Yield and Productivity of Washington Navel Orange Trees as Influenced by Sprays of Different Chemicals

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ABSTRACT

The influence of spraying Washington Navel oranges with three growth regulators and other chemicals at two different stages on the fruit drop, fruit retention, yield, growth and productivity was studied. Results showed that most chemicals had a significant effect on fruit retention, fruit drop, preharvest fruit drop and yield when sprayed at marble stage. However, NAA, GA_3 and KNO_3 were also effective at pea stage. In addition, Urea and 50 ppm GA_3 increased shoot length when sprayed at both stages. Fruit weight and length increased by spraying40 ppm NAA, 50 ppm GA_3 and KNO_3 at both dates. KNO_3, 2,4-D and 50 ppm GA_3 increased fruit diameter. On the other hand, acidity and TSS contents were not affected by any of the treatments at both stages.

INTRODUCTION

Citrus producers pay a major attention to produce a high yielding trees with high fruit quality in order to satisfy consumer demands. Thus, plant growth regulators had been widely used for many purposes in citrus production. Substances such as 2,4-D and NAA(Alpha-naphthyl -acetic acid) were added to control fruit drop (Coggins, 1995a). Gibberellic acid (GA_3), a naturally occurring plant hormone was used to improve fruit quality (Ibrahim *et al.*, 1994 and Merlo, 1997). In other studies 2,4-D and GA_3 were found to increase the yield of citrus trees. However, unsatisfactory results might be obtained when the wrong concentration is used and that could be harmful to the trees treated with such growth regulators. Thus, attends for using other chemicals such as potassium nitrate and urea were made for the same purpose. Many researchers studied the effect of spraying these chemicals either alone or in combination with growth regulators on fruit drop and quality of citrus trees (Koo and Reese, 1973, Bertin and Squali, 1974, Ferguson *et al.*, 1984, Erner *et al.*, 1993 and Ali and Lovatt, 1994). Moreover, date of application and concentration of the different substances must be considered according to the purpose aimed to obtain best results.

This study was conducted to evaluate the effect of concentration and date of spraying seven chemicals on growth, fruit retention, yield and fruit quality of Washington navel orange trees.

MATERIALS AND METHODS

The research was conducted in a private Citrus orchard at El-Tarh region, El-Behera Governorate during the growing seasons 2000 and 2001 on mature Washington Navel orange trees (*Citrus sinensis,* L.) budded on sour orange rootstock. The soil was clay well drained with water table about 120 cm. Trees were planted at 5 m apart and subjected to the same cultural practices usually done in the orchard. Eleven foliage treatments were applied at pea and marble stages with a group of 44 trees for each stage. Treatments in each group were arranged in a complete randomized design with 4 replicates for each treatment. The eleven spraying treatments were as follows: 1) water spray (control), 2) 20 ppm NAA, 3) 40 ppm NAA, 4) 25 ppm GA_3, 5) 50 ppm GA_3, 6) 10 ppm 2,4-D, 7) 20 ppm 2,4-D, 8) 0.5% urea , 9) 0.5% calcium acetate, 10) 0.5% calcium chloride, 11) 2% potassium nitrate. The surfactant Biofilm (30 cm/100 l water) produced by Biotechegypt was added to all sprayed chemicals in order to obtain best results. Surfactants are important substances in increasing the prospect of good spray coverage.

In order to study the effect of the different treatments on tree growth, two branches were tagged on two different sides of each tree in April for pea stage and May for the marble stage in both successive seasons 2000 and 2001. The length of spring non-fruiting shoots per branch were recorded at the end of each season.

Moreover, In April and May of both 2000 and 2001seasons, two branches were tagged on two different sides of each tree and the number of fruits on each branch was counted and recorded at every spraying date and after June drop. The percentage of fruit drop and fruit retention was calculated for each season as follows:

- % Fruit retention = (No. of fruits after June drop / No. of fruits at spray date) x 100
- % fruit drop = 100 - % fruit retention

The yield was recorded at harvest date in December of 2000 and 2001 expressed as weight (kg/tree). Ten fruits were sampled once at harvest date from each tree in both growing seasons in order to determine fruit quality characters. In each fruit sample, fruit weight, diameter and length, peel thickness were recorded. In the juice, total soluble solids were measured by a hand refractometer. Acidity and vitamin C content were also determined by titration. In addition, fruit color according to the color chart of Harding *et al.*(1940) and percentage of fruit creasing were also recorded.

The data were statistically analyzed according to the method of Snedecor and Cochran (1972).

RESULTS AND DISCUSSION

Fruit retention and fruit drop:

Trees sprayed at pea stage with NAA (40 ppm), GA_3 (25, 50 ppm) and KNO_3 retained more fruits when compared with the control in both seasons (Tables 1 and 3). In addition, no significant differences were observed between the gibberellic acid and potassium nitrate sprays. However, all treatments at marble stage significantly increased fruit retention in both seasons except for KNO_3 in the first season (Tables 1 and 3). No significant differences between growth regulators and the other chemicals were observed for spraying at marble stage.. Ghosh *et al.*(1995) found that spraying sweet orange with 25 ppm GA_3 at pea stage was the most effective on fruit retention. Also, Moreira et al., 1996 stated that fruit retention was improved by application of GA3.

Spraying NAA (40 ppm) and GA_3 (25 and 50 ppm) at pea stage decreased fruit drop in both seasons as compared with the control (Tables 1 and 3). Also, potassium nitrate at pea stage significantly decreased fruit drop in the first season only. However, no differences between both growth regulators and KNO_3 were observed. At marble stage, fruit drop was significantly decreased by all treatments in both seasons except for KNO_3 in the first season (Tables 1 and 3). Moreover, no significant differences between the growth regulators and the remaining chemicals were found in both seasons. On the other hand, 25 ppm GA_3 had a significant higher effect than 20 ppm 2,4-D in the first season only (Table 1). Koo and Reese (1973) found that Valencia orange trees receiving potassium had markedly low fruit drop. Also, Bertin and Squali (1974) reported that fruit drop was reduced by spraying clementine trees with GA_3 and KNO_3. In addition, many researchers reported the use of 2,4-D and NAA in controlling fruit drop in citrus trees, Coggins (1995a). In addition, Gregoriou *et al.* (1996) reported that application of GA_3 and 2,4-D at or before color break reduced fruit drop.

Preharvest fruit drop and yield:

No significant differences were obtained in the percentage of pre harvest fruit drop among treatments at pea stage in both seasons (Tables 1 and 3). However,at marble stage both GA3 (25 and 50 ppm) and 2,4-D (10 and 20 ppm) significantly lowered preharvest fruit drop than the control in the first season only. Moreover, no differences between the above mentioned growth regulators were found (Table 1). Evaluations of the effectiveness of NAA in relation to 2,4-D on preharvest fruit drop were made (Coggins, 1995a).

He reported that NAA has aproximately similar effect to 2,4-D in reducing fruit drop. In the recent study, NAA and 2,4-D had a similar effect on fruit retention and drop when sprayed at marble stage.

The yield was significantly increased by spraying NAA (20 and 40 ppm) and GA_3 (25 and 50 ppm) at pea stage in the first season (table 1). However, all treatments except NAA (20 ppm) increased yield as compared with the control in the second season (Table 3). In addition, 50 ppm GA_3 had a significant higher effect than 25 ppm GA_3, 2,4-D (10 and 20 ppm), urea and calcium chloride but not than potassium nitrate (Table 3).

At marble stage the yield was significantly increased by all treatments except for KNO_3 as compared with the control in the first season (Table 1). In addition , no significant differences were found between the two concentrations of the growth regulators used in this study. In the second season, yield of trees treated only with growth regulators was significantly increased as compared with the control (Table 3). Moreover, data in Table 3 showed that 50 ppm GA_3 had higher effect than NAA (20 and 40 ppm) and 2,4-D (10 ppm). These results are in agreement with those of Koo and Reese (1973) and Ali and Lovatt (1994). Whereas, Silva *et al.*(1998) reported that yield of Pera and Hamlin oranges was not affected by GA_3 sprays. The effect of urea on yield was also reported (Ali and Lovatt, 1994).

Shoot length:

Spraying with urea and 50 ppm GA_3 at both stages significantly increased shoot length in both seasons when compared with the control (Tables 1 and 3). In addition, shoot length was significantly increased by 25 ppm GA_3, 10 and 20 ppm 2,4-D and potassium nitrate when sprayed at pea stage and by 40 ppm NAA and 20 ppm 2,4-D at marble stage in the first season only as compared with the control (Table 1).Many researches showed the importance of growth regulators sprays on the vegetative growth of different citrus trees (Wang, 1981, Takahara *et al.*, 1990 and Castro *et al.*, 1998).

Fruit weight, length, diameter and fruit length/diameter ratio:

In both seasons, NAA at 40 ppm significantly increased fruit weight when sprayed at pea and marble stages as compared with the control. On the other hand, GA_3 at 25 and 50 ppm increased fruit weight in the second season only at the two spraying dates when compared with the control (Tables 1 and 3). Moreover, spraying potassium nitrate at pea stage significantly increased fruit weight in both seasons. Fruit length was significantly increased by spraying with 50 ppm GA_3 in the two dates of both seasons (Tables 1 and 3).

However, 40 ppm NAA, 20 ppm 2,4-D and KNO_3 increased fruit length when sprayed at pea stage in the first season only as compared with the control (Table 1).

Spraying 50 ppm GA_3 at marble stage increased fruit diameter as compared with the control in both seasons (Tables 1 and 3). On the other hand, fruit diameter was significantly affected by 50 ppm GA_3, KNO_3 and calcium acetate sprayed at pea stage in the second season only (Table 3). Also, 20 ppm of 2,4-D had significant effect on fruit diameter in the first season only in both spraying dates (Table 1). Both GA_3 and 2,4-D had significant effect on fruit length/diameter ratio as compared with the control at the two spraying dates in both seasons (Tables 1 and 3). Moreover, the data in Tables 1 and 3 showed that NAA, generally, increased the ratio at the two spraying stages (except for the pea stage in the second season). Also, spraying with $CaCl_2$ in marble stage significantly increased fruit length/diameter ratio in the second season only (Table 3). Similar results were reported by Erner *et al.*(1993) and Ibrahim *et al.*(1994) on Shamouti, Valencia and navel oranges. On the other hand, Bertin and Squali (1974) reported that small fruits were increased by GA_3 whereas KNO_3 generally increased fruit size. A research study indicated that better increase in size occurs with combination spray of 2, 4-D and KNO3 than with 2, 4-D alone (Coggins, 1995a).

Peal thickness, V. C, acidity and TSS:

In both seasons, peal thickness was significantly increased by all treatments at pea stage except for urea in the first season and urea and 20 and 40 ppm NAA in the second season (Tables 2 and 4). However, spraying 40 ppm NAA, 25 and 50 ppm GA_3, 20 ppm 2,4- D, $CaCl_2$ and KNO_3 at marble stage increased peal thickness in the first season only as compared with the control (Table 2). In the second season 20 ppm NAA, 25 and 50 ppm GA_3, calcium acetate and calcium chloride had a significant effect on peal thickness when sprayed at marble stage (Table 4). GA_3 was used in citrus grooves to delay rind aging. In this study it increases peel thickness and might help in delaying the rind aging and to extend the marketing period for navels. Moreover, the increase of peel thickness gives the fruit more stable condition for shipping which helps in improving exporting purpose.

At pea stage, vitamin C content was significantly increased by 25 and 50 ppm GA_3,10 and 20 ppm 2,4-D and calcium acetate sprays when compared with the control (Table 2). However, no significant differences were obtained in the second season for the same date (Table 4). Moreover, vitamin C content was not affected by any of the treatments in the second spraying date at the first season (Table 2). Whereas, in the second season 40 ppm NAA, 10 ppm 2,4-D, calcium acetate and calcium chloride significantly

Table 1. The effect of different chemical sprays on shoot length, fruit retention, drop, yield, fruit weight and length of Washington Navel orange trees in 2000.

Treatments		Shoot length (cm)		Fruit retention (%)		Fruit drop (%)		Preharvest drop (%)		Yield (kg/tree)		Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)		Fruit length/ Fruit diameter ratio	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Control		9.09	8.30	2.55	13.27	97.45	86.73	9.27	8.17	60	57	253	248	6.72	7.80	6.86	8.20	0.98	0.95
NAA	20 ppm	10.16	9.26	10.44	27.20	89.56	72.80	9.70	6.26	71	75	271	255	7.24	7.13	7.12	6.81	1.02	1.05
NAA	40 ppm	10.32	9.82	20.76	24.71	79.24	75.29	10.21	5.48	80	68	286	268	8.40	8.38	8.14	8.42	1.03	1.00
GA_3	25 ppm	10.74	8.86	10.86	21.29	89.14	78.71	9.00	3.36	73	70	273	280	8.92	10.56	8.63	9.92	1.03	1.06
GA_3	50 ppm	10.83	10.27	8.05	24.71	91.95	75.29	6.21	3.13	72	71	263	291	8.62	10.68	8.21	10.12	1.05	1.06
2,4-D	10 ppm	11.26	9.37	3.62	24.13	96.38	75.87	6.02	4.26	65	70	259	278	7.84	9.63	7.70	9.30	1.02	1.04
2,4-D	20 ppm	11.86	10.02	3.58	28.38	96.42	71.62	7.12	4.06	67	78	279	267	9.36	9.48	9.00	9.42	1.04	1.01
Urea	0.5%	12.31	11.22	6.26	22.41	93.74	77.59	8.01	7.71	63	67	232	240	7.12	7.91	7.36	8.08	0.97	0.98
Ca-acetate	0.5%	10.08	8.12	6.31	23.04	93.69	76.96	6.78	8.27	60	68	230	246	7.00	8.32	7.03	8.28	1.00	1.00
Ca-chloride	0.5%	10.21	8.08	5.91	22.01	94.59	77.99	7.27	7.36	57	66	242	236	7.32	7.93	7.46	8.17	0.98	0.97
K-nitrate	2%	10.82	9.07	10.80	18.31	89.20	81.69	7.01	8.12	64	63	276	253	8.32	8.08	8.65	8.58	0.96	0.94
$L.S.D_{0.05}$		1.52	1.40	4.23	7.61	4.17	6.03	NS	3.72	8	9	21	16	1.28	1.36	1.81	1.20	0.04	0.07

I: At pea stage spraying. II: At marble stage spraying.

Table 2. The effect of different chemical sprays on fruit quality of Washington Navel orange trees in 2000.

Treatments		Peel thickness (cm)		Creasing (%)		Color		Vitamin C (mg/100 mL)		Acidity (%)		TSS (%)	
		I	II	I	II	I	II	I	II	I	II	I	II
Control		0.38	0.32	10.70	8.63	5.0	5.0	46	52	0.96	1.02	13.0	12.2
NAA	20 ppm	0.40	0.36	6.10	7.24	4.8	5.0	50	55	0.92	0.99	12.6	12.4
NAA	40 ppm	0.41	0.38	7.21	6.26	5.0	5.0	48	60	0.99	1.03	12.6	12.8
GA_3	25 ppm	0.40	0.41	5.42	3.26	4.6	4.0	52	58	0.96	0.93	13.0	13.5
GA_3	50 ppm	0.42	0.43	4.60	3.37	4.6	3.8	54	60	1.01	0.90	12.7	11.6
2,4-D	10 ppm	0.40	0.36	5.62	4.26	5.0	4.2	62	50	0.97	0.82	12.2	11.8
2,4-D	20 ppm	0.41	0.38	6.00	7.86	5.0	4.5	60	47	0.92	0.96	12.4	12.8
Urea	0.5%	0.38	0.32	8.27	6.32	4.8	4.8	51	49	0.97	0.86	13.2	12.6
Ca-acetate	0.5%	0.42	0.34	4.27	5.72	5.0	5.0	56	52	0.99	0.96	12.8	11.8
Ca-chloride	0.5%	0.40	0.40	5.60	5.81	5.0	5.0	48	56	1.02	0.98	12.0	12.6
K-nitrate	2%	0.42	0.39	5.92	6.21	5.0	4.8	50	50	0.93	1.00	12.0	12.8
$L.S.D_{0.05}$		0.02	0.05	5.4	2.91	NS	NS	6.0	NS	NS	NS	NS	NS

I: At pea stage spraying. II: At marble stage spraying.

Table 3. The effect of different chemical sprays on shoot length, fruit retention, drop, yield, fruit weight and length of Washington Navel orange trees in 2001.

Treatments		Shoot length (cm)		Fruit retention (%)		Fruit drop (%)		Preharvest drop (%)		Yield (kg/tree)		Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)		Fruit length/ Fruit diameter ratio	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Control		10.53	8.62	1.66	10.31	98.34	89.69	7.08	6.32	53	61	264	272	7.93	8.13	7.86	8.36	1.01	0.97
NAA	20 ppm	11.61	8.87	6.57	21.32	93.43	78.68	6.00	4.36	58	68	277	283	8.02	8.21	8.00	8.06	1.00	1.02
NAA	40 ppm	12.48	9.72	12.83	23.56	87.17	76.44	7.00	3.21	63	70	293	302	8.16	8.72	8.02	8.42	1.02	1.04
GA_3	25 ppm	12.81	10.72	8.81	20.73	91.19	79.27	5.63	3.72	66	72	308	312	8.32	8.83	8.03	8.41	1.04	1.05
GA_3	50 ppm	13.87	10.60	9.93	25.21	90.08	74.79	4.76	3.24	76	76	318	321	8.60	8.98	8.42	8.62	1.02	1.04
2,4-D	10 ppm	12.73	9.78	5.67	20.21	94.33	79.79	6.31	4.76	64	70	283	300	8.08	8.45	7.82	8.24	1.03	1.03
2,4-D	20 ppm	11.93	9.63	6.73	23.83	93.27	76.17	5.08	5.20	62	72	296	286	8.13	8.13	7.93	8.00	1.03	1.02
Urea	0.5%	13.62	10.70	5.32	18.64	94.68	81.36	7.18	5.62	66	63	254	273	7.82	8.08	7.88	8.02	0.99	1.01
Ca-acetate	0.5%	10.25	9.21	5.06	20.28	94.94	79.72	5.26	4.09	67	60	262	281	7.98	8.18	8.06	8.36	0.99	0.98
Ca-chloride	0.5%	9.96	9.86	6.00	21.18	94.00	78.82	4.63	4.21	62	65	255	280	7.73	8.27	7.97	8.12	0.97	1.02
K-nitrate	2%	10.97	10.35	7.60	19.27	92.40	80.73	5.86	5.63	67	64	288	286	7.92	8.37	8.12	8.46	0.98	0.99
$L.S.D_{0.05}$		3.01	1.81	5.61	7.79	6.90	7.69	NS	3.10	8	6	21	16	0.42	0.67	0.19	0.21	0.02	0.05

I: At pea stage spraying. II: At marble stage spraying.

increased vitamin C content as compared with the control at marble stage (Table 4).

In addition, no significant differences in acidity and TSS contents were obtained among treatments at both spraying stages in both seasons (Tables 2 and 4). Similar results were obtained by Greenberg et al, 1995. In contrast, Ibrahim *et al.*(1994) stated that peel thickness, fruit TSS and TSS:acid ratio were significantly increased by GA_3 and promalin sprays.

Color and creasing:

Fruit color was not affected by any of the treatments at both spraying dates in both seasons (Tables 2 and 4). However, later spray of GA_3 was found to delay color break of navel oranges (Coggins, 1995b). Moreover, all treatments decreased the percent of creased fruits at both spraying dates (except for urea at pea stage) in both seasons when compared with the control (Tables 2 and 4).

In this study, the date of application had an influence on the various recorded data. Evaluation of the best spraying date was reported in many researches (Bertin and Squali (197), Ghosh et al (1995) and Coggins (1995a and b).

From the previous results, no significant differences were found between the growth regulators and other chemicals especially KNO_3 in most of the characters studied. Thus, the harmful effect of using such hormones with high concentrations can be avoided by using other chemicals. The use of different substances other than hormones alone or in combinations with growth regulators to improve the productivity of citrus grooves has been reported (Singh and Rethy, 1995 and Nakhlla, 1998). Moreover, most treatments were effective when sprayed at marble stage. The different spraying dates were also reported (Ghosh *et al.*, 1995).

Table 4. The effect of different chemical sprays on fruit quality of Washington Navel orange trees in 2001.

Treatments		Peel thickness (cm)		Creasing (%)		Color		Vitamin C (mg/100 mL)		Acidity (%)		TSS (%)	
		I	II	I	II	I	II	I	II	I	II	I	II
Control		0.34	0.40	11.82	7.38	5.0	4.8	56	48	1.08	1.00	12.6	13.2
NAA	20 ppm	0.33	0.42	8.90	6.18	5.0	5.0	57	52	0.98	1.07	12.2	12.6
NAA	40 ppm	0.36	0.41	8.28	5.12	5.0	5.0	50	57	1.01	1.03	12.6	12.4
GA_3	25 ppm	0.40	0.43	7.06	3.26	4.4	4.6	53	52	0.96	1.01	13.0	13.6
GA_3	50 ppm	0.40	0.44	6.13	4.16	4.2	4.8	56	50	0.98	0.92	13.2	12.8
2,4-D	10 ppm	0.38	0.41	7.36	5.26	4.8	5.0	60	56	0.99	1.02	13.0	13.6
2,4-D	20 ppm	0.42	0.40	6.12	4.16	5.0	5.0	56	50	0.82	0.93	12.8	13.8
Urea	0.5%	0.36	0.38	12.00	8.82	4.6	4.4	52	48	0.92	1.02	11.8	12.0
Ca-acetate	0.5%	0.41	0.43	6.21	3.12	5.0	5.0	58	56	1.00	0.92	12.2	12.6
Ca-chloride	0.5%	0.42	0.44	5.32	4.18	4.8	5.0	54	58	0.92	0.83	12.4	12.2
K-nitrate	2%	0.40	0.40	8.62	7.13	4.8	5.0	56	51	1.01	0.89	13.2	13.8
$L.S.D_{0.05}$		0.03	0.02	4.61	2.06	NS	NS	NS	8	NS	NS	NS	NS

I: At pea stage spraying. II: At marble stage spraying.

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الملخص العربى

تأثير الرش بمركبات مختلفة على محصول و إنتاجية أشجار البرتقال ابو سرة

هند على مرزوق ، حسن على قاسم

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أجريت هذه الدراسة فى عامى ٢٠٠٠ و ٢٠٠١ على أشجار برتقال أبو سرة بغرض دراسة تأثير الرش بمنظمات النمو وبعض الكيماويات الأخرى خلال مرحلتين لنمو الثمار (حجم البسلة والبلية) على التساقط والمحصول والنمو والجودة. ولقد وجد أن معظم المواد المستخدمة أثرت ايجابيا على معدل التساقط وبقاء الثمار وتساقط ما قبل الجمع و المحصول عندما رشت عند مرحلة النمو الثانية بينما كان لحامض النفثالين والجبريلليك ونترات البوتاسيوم ايضا تأثير عند رشهم فى مرحلة حجم البسلة. الرش بثيوريا و ٢٠ جزء فى المليون من حامض الجبريلليك ونترات البوتاسيوم عند كل من حجم البسلة والبلية ادى الى زيادة صون الثمرة. عمل الرش بحامض الجيبريللين ونترات البوتاسيوم الى زيادة وزن وطول وقطر الثمار. كما أدت جميع معاملات الرش عند حجم البسلة الى زيادة سمك القشرة. ومن ناحية أخرى لم تتأثر الحموضة ونسبة المواد الصلبة الذائبة الكلية بأى من المعاملات.