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Effect of spraying NAA and Sitofex on fruiting of Washington Navel orange trees grown under Assiut conditions, Egypt

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Abstract

This study was run out through 2021 and 2022 seasons in a private orchard at Dashlout, Assiut governorate, Egypt to assess the effects of NAA and CPPU on yield and fruit quality of Washington Navel orange trees. The applications were single or together of NAA at 5 to 10 ppm and CPPU at 50 to 100 ppm. NAA and CPPU were sprayed three times, at growth start (first week of March), after fruit setting (first week of May) and at two months later (first week of July). The experiments were arranged in randomized complete block design with three replicates, one tree each. Results showed that, the applications of NAA and CPPU was effective in enhancing yield as well as physical and chemical characteristics of the fruits over control treatment. Using NAA was superior to using CPPU in this respect. Spraying NAA and CPPU together was preferable than using each alone in this connection. Treating Washington Navel orange trees grown under Assiut conditions three times at growth start, just after fruit setting and at two months later with NAA at 10 ppm and CPPU at 100 ppm was responsible for promoting yield and fruit quality.

Keywords: NAA, CPPU, Washington Navel orange, yield, fruit quality.

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1. Introduction

Citrus is the first fruit crops in Egypt, Washington Navel orange cultivar has a great importance either for the local market or exported needs. Economically it ranks the top among orange cvs. since it for its delicious taste, besides being rich in vitamin C, organic acid and minerals (Economas and Clay, 1999). There has been an increasing use of plant growth regulators to improve the productivity of citrus crops. Most studies showed the important role of growth regulators with beneficial effects on tree fruiting (Coggins, 1993). Naphthalene acetic acid (NAA) is the most effective auxin for reducing fruit drop. Many studies declared that sprayed fruit crops at pre or post bloom with (NAA) at different concentrations to decrease fruit drop, increase fruit set, fruit retention, and improve fruit quality and yields as well as vegetative growth (Abd El-Rahman, 2005; Arif-Khan *et al.*, 1993; Gofur *et al.*, 1998; Notodimedjo, 1999; Ragab, 2002; Singh, *et al.*, 1994). Spraying GA_3, CPPU, NAA and ABA increased the growth, yield and improved the fruit quality. In addition, they can be easily used instead of laborious postharvest treatment to extend or increase the storability life trees (Abd El-Raheem *et al.*, 2013; Al-Obeed, 2010; El-Kosary, 2009; Khodair, 2015). CPPU has a common active site with purine cytokinins such as ziatin. These results suggests that CPPU reacts using mechanisms similar to those used by true cytokinins, even though CPPU compounds seem to have few structural features in common with true cytokinins compounds. It plays a role in cell division and cell wall elongation, also, it is acytokinin like substance which has storing cytokinine activity by inducing fruit growth at low rates (Kurosaki *et al.*, 1981; Nickell, 1985; Ogata *et al*., 1988). Using CPPU is beneficial in reducing fruit drop and increasing productivity as well as improving fruit size, fruit firmness, delaying maturation, yield and fruit quality (Nickell, 1985). The target of this study was examining the effect of NAA and CPPU on yield and fruit quality of Washington Navel orange trees grown under Assiut climatic conditions, Egypt.

2. Materials and methods

2.1 Experimental site and treatments description

This study was carried out during 2020 and 2021 seasons on twenty- seven uniform and similar in vigour 10- years old Washington navel orange trees onto sour orange rootstock. The selected trees are grown in a private citrus orchard located at Dashlout district, Assiut governorate, Egypt. Meteorological data in Assiut region during 2020 and 2021 seasons are presented in Table (1). The trees are planted at 4.0 × 4.0 meters apart. The texture of the soil is sandy with a water table not less than two meters deep. Drip irrigation system was

carried out using well water. The selected trees subjected to the normal horticultural practices that already applied in the citrus orchards.

Table (1): Temperatures and relative humidity for Assiut governorate, Egypt during 2020 and 2021 seasons.

Year	2020						2021					
Month	Temperature			Humidity			Temperature			Humidity		
	Max	AVG	Min	Max	AVG	Min	Max	AVG	Min	Max	AVG	Min
1	18.13	11.78	6.04	80.64	61.35	41.32	20.93	13.69	6.49	83.26	61.07	38.42
2	20.98	14.23	7.66	78.03	86.85	36.65	21.49	14.32	6.49	81.96	59.28	38.71
3	30.61	18.59	10.88	68.12	46.34	26.93	26.63	18.96	10.32	67.93	45.84	26.22
4	29.78	22.59	15.17	60.43	40.01	24.76	32.02	23.56	14.57	57.96	36.65	19.1
5	34.98	27.48	19.68	54.32	37.11	23.58	37.69	29.82	21.43	48.26	30.55	17.81
6	38.17	30.61	23.04	51.1	34.86	21.46	36.79	29.94	22.82	47.6	30.57	17.9
7	38.21	31.07	24.02	52.64	36.26	22.84	38.87	32.09	25.09	45.32	29.07	17.84
8	38.04	31.17	22.99	56.32	39.41	24.74	39.25	31.81	24.82	47.22	29.54	16.13
9	37.29	30.23	22.41	59.7	42.2	26.23	35.17	28.24	21.89	62.03	40.9	24.26
10	34.03	27.04	20.89	68.52	49.03	31.84	32.35	24.46	16.97	69.38	46.52	24.42
11	24.63	18.83	13.28	72.93	56.26	41.56	28.28	20.56	13.87	74.56	52.87	30.63
12	22.91	15.92	9.86	75.29	55.82	36.06	20	13.79	7.46	78.03	56.49	36.1

Max= Maximum, AVG= Average, Min= Minimum. Source: underground weather web site.

This experiment included the following nine treatments:

T_1: Control.
T_2: Spraying NAA at 5 ppm.
T_3: Spraying NAA at 10 ppm.
T_4: Spraying CPPU at 50 ppm.
T_5: Spraying CPPU at 100 ppm.
T_6: Spraying NAA at 5 ppm + CPPU at 50 ppm.
T_7: Spraying NAA at 5 ppm + CPPU at 100 ppm.
T_8: Spraying NAA at 10 ppm + CPPU at 50 ppm.
T_9: Spraying NAA at 10 ppm + CPPU at 100 ppm.

Each treatment was replicated three times, one tree per each. All NAA and CPPU were sprayed three times at growth start (first week of March), after fruit setting (first week of May) and at two months later (first week of July). Triton B as a wetting agent was added at 0.05 and all the trees were sprayed till run off (20 L/tree). The experiment was arranged in a randomized complete block design (RCBD) with three replication, one tree each, during both seasons. The following parameters were measured.

2.2 Yield components

Ten distributed fruiting shoots around trees were chosen and labeled. The number of flowers per each shoot was count. After fruit set and before harvest, the fruit set and fruit retention for each shoot was calculated as:

$$Fruit\ swet\ or\ fruit\ retention\ \% = \frac{Total\ fruit\ number}{Total\ flower\ number}$$

Yield expressed in weight per tree (kg).

2.3 Fruit quality

Samples of ten fruits were randomly taken from each tree to estimate the fruit quality: Physical characters of the fruits, *i.e*., weight (g.), height and diameter (cm)

of fruit, percentages of fruit pulp and peel thickness (cm). Chemical characteristics of the fruits, *i.e.*, TSS%, total acidity percentage (as g citric acid / 100 ml juice) (A.O.A.C., 2000), total, reducing, and non- reducing sugars percentage (Lane and Eynone, 1965 and A.O.A.C., 2000) and vitamin C (as mg / 100 ml juice (A.O.A.C., 2000). The obtained data were statistical analysis which was done using new L.S.D. at 5% for marking all comparisons among the nine treatment means (Mead *et al.*, 1993).

3. Results

3.1 Yield components

Data presented in Table (2 and 3) showed the effect of NAA and CPPU on percentages of initial fruit setting and fruit retentions as well as yield on Washington Navel orange trees during 2020 and 2021 seasons. It is obvious from the data that the results took similar trend during the two studied seasons. In general view, data showed that single or together spraying of NAA or CPPU significantly increased percentages of initial fruit set and fruit retention and yield/tree compared to the check treatment (water spraying). The promotion on the percentages of initial fruit set and fruit retention and yield/tree was significantly related to the application of NAA and CPPU. Combined application of NAA at 5 to 10 ppm and CPPU at 50 to 100 ppm was significantly preferable than using NAA or CPPU alone in this respect. Using NAA was significantly superior than using CPPU in this respect. The maximum fruit retention (1.90 & 1.91%) and yield (32.3 & 33.3 kg.) were recorded on the trees that sprayed with NAA at 10 ppm and CPPU at 100 ppm. The untreated trees produced the minimum yield (13.2 & 13.5 kg). The percentages of increment on the yield due to spraying NAA at 10 ppm and CPPU at 100 ppm over the check treatment reached 144.7 and 146.7% during 2020 and 2021 seasons, respectively.

Table (2): Effect of spraying NAA and CPPU on yield components of Washington Navel orange trees during 2020 and 2021 seasons.

Treatments	Initial fruit setting (%)		Fruit retention (%)		Yield/ tree (kg)		Fruit weight (g)	
	2020	2021	2020	2021	2020	2021	2020	2021
Control	3.44	3.48	1.60	1.66	13.2	13.5	348.3	355.0
Spraying NAA at 5 ppm	3.80	3.82	1.77	1.79	26.8	26.5	372.3	371.7
Spraying NAA at 10 ppm	3.88	3.91	1.81	1.83	28.3	28.8	385.7	385.0
Spraying CPPU at 50 ppm	3.60	3.63	1.71	1.73	25.0	24.6	365.3	372.7
Spraying CPPU at 100 ppm	3.71	3.73	1.77	1.78	25.9	27.4	370.3	375.0
Spraying NAA at 5 ppm + CPPU at 50 ppm	3.85	3.90	1.80	1.82	27.1	27.9	377.7	382.7
Spraying NAA at 5 ppm + CPPU at 100 ppm	3.92	3.95	1.84	1.85	28.4	28.7	383.3	382.0
Spraying NAA at 10 ppm + CPPU at 50 ppm	4.05	4.11	1.88	1.89	30.4	30.7	402.3	404.0
Spraying NAA at 10 ppm + CPPU at 100 ppm	4.16	4.18	1.90	1.91	32.3	33.3	414.8	422.0
New L.S.D. at 5%	0.06	0.08	0.03	0.04	1.3	1.4	5.4	6.1

Table (3): Effect of spraying NAA and CPPU on some physical characters of Washington Navel oranges during 2020 and 2021 seasons.

Treatments	Fruit height (cm)		Frit diameter (cm)		Pulp (%)		Fruit peel thickness (cm)	
	2020	2021	2020	2021	2020	2021	2020	2021
Control	8.9	8.8	7.0	6.9	61.8	62.3	0.37	0.36
Spraying NAA at 5 ppm	11.0	11.1	7.7	7.9	64.0	64.6	0.33	0.36
Spraying NAA at 10 ppm	11.4	11.5	7.9	8.1	64.8	65.0	0.31	0.30
Spraying CPPU at 50 ppm	10.3	10.5	7.5	7.8	63.2	63.8	0.35	0.34
Spraying CPPU at 100 ppm	10.7	10.8	7.0	7.9	63.8	64.2	0.33	0.32
Spraying NAA at 5 ppm + CPPU at 50 ppm	11.5	11.6	8.0	8.2	65.0	65.8	0.31	0.30
Spraying NAA at 5 ppm + CPPU at 100 ppm	11.6	11.8	8.2	8.4	65.9	66.7	0.29	0.28
Spraying NAA at 10 ppm + CPPU at 50 ppm	11.7	11.9	8.6	8.7	66.6	67.0	0.28	0.27
Spraying NAA at 10 ppm + CPPU at 100 ppm	11.9	12.0	9.0	9.1	67.5	68.0	0.26	0.25
New L.S.D. at 5%	0.3	0.4	0.1	0.2	1.25	1.42	0.09	0.11

3.2 Fruit quality

Data in Tables (2 to 5) clearly show that single or combined spraying of NAA at 5 to 10 ppm and CPPU at 50 to 100 ppm three times significantly increased the weight, pulp percentage and dimension of fruit as well as juice %, TSS %, TSS/acid ratio, sugars content and vitamin C content and significantly decreased, fruit peel thickness and total acidity % over the control treatment. Using CPPU and NAA in ascending order significantly was responsible for promoting the fruit quality. The heaviest fruit (414.8 & 422 g) and highest TSS (12.3 & 12.5%) were recorded on the trees that sprayed with NAA at 10 ppm plus CPPU at 100 ppm. On other hand, the least values of these traits recorded on untreated trees. Hence, the increment percentage of fruit weight attained (19.09 & 18.87%) and TSS (17.14 & 19.05%) due to spray NAA along with CPPU compared to untreated one. Fruit quality was significantly improved in response to spraying of NAA at 5 to 10 ppm besides CPPU at 50 to 100 ppm compared to using each alone in this respect. The best results with regard to quality of the fruits were obtained with using NAA at 10 ppm and CPPU at 100 ppm together. Such fruit improvement is very important target that induce an increase in packable yield. These results were true during both seasons.

Table (4): Effect of spraying NAA and CPPU on some chemical characteristics of Washington Navel oranges during 2020 and 2021 seasons.

Treatments	Juice (%)		TSS (%)		Total acidity (%)		TSS/ acid	
	2020	2021	2020	2021	2020	2021	2020	2021
Control	46.8	47.0	10.5	10.5	1.040	1.040	10.1	10.1
Spraying NAA at 5 ppm	49.5	49.8	11.0	11.1	1.010	1.009	10.9	11.0
Spraying NAA at 10 ppm	50.2	51.0	11.2	11.3	0.986	0.978	11.4	11.6
Spraying CPPU at 50 ppm	47.5	47.9	10.7	10.8	1.030	1.024	10.4	10.5
Spraying CPPU at 100 ppm	48.1	48.8	10.8	11.0	1.017	1.013	10.6	10.8
Spraying NAA at 5 ppm + CPPU at 50 ppm	50.0	50.8	11.3	11.2	0.984	0.981	11.5	11.5
Spraying NAA at 5 ppm + CPPU at 100 ppm	50.8	51.5	11.7	11.8	0.957	0.952	12.2	12.4
Spraying NAA at 10 ppm + CPPU at 50 ppm	51.4	52.0	12.0	12.2	0.940	0.930	12.8	13.1
Spraying NAA at 10 ppm + CPPU at 100 ppm	52.5	53.0	12.3	12.5	0.932	0.927	13.2	13.5
New L.S.D. at 5%	0.8	1.1	0.4	0.5	0.022	0.024	0.3	0.4

Table (5): Effect of spraying NAA and CPPU on sugar contents and vitamin C of Washington Navel oranges during 2020 and 2021 seasons.

Treatments	Total sugars (%)		Reducing sugars (%)		Non- reducing sugars (%)		Vitamin C (mg/100 ml juice)	
	2020	2021	2020	2021	2020	2021	2020	2021
Control	7.95	7.94	3.69	3.67	4.26	4.27	48.6	48.7
Spraying NAA at 5 ppm	8.90	9.05	3.85	3.90	5.05	5.15	51.0	51.9
Spraying NAA at 10 ppm	9.50	9.60	3.94	3.98	5.56	5.62	52.2	53.0
Spraying CPPU at 50 ppm	8.15	8.18	3.80	3.85	4.35	4.33	49.8	50.0
Spraying CPPU at 100 ppm	8.80	9.00	3.88	3.92	4.92	5.08	50.5	51.8
Spraying NAA at 5 ppm + CPPU at 50 ppm	9.40	9.55	3.95	3.98	5.45	5.57	53.0	53.6
Spraying NAA at 5 ppm + CPPU at 100 ppm	9.58	9.70	4.00	4.09	5.58	5.61	53.8	54.2
Spraying NAA at 10 ppm + CPPU at 50 ppm	9.85	9.95	4.17	4.19	5.68	5.76	54.1	54.8
Spraying NAA at 10 ppm + CPPU at 100 ppm	10.20	10.30	4.15	4.25	6.05	6.05	55.2	55.3
New L.S.D. at 5%	0.54	0.62	0.38	0.44	0.49	0.52	1.1	1.2

4. Discussion

The effect of plant growth regulators has become important in agriculture today. They have the ability to control fruit set, increase yield, fruit size, color and shape, thereby increasing marketability. In addition, by hastening or delaying maturation the grower can utilize peak, demands avoid unfavourable environmental conditions and extend the market period (El-Salhy *et al*., 2009; Fishel *et al*., 2006; Retamales *et al*., 1994; Whiteng, 2007). Plant growth regulators play an important and major role in regulating fruit growth and development. Some of these substances were used in controlling ripening fruits (delayed ripening) as well as improving the fruits quality which act for increasing the income and the revenues of farmers. (Abd El-Raheem *et al*., 2013; Kassem *et al.*, 2011; Khodair, 2015). Naphthalene acetic acid (NAA) is the most effective auxin for reducing fruit drop many growers of citrus sprayed their orchards at pre or post- bloom with (NAA) at different concentrations to decrease fruit drop, increase fruit set, fruit retention and improve yield and fruit quality as well as vegetative growth (Abd El-Rahman, 2005; Gofur *et al.*, 1998; Notodimedjo, 1999; Ragab, 2002; Singh *et al.*, 1994). Sitofex (CPPU) is a new plant growth regulator which has strong cytokinin activity by inducing fruit growth at low rates. The application of sitofex at 1 to 20 ppm causes great effects on fruit size. The effectiveness was related to application techniques, plant developmental stage at the moment of application, and other variables (Nickell, 1985 and Ogata *et al.*, 1988). Studies on the synthetic cytokinin CPPU (N-(2-chloro-1-pyriodinyl) N-phyenylurea) has indicated that in many fruit crops. It is one of the main factors affecting fruit growth and fruit size. CPPU gave promising results in controlling fruit growth and cropping (Abd El-Raheem *et al*., 2013; El-Kosary, 2009; El-Salhy *et al*., 2009; Kassem *et al*., 2011). The higher content of Sitofex from cytokinins surely reflected on enhancing cell division and the elongation of fruits, (Nickell, 1985). The improvement of the fruit quality in response to use some plant growth regulators were reported by

Abd El-Rahman (2005), Soliman and Enas (2007), El-Kosary (2009), Al-Obeed (2010), Kassem *et al*. (2011), Abd El-Raheem *et al*. (2013), Ghazzawy (2013), Khodair, (2015) and Ragab, (2020).

5. Conclusion

On the light of the previous results, it could be concluded that carrying out three sprays of NAA at 10 ppm besides CPPU at 100 ppm at growth start, just after fruits setting and two months later was responsible for promoting yield and fruit quality of Washington navel orange trees grown under Assiut climatic conditions, Egypt.

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