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ORIGINAL ARTICLE

PGR FOR CONTROLLING PRE-HARVEST FRUIT DROP AND IMPROVING QUALITY OF KINNOW

Rajesh Sihag, Manish Bakshi* and Narendra Singh Bhandari

Domain of Horticulture, Lovely Professional University, Phagwara-Jalandhar G.T. Road, Phagwara - 144 411, India.
E-mail: manish.22187@lpu.co.in

Abstract : A field trial was conducted to evaluate the effect of PGR (2, 4-D, NAA and GA_3) at different concentrations on fruit drop and enhancement in fruit quality of Kinnow. Three sprays of PGR *viz.* 2, 4-D, NAA and GA_3 were given to the Kinnow plants as per the treatment concentrations from initiation of flowering to before harvesting. The results revealed that among all the PGR's tried at different concentrations, spray of 2, 4-D @ 30 ppm was the most promising in reducing the fruit drop in Kinnow as fruit physical and chemical characters were found to be superior as compared to all other treatments. There was an enhancement in the fruit size with the application of 2, 4-D @ 30 ppm, which led to an overall increase in the yield of Kinnow.

Key words : Kinnow, PGR, Fruit drop, Quality, Yield.

1. Introduction

Citrus is grown throughout the world in tropical and sub-tropical climate and is the second most important fruit crop after grape in area and production in the world. Among all citrus fruit species, Kinnow (*Citrus nobilis* x *Citrus deliciosa*) is most important citrus fruit crop grown in India over an area of about 3.30 lakh hectares with a production of 34.31 lakh tonnes annually and occupy 4.6% and 3.9% of total area and production under fruit crop. In India, the area under Kinnow cultivation in Punjab is 47 thousand hectares with production of 10.81 lakh tonnes and the productivity of 21.6 tonnes per hectares [Anonymous (2015)]. In Punjab, Kinnow is mostly grown in areas of Abohar, Fazilka, Ferozpur, Muktsar and Bathinda.

Kinnow is a fair source of vitamin C and its daily consumption protects against scurvy disease, pulp is used to make jam, squash, juice, sauce, syrup and its outer skin can be used to make cosmetics and essence. It is the main source of peel oil and citric acid which has international market value. It is rich in fiber [Sharma *et al*. (2007), Altaf (2006)]. Kinnow mandarin though bears 40,000-80,000 flowers but only few hundred (400-1200) reach maturity due to excess flower and fruit drop at various stages of fruit development. This continued drop at various stages of fruit development results in considerable reduction in yield and leads to low profit to citrus growers [Kumar *et al.* (2018)]. Therefore, this problem attracted the attention of large number of researchers to find some positive control measures on fruit drops, quality and quantity through the use of plants growth regulators (PGRs) and other chemicals. The lack of knowledge on the pivotal physiological mechanisms underlying fruit growth and development raises obstacles to generation of proper strategies required for economical production of citrus fruits. Therefore, keeping in view the above facts, a study was undertaken on standardizing concentrations of plant growth regulators for controlling fruits drop and improving quality and yield of Kinnow.

2. Materials and Methods

Research trial was laid at V.P.O. Panjkosi, Tehsil Abohar, District Fazilka, Punjab located between 30.17° N latitude and 74.06° E longitude at an elevation of 184 m during the year 2017-18. Local Kinnow trees grafted on mandarin rootstocks of uniform health and vigour were selected for the purpose of the study. A total of seven treatments were used *viz.* T_1 (Control), T_2 (2,4-D @ 20ppm), T_3 (2,4-D@30 ppm), T_4 (NAA @ 10 ppm), T_5 (NAA @ 20 ppm), T_6 (GA-$_3$ @ 50

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ppm) & T_7 (GA_3 @ 100 ppm). The treatments were replicated thrice with one plant per treatment and the experiment was laid out in randomized block design. The spray schedule followed is as under:

S. No	PGR's	Time of application		
		1st Spray	2nd Spray	3rd Spray
1.	2-4-D	(2nd week) April	(1stweek) September	(1stweek) November
2.	NAA	(2nd week) April	(1stweek) September	(1stweek) November
3.	GA3	(2nd week) April	(1stweek) September	(1stweek) November

The required amount of each PGR for each treatment was weighed on an electronic balance. The quantity of PGRs as per the treatment concentration was made by dissolving in 70% ethanol and then making up the volume. Observations on fruit set and fruit drop were recorded during blossoming period of the plant. Yield was calculated based on number of fruits per plant and mean fruit weight for each treatment. Cumulative yield per hectare was worked out by multiplying average fruit yield per plant and number of plants per hectare (6 × 6 m spacing-row to row and plant to plant). Fruit length and fruit width was estimated by drawing a random sample of 10 healthy fruits from each treatment using Digital Vernier's Caliper and mean value was expressed in centimeters (cm). Fruit weight, peel weight and pulp weight was recorded using digital electronic balance and expressed in grams. Fruit volume by estimated using water displacement method and expressed in millilitre (ml). TSS of Kinnow was estimated using hand refractometer. Ascorbic acid was estimated as per the method described by Ruck (1969). Titratable acidity, total sugars (reducing and non-reducing) was estimated as per the method described by A.O.A.C. (1995). The data generated during the course of study was subjected to analysis of variance (ANOVA) and statistically analyzed using OPSTAT software [Sheoran *et al.*, (1998)].

3. Results and Discussion

Flowering characteristics

The phonological data of Kinnow under the experiment on effect of different PGR's showed statistically significant results among all the treatments and are summarized in Table 1. It was observed that minimum fruit drop (18.73%) was recorded in the treatment comprising foliar application of 2, 4-D @ 30 ppm whereas maximum fruit drop percentage was recorded under control (35.50%). Application of growth regulators to Kinnow plants with 2, 4-D @ 20 ppm recorded the second lowest fruit drop percentage (22.57). Maximum fruit retention (80.90%) was obtained in T_3 treatment (2, 4-D @ 30 ppm), which was followed by (80.37%) recorded with 2, 4-D @ 20ppm in (T_2) and (70.50%) 10 ppm NAA (T_4) treatments, respectively. However, the minimum fruit retention (66.17%) was observed in control. The cell of the abscission layer secretes hydrolytic enzymes like cellulase and pectinase. These enzymes dissolve the cell wall. The organ detaches at this point and falls. Auxin inhibits the action of these enzymes and prevents abscission. Lavish blooming is the main consideration for organic product drop as indicated by Ashraf *et al*. (2012). Abscission of frail fruitlets is the primary driver of starting dropping, which shows up after anthesis. Because of irregularity of development controllers (auxins, cytokinins and gibberellins), abscission layer is formed at the stem, which brings about organic product drop. The application of 20 ppm 2,4-D treatment was observed by Nawaz *et al*. (2008) as most effective for lowest fruit drop of 12.95% and increased number of fruits/plant and fruit weight/plant in Kinnow mandarin.

Yield parameters

Perusal of the Table 2 showed that maximum number of fruits per plant (839), maximum yield (208 kg per plant) and cumulative yield (57.41 tonnes per hectare) was recorded under treatment T_3. The increase in fruit yield might be due to reduction in fruit drop. The increase in yield of Kinnow mandarin fruits by application of 2, 4-D and GA_3 treatments may be attributed to the fact that partitioning of assimilates by 2, 4-D and GA_3 more towards the fruit development and better translocation of assimilates further leads to improvement in yield contributing characters like size and weight of fruits as evident by the present study which finally increased the yield. Similar beneficial effect of 2, 4-D on number of fruit per tree and fruit retention percent was also recorded by Khalid *et al*. (2012) in Kinnow mandarin.

Fruit physical characters

Data presented in Table 3 corresponds to the effect of PGR on physical attributes of Kinnow fruit. Average weight of Kinnow fruits significantly increased with the application of different plant growth regulators as observed in the experiment. However, among all the

Table 1 : Effect of foliar application of PGR's on fruit set, fruit drop and fruit retention in Kinnow.

Treatments	Fruit set (%)	Fruit drop (%)	Fruit retention (%)
T_1 (Control)	30.59	35.50	66.17
T_2 (2-4-D @20 ppm)	33.53	22.57	80.37
T_3 (2-4-D @ 30ppm)	29.37	18.73	80.90
T_4 (NAA @ 10 ppm)	28.58	30.47	70.50
T_5 (NAA @ 20 ppm)	31.37	30.00	69.70
T_6 (GA_3 @ 50 ppm)	28.62	33.03	66.60
T_7 (GA_3 @ 100 ppm)	30.93	30.47	69.17
S.Em (±)	0.67	0.88	0.94
CD at 5%	2.09	2.75	2.95

Table 2: Effect of foliar application of PGR's on yield characters in Kinnow.

Treatments	No. of fruits/ plant	Fruit yield (Kg/plant)	Cumulative yield (t/ ha)
T_1 (Control)	643	106	29.3
T_2 (2-4-D @20 ppm)	800	153	42.2
T_3 (2-4-D @ 30ppm)	839	208	57.4
T_4 (NAA @ 10 ppm)	719	161	44.3
T_5 (NAA @ 20 ppm)	703	140	38.6
T_6 (GA_3 @ 50 ppm)	654	143	39.4
T_7 (GA_3 @ 100 ppm)	702	173	47.6
S.Em (±)	0.77	1.02	0.89
CD at 5%	2.39	3.17	2.76

treatments, maximum average weight of fruit (245.37 g), fruit volume (244.83ml) and specific gravity (1.0) was recorded under treatment T_3 (2, 4-D @ 30 ppm. Maximum fruit length (6.34 cm) was recorded with the spray of T_3 treatment (2, 4-D@ 30 ppm), fruit breadth (7.0 cm) and pulp weight (185.94 g) of Kinnow fruit was observed with 30 ppm 2, 4-D (T_3) treatment. Minimum peel weight (55.44g) of fruit was recorded with the spray of 50ppm GA_3 (T_6) treatment. The increase in physical parameters with the application of plant growth regulators may be due to optimum supply of growth hormones in right amount during the entire crop growth period causing vigorous vegetative development of the plants and ultimately production of more photosynthates [Modise *et al.* (2009)]. The other possible reason for enhancement of fruit size with 2,4-D, NAA and GA_3 might be due to their involvement in hormonal metabolism, increased cell division, elongation and expansion of cell [Amiri *et al.* (2012)]. The minimum number of seeds per fruit (7.67) was observed in T_7 (GA_3 @ 100 ppm), followed by T_6 (11.33). However, the maximum number of seeds per fruit (23.67) was recorded 2, 4-D @ 20ppm (T_2). The reduction in the number of seeds/fruit may be due to the stimulatory effect of GA_3 on parthenocarpic fruit development. The present results are in consonance with the indings of Saleem *et al.* (2008) in 'Blood Red' sweet orange and Zhang (2003) in mandarin.

Chemical characteristics

Fruit chemical characters were affected significantly under spray of PGRs at different concentrations (Table 4). Maximum value of TSS (11.90 ºbrix), minimum titratable acidity (0.83 %) and maximum TSS/Acid Ratio (14.18) was recorded under 2, 4-D @ 30ppm (T_3). Beneficial effect of 2, 4-D may be due to its influence on physiological process, particularly respiration and photosynthesis, which possibly led to accumulation of dry matter, minerals and carbohydrates. Similar beneficial effect on TSS was also recorded by Ashraf *et al.* (2012) in Kinnow and Kumar *et al.* (2012) in strawberry. Maximum ascorbic acid (36.41mg/100g juice) content, total sugars (9.51%) and non-reducing sugar (5.74%) was recorded with 2, 4-D @ 30 ppm(T_3) while, the lowest ascorbic acid (30.12 mg/10gm juice) was recorded in control (T_1). Highest reducing sugar (3.89%) was observed in 50 ppm GA_3 (T_6) treatment. The maximum organoleptic rating due to application of 2, 4-D treatment might be due to better sugar acid ratio and overall enhancement of fruit quality. Increase in reducing sugar was more in GA_3 treated fruits as compared to control. This might be due to GA_3 induced synthesis of invertase enzyme. Invertase enzyme is responsible for breakdowm of sucrose into fructose and glucose [Jain *et al.* (2014)]. Ashraf *et al.* (2012) also reported that foliar applications of 2, 4-D treatment improved the fruit weight, number of fruits per plant, juice percentage, total soluble solids (TSS), ascorbic acid content, acidity and TSS/acid ratio in Kinnow. Similar finding was also reported by Singh *et al.* (2017) in guava. Maximum juice content (50.53%) was observed with 30ppm 2, 4-D (T_3) treatment which was closely followed (48.35 %) by T_7 (48.35%), T_6 (46.03%), T_2 (45.14 %) and T_5 (44.22 %) treatments. However, the minimum juice content was observed under control (43.57%). Khalid *et al.* (2012) also reported significant increase in juice content of Kinnow mandarin with the application of GA_3 at different concentrations.

Table 3 : Effect of foliar application of PGR's on fruit physical characters of Kinnow.

Treatments	Fruit weight(g)	Fruit volume (ml)	Specific gravity	Fruit length (cm)	Fruit width(cm)	Pulp weight (g)	Peel weight (g)	Number of seeds
T_1	170.69	182.33	0.9	5.35	6.10	116.91	53.78	19.33
T_2	231.67	243.00	0.9	5.80	6.88	171.30	60.36	23.67
T_3	245.37	244.83	1.0	6.34	7.00	185.94	59.43	22.67
T_4	202.23	203.00	1.0	5.41	6.18	139.25	62.89	22.00
T_5	247.33	247.33	1.0	5.50	6.42	183.12	63.75	18.00
T_6	223.67	223.33	1.0	5.64	6.57	168.22	55.44	11.33
T_7	200.57	219.00	0.9	5.78	6.62	139.33	59.92	7.67
S.Em (±)	0.99	1.13	0.01	0.08	0.01	0.68	0.48	0.86
CD at 5%	3.08	3.53	0.05	0.27	0.04	2.12	1.51	2.69

Table 4 : Effect of foliar application of PGR's on fruit chemical characteristics of Kinnow.

Treatments	TSS (°Brix)	Acidity (%)	TSS: acid ratio	Ascorbic acid (mg per 100 ml juice)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Juice content (%)
T_1	11.10	1.12	9.90	30.12	8.91	3.47	5.44	43.57
T_2	11.33	0.87	13.05	34.01	9.10	3.63	5.47	45.14
T_3	11.77	0.83	14.18	36.41	9.51	3.77	5.74	50.53
T_4	11.33	1.01	11.25	31.29	9.30	3.72	5.58	43.67
T_5	11.10	0.95	11.67	31.96	9.38	3.78	5.60	44.22
T_6	11.70	0.95	12.35	35.03	9.10	3.89	5.21	46.03
T_7	11.90	0.89	13.37	35.84	9.12	3.85	5.27	48.35
S.Em (±)	0.06	0.01	0.19	0.34	0.01	0.01	0.007	0.23
CD at 5%	0.21	0.03	0.62	1.07	0.04	0.04	0.02	0.72

The present study holds promise and from the results obtained, it was concluded that application of 2, 4-D @ 30 ppm can not only reduce the fruit drop, three foliar sprays of 2, 4-D starting from flower initiation till harvesting can be useful in reducing fruit drop, improving fruit set and fruit retention besides reaping a good fruit yield with improved fruit quality.

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