various citrus fruits.

Table 1: Influence of pre-harvest spray of various chemicals on fruit yield parameters of Kinnow mandarin.

Treatments	Fruit set (%)	Fruit drop (%)	Fruit retention (%)	Fruit yield (Kg/tree)
T_1 – 2,4-D 10ppm	81.97	32.20	68.57	75.13
T_2 – 2,4-D 20 ppm	76.56	35.93	62.12	73.28
T_3 – 2,4-D 30ppm	62.08	41.75	56.12	70.73
T_4 – NAA 15 ppm	55.92	49.17	48.20	64.44
T_5 – NAA 20 ppm	49.42	54.74	45.32	60.81

T_6 – NAA 25 ppm	51.98	52.36	46.46	62.16
T_7 – SA 10 ppm	57.58	43.42	53.80	68.69
T_8 – SA 20 ppm	64.40	40.54	58.95	71.71
T_9 – SA 30 ppm	54.47	44.00	52.02	65.78
T_{10} – Control	40.84	62.46	42.97	58.18
CD (p=0.05)	7.82	5.39	4.35	5.66

Table 2: Influence of pre-harvest spray of various chemicals on fruit physical parameters of Kinnow mandarin

Treatments	Fruit size		Fruit weight (g)	Seed count
	Fruit length(cm)	Fruit breadth (cm)		
T_1 – 2,4-D 10 ppm	10.90	6.86	152.93	19.00
T_2 – 2,4-D 20 ppm	11.33	7.11	167.23	22.33
T_3 – 2,4-D 30ppm	10.06	6.42	126.67	24.00
T_4 – NAA 15 ppm	11.30	7.09	158.03	25.33
T_5 – NAA 20 ppm	9.77	6.34	88.03	24.00
T_6 – NAA 25 ppm	10.13	6.49	97.83	23.67
T_7 – SA 10 ppm	10.33	6.68	105.63	26.00
T_8 – SA 20 ppm	10.73	6.78	149.67	22.67
T_9 – SA 30 ppm	10.37	6.75	138.87	25.67
T_{10} – Control	9.73	6.03	118.87	28.33
CD (p=0.05)	0.76	0.59	15.24	4.78

Table 3: Influence of pre harvest spray of various chemicals on bio-chemical parameters of Kinnow mandarin

Treatments	TSS	Titratable acidity	TSS: Acid ratio	Reducing sugar (%)	Total sugars (%)	Ascorbic acid content (mg/100 g of juice content)
T_1 – 2,4-D 10ppm	11.20	0.89	12.49	4.11	8.66	21.83
T_2 – 2,4-D 20 ppm	10.93	0.94	11.59	3.83	7.14	22.94
T_3 – 2,4-D 30ppm	11.10	0.92	12.01	3.97	7.95	24.16
T_4 – NAA 15 ppm	11.37	0.93	12.21	3.85	7.51	24.38
T_5 – NAA 20 ppm	11.77	0.92	12.83	3.85	7.62	23.89
T_6 – NAA 25 ppm	11.73	0.90	12.99	4.01	8.13	22.90
T_7 – SA 10 ppm	12.3	0.84	14.64	4.40	9.49	25.07
T_8 – SA 20 ppm	12.20	0.86	14.24	4.23	9.08	24.91
T_9 – SA 30 ppm	12.00	0.85	14.29	4.09	8.72	24.09
T_{10} – Control	10.23	0.96	10.84	3.38	7.03	20.96
CD (p=0.05)	0.57	NS	0.63	0.09	0.49	NS

Conclusion

It is concluded from the present study that 2,4-D 10 ppm significantly checked the fruit drop (32.20%) and resulted in maximum fruit yield (75.13 kg/tree) with maximum fruit retention (68.57%) in Kinnow mandarin. Fruit physical parameters in terms of size (lxb) and weight was also improved with the pre-harvest application of 2,4-D 20 ppm (T2) and was also closely followed by treatment T1 (2,4-D 10 ppm). Whereas the biochemical parameters of Kinnow fruits were statistically improved by the use of SA 10 ppm (T7). Hence, it has been suggested that 2,4-D 10 ppm can be used for controlling fruit drop as well as to improve the yield attributes while SA 10 ppm for improving the quality of Kinnow fruits.

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