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Impact of growth regulators on fruit drop and yield parameters of sweet orange (*Citrus sinensis* Osbeck) cv. Jaffa

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Abstract
The present investigation was carried out at Research Orchard of Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar, during the year 2015-16 to study the effect of growth regulators on fruit drop, yield and quality of sweet orange (*Citrus sinensis* Osbeck.) cv. Jaffa. The Hormones such as GA3, 2,4-D and NAA in different concentrations was sprayed twice, i.e., in last week of March and first week of July. The results revealed that maximum reduction of fruit drop from May to harvesting and percent fruit retention was recorded with the treatment NAA 20 ppm. The fruit yield parameters, i.e., number of fruits per plant and fruit yield per plant, were obtained highest with NAA 20 ppm, while the other parameters like fruit weight and fruit size, length were recorded highest with foliar application of GA3 30 ppm. Where all hormonal treatments shown significantly better performance than control respectively.

Keywords: NAA, GA3, 2,4-D, Fruit size, Yield

Introduction
Sweet orange is the second largest citrus fruit cultivated in the country. It is more convenient to grow under dry arid conditions coupled with distinct winter and summer season with low rainfall. Many varieties of sweet orange have been introduced in India, while only few are prolific bearer having good quality. Currently, exotic cultivars like Jaffa, Blood Red and Pineapple are performing well in Punjab, Haryana and Rajasthan. Among exotic cultivars, Jaffa is an important commercial cultivar of sweet orange. It is one of the mid-season cultivars of sweet orange with wider adaptability.

Fruit drop in citrus crops is a serious problem and a limiting factor for obtaining increased fruit yield. In citrus, there is heavy flowering, and initially, fruit set is high but continuous dropping of fruits at various stages of fruit growth results in considerable reduction in total yield. It is estimated that the fruit drop in citrus cultivars commencing from August continues up to the end of December. Citrus trees produce a very large number of flowers; 30-150 times more than they can bear the fruits. Due to heavy production of flowers, a high post setting drop of fruit lets is occurred and growers are not much concern about this drop. The fruit dropping, which is continued from marble stage of fruit development to till harvest, need to be controlled or minimized for getting profitable income. There are several growth regulators which have been tried to check this malady Antoniolli *et al.,* 2003 [1], Babu *et al.,* 2001 [2] at different situation on different cultivars of sweet orange.

Plant growth regulators (PGR's) are known to have a great influence on fruit drop and fruit retention in fruit trees. An imbalance of auxins, cytokinins and gibberellins for example may lead to the formation of abscission layer at the stem point and eventually fruit drop (Chen *et al*., 2006) [3].

Out of various growth regulators, foliar application of synthetic auxin 2,4-dichlorophenoxy acetic acid checks fruit drop (Kaur *et al*., 2007) [9]. Although few reports on the effect of 2,4-D on fruit drop, yield and quality of sweet orange are there in the literature but the effect of growth regulators on fruit drop, yield and quality of sweet orange has not ye.

Materials and Methods
The present investigation was conducted at experimental orchard of Department of Horticulture, CCS Haryana Agricultural University, Hisar during the year 2014-15. Treatment imposed as a GA_3 10 ppm (T1), GA_3 20 ppm (T2), GA_3 30 ppm (T3), 2,4-D 5ppm (T4), 2,4-D 10 ppm (T5), 2,4-D 15 ppm (T6), NAA 20 ppm (T7), NAA 30 ppm (T8), NAA 40 ppm (T9), (control) (T10) i.e. water spray. There were two spray schedules i.e. last week of march and

first week of July). The experiment comprising of 10 treatment combinations was laid out in randomized block design with three replications. Sixteen years old uniformly grown trees spaced at 6 m x 6 m were selected for present study. They were kept under uniform conditions of orchard management during the study period where all the agronomic practices were carried out as per package of practices.

Results and Discussion

Fruit drop

Hormonal spray at different concentrations of GA_3, 2,4-D and NAA affected the fruit drop significantly during May to October. The minimum fruit drop was recorded with foliar application of NAA 20 ppm from May to October (3.33, 2.67, 2.00, 1.00, 1.00 and 0.67 fruits/tree, respectively, data presented in Table 1), which was closely followed by the treatment 2,4-D 10 ppm, whereas, the maximum fruit drop was recorded with control treatment from May to October (5.33, 5.00, 4.00, 4.00, 4.00 and 4.00 fruits/tree, respectively), closely followed by GA_3 20 ppm and GA_3 30 ppm.

Table 1: Effect of growth regulators on number of fruit drop per tree during the month of May to October in sweet orange cv. Jaffa

Treatments	Fruit drop					
	May	June	July	August	Sept.	Oct.
T_1: GA_3- 10 ppm	4.67	4.00	3.67	2.67	2.67	2.67
T_2: GA_3- 20 ppm	5.00	4.33	3.67	3.33	3.33	3.00
T_3: GA_3- 30 ppm	5.00	4.63	4.33	3.33	3.33	3.00
T_4: 2,4-D- 5ppm	4.33	3.33	3.00	2.33	2.00	2.00
T_5: 2,4-D- 10 ppm	3.67	2.67	2.33	1.33	1.00	1.00
T_6: 2,4-D- 15 ppm	4.67	3.67	3.33	3.00	3.00	2.33
T_7: NAA- 20 ppm	3.33	2.67	2.00	1.00	1.00	0.67
T_8: NAA- 30 ppm	4.33	3.67	3.00	2.67	2.33	2.00
T_9: NAA- 40 ppm	4.67	4.00	3.33	2.67	2.67	2.33
T_{10}: Control- water spray	5.33	5.00	4.00	4.00	4.00	4.00
C.D. at 5%	0.96	1.02	0.92	0.79	0.64	0.64

The decrease in fruit drop in this study with the application of growth regulator might be attributed to the fact that making up the deficiency of endogenous auxin prevented the formation of abscission layer possibly through the inhibition of enzymatic activity caused by pectinase and polygalactouronase enzyme. (Dhaliwal *et al.*, 2009 [4], Gurjar *et al.*, 2014 [6], Sharmal *et al.*, 2013) [13].

Yield Parameters

The data presented in Table 2 shown that the number of fruits per tree was significantly influenced by different concentrations of GA_3, 2,4-D and NAA. The highest number of fruits per tree (246.67), maximum fruit yield (44.32 kg/plant) and maximum fruit retention (86.22%) was recorded from the plant sprayed with NAA 20 ppm while the minimum number of fruits per plant was recorded under control treatment respectively. while the other parameters of fruit like fruit weight (180.00 g), fruit length (6.67 cm), and fruit breadth (6.97 cm), were obtained highest with foliar application of GA3 30 ppm than other treatments.

Table 2: Effect of growth regulators on number of fruits per tree and fruit weight (g) in sweet orange cv. Jaffa

Treatments	Number of fruits per tree	Fruit weight (g)	Fruit yield (kg/plant)	Fruit length (cm)	Fruit breadth (cm)	Percent fruit retention
T_1: GA_3- 10 ppm	186.67	178.00	33.23	6.33	6.73	80.36
T_2: GA_3- 20 ppm	172.67	179.33	30.97	6.43	6.77	77.04
T_3: GA_3- 30 ppm	165.33	180.00	29.76	6.67	6.97	74.63
T_4: 2,4-D- 5ppm	235.33	170.67	40.16	6.23	6.67	83.54
T_5: 2,4-D- 10 ppm	243.33	173.33	41.71	6.20	6.63	83.78
T_6: 2,4-D- 15 ppm	202.67	169.33	34.32	6.00	6.43	82.16
T_7: NAA- 20 ppm	246.67	179.67	44.32	5.83	6.37	86.22
T_8: NAA- 30 ppm	227.67	178.67	40.68	6.10	6.57	82.85
T_9: NAA- 40 ppm	168.67	174.67	26.46	6.27	6.70	76.35
T_{10}: Control- water spray	163.00	163.33	26.63	5.67	6.27	70.38
C.D. at 5%	2.86	4.09	2.67	0.26	0.26	2.51

The maximum number of fruits per plant with NAA 20 ppm might be attributed to less dropping of flowers and fruits, as the application of growth regulators made up the deficiency of endogenous auxin, which prevented formation of abscission layer possibly through the inhibition of enzymatic activity at higher temperature. The results of present investigation are in conformation with the findings of (Greenberg *et al*., 2006) [5]. who observed that 2,4-D 40 mg/l, NAA 300 mg/l and 3,5,6-TPA 15 mg/l accumulate 150 fruits per plant, respectively. (Nawaz *et al*., 2008) [10]. who reported that the number of fruits per plant increased significantly with the application of 2,4-D, GA_3 and NAA during last week of November in Kinnow mandarin, (Hussain *et al.* 2011) [8]. Who observed the highest number of fruits per plant in treatment 5 mg/l GA_3 (682.33) followed by 10 mg/l 2,4-D and 5 mg/l NAA with 659.66 and 647.66 fruits per plant, respectively and (Saleem *et al.*, 2013 [13], Patel *et al.* 2013) [11]. who observed that the highest number of fruits per tree was recorded with treatment NAA 200 mg/l (1020.33). (Tiwanja *et al.*, 2007, Thind *et al.*, 2008) [15, 14] also concluded same results in their investigation.

Conclusion

Based on the above experiments findings, we concluded that NAA had positive effect on fruit drop control, while GA_3 and 2,4-D had significant impact on yield parameters. Over all hormones proved that the maximum percent fruit retention

and fruit yield per plant, fruit weight and other parameters respectively.

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