

Effect of GA₃ and Potassium Nitrate in Different Dates on Fruit Set, Yield and Splitting of Washington Navel Orange

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Abstract: Two concentrations of GA₃ were used alone or with 0.5% urea i.e. (50 and 100 ppm) and three levels of potassium nitrate (KNO₃, 2, 4 and 6% were tested as foliar sprays at different times i.e. first time application at full bloom stage, the second time application was at fruit diameter from 1.5-2.0 cm and (first and second time of application) for investigation their effects on fruit set, yield, fruit quality and splitting of 40-years-old Washington navel orange (*Citrus Sinensis*), trees budded on Sour Orange (*Citrus aurantium*, L.Osbeck) rootstock during 2008 and 2009 seasons.

Data indicated that, all treatments increased fruit set, yield and fruit quality and decreased fruit splitting as compared with control treatment. Data also revealed that, foliar sprays of trees by (GA₃ at 50 ppm) with or without 0.5% urea were superior for inducing the highest increase of fruit set and yield, in addition KNO₃ at 4% comparing with 2% and 6%. Also, KNO₃ treatments increased fruit size, peel thickness and juice acidity especially with high concentrations; on the other hand, the use of GA₃ at 50 or 100 ppm alone or with 0.5% urea increased fruit T.S.S and reduced nitrite and nitrate contents in fruit juice as compared with KNO₃ treatments. Moreover, it is noticed that trees sprayed at first application or first and second time of application gave the best results, while second application was the best for reducing fruit splitting. It could be recommended the best treatment for increasing yield and gave high fruit quality is GA₃ at 50 ppm with or without 0.5% urea at full bloom stage especially in respect with reducing nitrite and nitrate in fruit juice, and use KNO₃ 4% at the second time of application to reduce fruit splitting.

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1. Introduction

Navel orange is a popular fresh fruit due to its seedless, large size, characteristic flavor and aroma (Wardowski, *et al.*, 1985). Also, navels orange are in important source of early season income for citrus growers in some commercial citrus areas of the world. Yields are erratic and usually low in many areas due to lack functional pollen, rarely produce viable ovules and in addition, are weakly parthenocarpic (Krezdorn, 1965). Flower and fruit drop of navel orange occurred in three phases and amount to a total 91%, giving a fruit set of 9% (Villafane, *et al.*, 1989). Gibberellic acid (GA₃) and potassium nitrate have a board range of uses in citriculture; Gibberellins have been used in citrus production with several objectives including bloom reduction, increased fruit setting, improvement of fruit quality and improved maturation control (Agustí and Almela, 1991). The application of gibberellic acid soon after flowering at doses between 10 and 15 ppm can result in delayed abscission and increased fruit set, mainly in Clementine tangerines (Fornes *et al.*, 1992; El-Otmani, 1992). However, the increase in fixing and productivity does not happen frequently and depends on factors including variety, plant status and time of application (Davies, 1987; Talón *et al.*, 1997). Also, GA₃ increased fruit set in navels orange (Smith, 1993; Babu and Lavania, 1985), in tangerine hybrids (Brosh and Monselise, 1977) and increased the yield either as number or weight of fruits per tree of Washington navel

orange (Ibrahim, *et al.*, 1994). Positive results have been obtained with potassium nitrate supplementation even with good plant nutritional status, which is possibly related to the lower ability to mobilize mineral reserves necessary for the period (Ruiz *et al.*, 2001). On the other hand, potassium decreases the loss of fruit from splitting (Lavon, *et al.*, 1992); also, GA₃ reduces fruit splitting when applied shortly after the end of the June drop in "Nova" hybrid mandarin (Garcia, *et al.* 1994). GA₃ application improved fruit quality (Davies, *et al.*, 1999 and 2001), while KNO₃ increased fruit size and juice acidity for Shamuti and Valencia oranges (Erner *et al.* 1993).

The purpose of this work is to study the effect of Gibberellic acid (GA₃) and potassium nitrate (KNO₃) sprays at different times and concentrations on fruit set, yield, fruit splitting and fruit quality on Washington navel orange trees. Hence, to identify the best treatments for achieve the highest return for the growers.

2. Material and Methods

The experiment was carried out in the private orchard belonged for Mr. Hassan Marie in Benha, El-Kalubiah Governorate, Egypt, in 2008 and 2009 seasons on forty-years-old of "Washington navel" (*Citrus Sinensis*) orange trees grafted on Sour orange rootstock (*Citrus aurantium*, L.Osbeck) and were planted at 5×5 m spacing in clay soil. Ninety-six "Washington navel" orange trees were divided into

twenty four groups according to vigor and number of flowers and used for data collection. The design was a randomized block with 4 single-tree replicates and 8 treatments with 3 time intervals of spray all treatments. The experiment involved the following eight treatments. GA₃ at 50 ppm and 100 ppm plus the same concentrations of GA₃ with 0.5% urea; potassium nitrate treatments was used at three levels 2, 4 and 6%; the control trees untreated. Trees were sprayed on full bloom stage (first application), fruit diameter from 1.5-2.0 cm (second application) and both (first and second time of application). The total number of flowers was counted before treatments and commercially available urea containing 46% N and Berlex (containing 92% GA₃ and 8% of other gibberellins) were used in the trials. Triton B at 0.1% was used as a wetting agent for all spraying solutions. In addition foliar spray of potassium treated as KNO₃ 98%. All trees generally received adequate organic and inorganic fertilization. Irrigation was given at intervals of about 10-15 days in summer and 15-21 days in winter. However, a balanced foliar fertilization of all microelements was adopted three times yearly (February, May and August). The following parameters of the studied treatments were carried out.

Fruit set percentage

Fruitlets and fruits drop were expressed as an accumulative percentage per tree. Percentage of fruit set = number of fruit set during a given interval × 100/ number of fruit at the beginning of the interval.

Yield

Weight (kg) and number of mature fruits per tree were recorded at late November of each season.

Fruit splitting percentage

Determination dates of beginning primary symptoms of splitting for each treatment were observed and recorded. Total number of fruits was counted for each tree at the end of July to end of October 2008 and 2009. Percentage of fruit splitting was calculated using the following equation. Fruit splitting percentage = number of splitting fruits × 100/ total number of fruits.

Nitrite and nitrate contents in fruit juice

A sample of 10 ml of fruit juice was taken from each replicate to determine nitrite and nitrate according to the methods outlined by (Sen and Donaldson, 1978).

Physical properties of fruits

Fruit weight, fruit size, fruit length and diameter and peel thickness for each fruit were measured by using the varinier caliper. Juice volume, also Juice weight percentage was calculated by using the following equation. Juice weight % = average juice weight (gm.) per fruit × 100 / average fruit weight (gm.).

Chemical properties of fruits

Total soluble solids (T.S.S %) was determined by using Zeiss hand refractometer, total acidity was determined according to (A.O.A.C., 1995), also T.S.S/Acid was calculated.

Statistical analysis.

The experiment was designed in completely randomized block design with four replicates for each treatment and each replicate was represented by one tree. The obtained data of both seasons were subjected to analysis of variance according to (Clark and Kempson, 1977) and the means were differentiated using Duncan multiple range test at 5% level (Duncan, 1955).

3. Results and Discussion

Fruit set percentage

It is obvious from Tables (1&2) that the difference between the use of gibberellic acid and potassium nitrate on fruit set of Washington navel orange were significant. The results revealed that, trees spraying with both GA₃ and KNO₃ enhanced fruit set, whereas trees treated by GA₃ 50ppm + 0.5% urea gave significantly the highest fruit set percentage at (30, 60,165 and 205 days) after full blooming followed by trees sprayed with GA₃ 50ppm alone, while the lowest values of fruit set percentage were obtained by trees treated by KNO₃ 2% and control treatment meanwhile, the other treatments gave the intermediate values in this regard during the two seasons. On the other hand, concerning the time intervals of spray for all treatments, data revealed that, trees sprayed at (first application+ second application) had the highest significant values for fruit set followed by first application alone(full bloom) while second time of application (fruit diameter from 1.5-2.0 cm) gave the lowest significant values during two seasons. Several scientific trials show that the gibberellins increase the cell wall flexibility by stimulating the synthesis of new cellulose polymers (Richards *et al.*, 2001). The present results are a general in harmony with (Davies, 1987) who stated that, gibberellins could reduce the senescence of leaves and fruits. Also; (Brosh, *et al.*, 1975 and Tominaga, 1998) reported that, GA₃ and KNO₃ decreased abscission of fruitlets in navel oranges and grapefruit. In addition, potassium nitrate (KNO₃) enhanced fruit set and increased yield of orange and mandarin trees (El-Deeb, 1989; El-Fangary, 1998 and Mostafa, *et al.*, 2005).

Fruit weight (gm)

Results in Table (3) showed that no constant trend during two studied seasons for fruit weight due to different treatments was noticed on Washington navel orange. Whereas, foliar sprays of trees by KNO₃ 2% scored the highest significant values for fruit weight at the (first and second time of application) in the first season, while trees sprayed with GA₃ 50ppm gave the maximum values at full bloom stage in the second season. On the other hand, trees treated by GA₃ 100 ppm gave the lowest significant values for fruit weight at (second time of application) and (first and second time of application) in the first season. Meanwhile, the lowest values were on KNO₃ 4% treatment at full bloom stage in the second season. Anyhow, the differences between all treatments were high to be significant.

Fruit number/tree

Data in the Table (3) revealed that, all treatments increased fruit number with some fluctuations as compared with control treatment. On the other hand, it was noticed that the maximum fruit number were obtained during foliar sprays of trees at full bloom stage (first application) and (first and second time of application) while second application gave the lowest significant values of fruit number in the first and second season.

Yield

Yield as weight (Kg/tree or ton/fed.) are shown in Table (4) yield was significantly increased by all treatments either with spraying gibberellic acid or with KNO_3 at any concentrations as compare to the control treatment. However, yield was gradually increased by spraying of KNO_3 2% than the control then the range of increase was higher when trees treated by KNO_3 at 6% then 4 % concentrations and reached the maximum with gibberellic acid (GA_3) treatments especially (GA_3 50ppm + 0.5%urea) which gave the highest yield (yield Kg/tree and ton/fed.) for the first and second seasons. Also, data revealed that trees sprayed at (first application) and (first and second time of application) scored the higher averages as compared with those sprayed at (second application). From the above results, it is interest to notice that, GA_3 and KNO_3 at different rates spraying increased the yield of Washington navel orange trees. These results are in the same line with those obtained by (Smith, 1993; Babu and Lavania, 1985) in navel orange and (Brosh and Monselise, 1977) in tangerine hybrids; they found that gibberellic acid (GA_3) increased fruit set. Also, (Ibrahim, *et al.* 1994) reported that, trees spraying with GA_3 increased the yield of Washington navel orange. Likewise, (El-Fangary, 1998 and Mostafa, *et al.*, 2005) found that, KNO_3 enhanced fruit set and increased yield of orange and mandarin trees.

Fruit splitting percentage

It is evident from the results shown in Fig. (1) that gibberellic acid and potassium nitrate treatments decreased fruit splitting percentage as compared with control treatment especially trees treated by KNO_3 6% gave the lowest significant values of fruit splitting due to the peel thickness of fruits which increased with increasing the concentration of potassium nitrate Table (8). This finding is in parallel with the finding of (Josan *et al.*, 1995) in Lemon who reported that the thicker peel helps to resist fruit puncture. While the other treatments gave the intermediate values during two seasons (2008 & 2009). Also, it can be noticed that, the splitting tendency is greatly depended on the stage of development of the fruit whereas, full bloom stage (first application) scored the maximum significant average for fruit splitting while, trees treated at (second application) or (first and second time of application) had the minimum significant averages of fruit splitting, although

GA_3 treatments scored decreasing of fruit peel thickness, these results may be due to the elastic walls of fruit cells as a result of spraying with GA_3 in these stages. This explanation can be agreed with (Richards *et al.*, 2001) they found that, the gibberellins increase the cell wall flexibility by stimulating the synthesis of new cellulose polymers.

Nitrite and nitrate content in fruit juice

As shown in Tables (5& 6) results revealed that, nitrite and nitrate contents in fruit juice were affected by different treatments in the two seasons. It is clear that, trees sprayed with (KNO_3) gave the highest values for nitrite and nitrate in their fruit juice especially with high concentrations, while, trees sprayed with gibberellic acid (GA_3) either 50 ppm alone or plus 0.5 % urea gave the lowest values in fruit juice than the other treatments. This means that, the beneficial effect of spraying GA_3 either 50 ppm or plus 0.5% urea was mainly on reducing nitrite and nitrate in fruit juice. Also, it is noticed from Table (5&6) that the time of applications did not show any distinctive effect on nitrite and nitrate contents in fruit juice in the first and second seasons. In this respect, (Ibrahim, 1994 and Abd El-Migeed, *et al.*, 2007) mentioned that, mineral nitrogen fertilization easily forms nitrate in fruit juice as compare with using organic fertilizers.

Physical properties of fruits

Fruit diameter and length (mm)

Data in Table (7) indicated that the statistical analysis showed no significant differences between all treatments on Washington navel orange fruits in the first season, while trees sprayed with GA_3 100 ppm enhanced significant increased fruit diameter and length (mm) in the second season. Anyhow, the differences between all treatments were low to be significant.

Fruit size

It is clear from Table (8) that, all treatments increased fruit size as comparing with control especially with high concentration of potassium nitrate in the first and second season (2008 & 2009) may be due to increasing of fruit peel thickness. The present results are in a general harmony with (Okada, *et al.*, 1994) on Satsuma mandarin they mentioned that fruit size increased as K fertilization increased, also (Abd El-Rahman, 2005) found that spraying with promalin at 45 ppm and GA_3 at 50 ppm increased fruit size on navel orange fruits.

Peel thickness

Data in Table (8) showed that, peel thickness was affected by different treatments in the first and second seasons, and it is clear that, GA_3 treatments reduced significant values for fruit peel thickness, on the other hand, it is noticed that, peel thickness increased with increasing the concentration of potassium nitrate. The same observation was reported by (Zaied, *et al.*, 2006) on Washington navel orange.

Table (1) Fruit set percentage (after 30 & 60days) of Washington navel orange trees as affected by gibberellic acid and potassium nitrate during 2008 and2009 seasons.

Treatments(T)	Fruit set % (after 30days)								Fruit set % (after 60days)							
	2008, Season				2009, Season				2008, Season				2009, Season			
	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)
Control	64.80j	64.80j	64.80j	64.80E	66.65i	66.65i	66.65i	66.65E	27.09i	27.09i	27.09i	27.09D	28.06k	28.06k	28.06k	28.06F
GA ₃ 50ppm	74.0cde	66.45hij	77.2abc	72.55B	75.3cd	69.15ghi	79.75a	74.73B	33.10c	29.16defg	35.74a	32.67A	34.81cd	29.42ik	36.69ab	33.64B
GA ₃ 100ppm	69.90fg	66.20hij	75.0bcd	70.37C	72.6def	67.00i	76.10bc	71.90C	30.92d	28.10ghi	33.60c	30.87B	32.86fg	28.56k	35.16cd	32.19CD
GA ₃ 50ppm+0.5%urea	76.8abc	69.30fgh	79.40a	75.17A	78.5ab	72.33def	81.20a	77.34A	35.57ab	30.79d	37.48abc	33.61A	37.01ab	31.47hi	37.80a	35.43A
GA ₃ 100ppm+0.5%urea	71.70ef	67.5ghij	77.90ab	72.37B	73.5cde	68.70hi	79.0ab	73.73B	30.91d	28.22fghi	34.45abc	31.19B	33.33ef	28.56k	35.99bc	32.63C
KNO ₃ 2%	65.35ij	64.90j	65.10ij	65.12E	67.25hi	66.82i	67.0i	67.02E	27.40hi	27.11i	27.54hi	27.30D	28.08k	28.05k	28.41k	28.33F
KNO ₃ 4%	68.2ghi	67.0ghij	73.20de	69.47CD	70.10fgh	68.25hi	74.30cde	70.88CD	30.08def	28.80efgh	33.74bc	30.87B	31.65ghi	28.87k	34.40de	31.64D
KNO ₃ 6%	67.45ghi	66.70hij	69.0fgh	67.59D	69.0ghi	66.90i	71.75efg	69.22D	29.58defg	27.79ghi	30.53de	29.29C	30.71ij	28.27k	32.29fgh	30.42E
Mean (Time)	69.78B	66.56C	72.70A		71.61B	68.23C	74.47A		30.57B	28.37C	32.15A		32.06B	28.96C	33.60A	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table (2) Fruit set percentage (after 165 & 205days) of Washington navel orange trees as affected by gibberellic acid and potassium nitrate during 2008 and2009 seasons.

Treatments(T)	Fruit set % (after 165days – color break)								Fruit set % (after 205days)							
	2008, Season				2009, Season				2008, Season				2009, Season			
	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)
Control	5.97g	5.97g	5.97g	5.97E	6.30h	6.30h	6.30h	6.30E	2.04g	2.04g	2.04g	2.04D	2.18j	2.18j	2.18j	2.18D
GA ₃ 50ppm	7.85b	7.0bcd	8.69a	7.92B	8.38c	6.57gh	9.02b	7.99B	2.77b	2.32def	3.09a	2.73B	2.99cde	2.22ij	3.25bc	2.82B
GA ₃ 100ppm	6.7def	6.59efg	7.46bcd	6.92CD	7.31ef	6.56gh	7.98cd	7.28C	2.33def	2.10fg	2.6bcd	2.34C	2.57fgh	2.23ij	2.84def	2.54C
GA ₃ 50ppm+0.5%urea	8.69a	7.69bc	9.45a	8.61A	9.45b	7.89cd	10.03a	9.12A	3.12a	2.61bcd	3.39a	3.04A	3.44ab	2.76def	3.70a	3.30A
GA ₃ 100ppm+0.5%urea	6.91cde	6.56efg	7.81b	7.09C	7.53de	6.75gh	8.36c	7.55C	2.42cde	2.16efg	2.73bc	2.44C	2.68fg	2.29hij	2.99cde	2.65BC
KNO ₃ 2%	6.07g	6.05g	6.10g	6.07E	6.31h	6.36h	6.36h	6.34E	2.09fg	2.04g	2.09fg	2.07D	2.18j	2.19j	2.22ij	2.20D
KNO ₃ 4%	6.75def	6.19fg	7.69bc	6.88CD	7.50def	6.45h	8.30c	7.42C	2.39def	2.17efg	2.76b	2.44C	2.68fg	2.26ij	3.00cd	2.65C
KNO ₃ 6%	6.64efg	6.00g	7.02cde	6.55D	7.02fg	6.38h	7.55de	6.98D	2.31def	2.15efg	2.5bcd	2.32C	2.49ghi	2.27ij	2.70efg	2.49C
Mean (Time)	6.95B	6.54C	7.52A		7.48B	6.66C	7.99A		2.43B	2.20C	2.65A		2.65B	2.30C	2.86A	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table (3) Fruit weight and number of Washington navel orange trees as affected by gibberellic acid and potassium nitrate during 2008 and 2009 seasons.

Treatments(T)	Fruit weight (gm.)								Fruit number / tree							
	2008, Season				2009, Season				2008, Season				2009, Season			
	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)
Control	232gh	232gh	232gh	232D	268g	268g	268g	268D	310g	310.g	310.0g	310.0D	290.0j	290.0j	290j	290.0E
GA ₃ 50ppm	248d	222jk	220jk	230D	310a	294cd	298c	300.7A	510d	517d	580abc	535.7B	436de	350.0i	440de	408.7C
GA ₃ 100ppm	225ij	210L	210L	215F	304b	284e	292d	293.3B	580abc	535cd	636a	538.7A	400.7fg	370hi	434.3de	401.7C
GA ₃ 50ppm+0.5%urea	230hi	224j	217k	223.7E	278f	280ef	292d	283.3C	555bcd	541cd	610ab	568.7A	503.3a	385gh	460bcd	449.4A
GA ₃ 100ppm+0.5%urea	208L	240ef	218k	222E	272g	282ef	298c	284C	600ab	510d	620a	576.7A	471.7bc	380gh	430ef	427.2B
KNO ₃ 2%	206L	254c	272a	244B	210n	220m	233kl	220.9G	387f	293.3g	330g	336.8D	375ghi	350.0i	400g	375.0D
KNO ₃ 4%	262b	248d	236fg	248.7A	232L	252h	245i	243E	442.7ef	400ef	440ef	427.6C	488ab	395gh	471bc	451.3A
KNO ₃ 6%	238ef	242e	238ef	239.3C	237jk	238j	231L	235.3F	440e	400ef	430ef	424.8C	445cde	394gh	451cde	430.0B
Mean (Time)	231.1B	234.0A	230.4B		263.9B	264.7B	269.6A		478.6A	438.3B	494.5A		426.2A	364.3B	422A	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table (4) Yield (Yield Kg. /tree and ton / fed.) of Washington navel orange trees as affected by gibberellic acid and potassium nitrate during 2008 and 2009 seasons.

Treatments(T)	Yield Kg. /tree								Yield ton / fed.							
	2008, Season				2009, Season				2008, Season				2009, Season			
	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)
Control	72.02j	72.02j	71.02j	71.90C	77.54k	77.54k	77.54k	77.54G	11.52j	11.52j	11.52j	11.52C	12.44k	12.44k	12.44k	12.44G
GA ₃ 50ppm	127abcd	115cdef	127.6abcd	123.2A	133.4abc	102.5hi	130.95bc	122.2B	20.3abcd	18.39cdef	20.42abc	19.71A	21.35abc	16.40hi	20.95bc	19.57B
GA ₃ 100ppm	130.6abc	111.9defg	136.39a	126.3A	121.7de	105.1hi	126.7cd	117.8C	20.9abc	17.91defg	21.82a	20.21A	19.48de	16.81hi	20.28cd	18.86C
GA ₃ 50ppm+0.5%urea	127.5abcd	121.2abcd	132.4ab	127.0A	139.95a	107.75gh	134.29ab	127.3A	20.4abcd	19.4abcd	21.18ab	20.32A	22.39a	17.24gh	21.49ab	20.37A
GA ₃ 100ppm+0.5%urea	124.7abcd	122.3abcd	135.23a	127.4A	128.3bcd	107.13gh	128.07bcd	121.2BC	19.95abcd	19.57abcd	21.64a	20.39A	20.53bcd	17.14gh	20.49bcd	19.39BC
KNO ₃ 2%	79.86ij	74.87ij	90.11hi	81.61C	78.62k	76.95k	93.01j	82.86F	12.78ij	11.98ij	14.42hi	13.06C	12.58k	12.31k	14.88j	13.26F
KNO ₃ 4%	115.7bcde	98.83fgh	102.7fgh	105.7B	113.2fg	99.33ij	115.18ef	109.2D	18.51bcde	15.81fgh	16.42fgh	16.92B	18.11fg	15.89ij	18.43ef	17.48D
KNO ₃ 6%	105.8efgh	97.31gh	102.3fgh	101.8B	105.6hi	93.69j	103.69hi	101.0E	16.92efgh	15.57gh	16.36fgh	16.29B	16.89hi	14.99j	16.59hi	16.16E
Mean (Time)	110.4A	101.7B	112.3A		112.3A	96.21B	113.7A		17.66A	16.27B	17.97A		17.97A	15.41B	18.19A	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

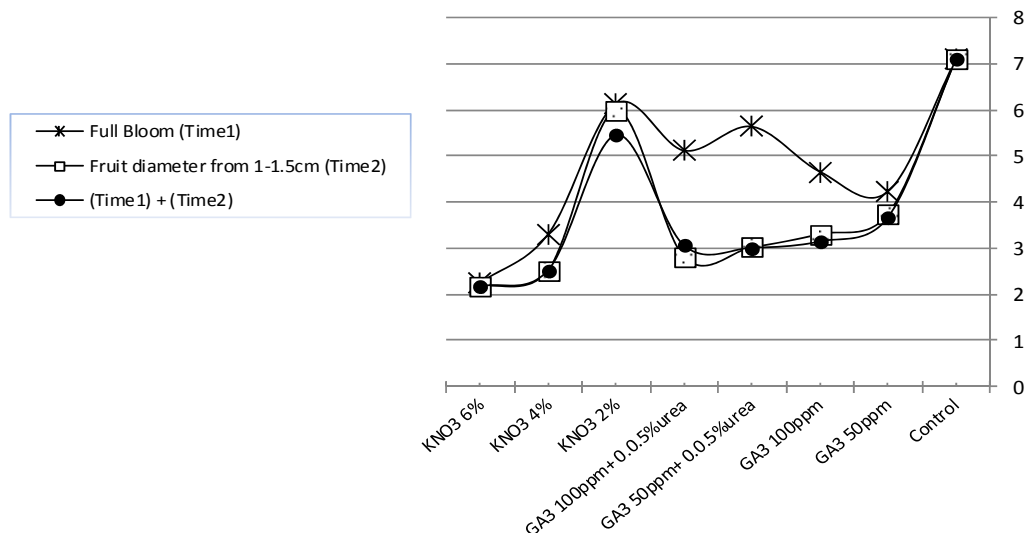


Fig. (1) Average of fruit splitting percentage of Washington navel orange trees as affected by gibberellic acid and potassium nitrate during two seasons.

Table (5) Nitrite in fruit juice of Washington navel orange trees as affected by gibberellic acid and potassium nitrate during 2008 and 2009 seasons.

Treatments(T)	NO ₂ (ppm)							
	2008, Season				2009, Season			
	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)
Control	2.51cdef	2.51cdef	2.51cdef	2.51CD	2.53fg	2.53fg	2.53fg	2.53C
GA ₃ 50ppm	2.51cdef	2.49def	2.50def	2.50CD	2.51g	2.53fg	2.54fg	2.53C
GA ₃ 100ppm	2.48ef	2.51cdef	2.47f	2.49D	2.54fg	2.54fg	2.53fg	2.54BC
GA ₃ 50ppm + .0.5%urea	2.52cdef	2.54cd	2.52cdef	2.53C	2.56defg	2.57cdef	2.56defg	2.56B
GA ₃ 100ppm + 0.5%urea	2.51cdef	2.50def	2.53cde	2.51CD	2.58bcde	2.56defg	2.55efg	2.56B
KNO ₃ 2%	2.61ab	2.56bc	2.60ab	2.59AB	2.60abcd	2.62abc	2.61abc	2.61A
KNO ₃ 4%	2.52cdef	2.64a	2.60ab	2.58B	2.61abcd	2.63ab	2.62abc	2.62A
KNO ₃ 6%	2.60ab	2.60ab	2.65a	2.62A	2.63ab	2.64a	2.65a	2.64A
Mean (Time)	2.53 A	2.54 A	2.55 A		2.57 A	2.58 A	2.58 A	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table (6) Nitrate in fruit juice of Washington navel orange trees as affected by gibberellic acid and potassium nitrate during 2008 and 2009 seasons.

Treatments(T)	NO3 (ppm)							
	2008, Season				2009, Season			
	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)
Control	46.40efg	46.40efg	46.40efg	46.40C	43.38fg	43.38fg	43.38fg	43.38D
GA ₃ 50ppm	40.52jkl	42.65ij	44.66ghi	42.61D	38.41i	39.53hi	44.66f	40.83E
GA ₃ 100ppm	40.51jkl	40.49jkl	40.49jkl	40.50E	43.35fg	42.56fg	44.57f	43.49D
GA ₃ 50ppm + 0.5%urea	38.24L	39.61kl	40.71jk	39.53E	38.61i	39.72hi	41.61gh	39.98E
GA ₃ 100ppm + 0.5%urea	40.60jkl	43.67hi	46.54efg	43.60D	48.41e	48.52e	54.52bc	50.48C
KNO ₃ 2%	47.41def	48.56cde	45.30fgh	47.09C	53.55bcd	48.79e	51.75d	51.36C
KNO ₃ 4%	47.29ef	48.66cde	49.72bcd	48.55B	52.53cd	52.36cd	55.72b	53.54B
KNO ₃ 6%	50.94abc	51.14ab	52.54a	51.54A	54.47bc	55.59b	59.62a	56.56A
Mean (Time)	43.99 B	45.15 A	45.80 A		46.59 B	46.31 B	59.62 A	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different

Juice weight percentage

Juice weight percentage of fruits is shown in Table (9); the changes of juice weight percentage were slightly fluctuated during two seasons. No obvious trend could be detected between all treatments. These results agree with the finding of (Abd El-Rahman, 2005) on navel orange trees, who mentioned that spraying gibberellic acid had no significant effect on juice weight percentage. In the same direction (Davies *et al.*, 1999) stated that, effects of GA₃ on juice fruits were variable, this inconsistency may be related to time of application.

Chemical properties of fruits

T.S.S percentage

Table (9) clearly showed that all treatments did not show a constant trend during two seasons for T.S.S percentage in fruit juice of Washington navel orange. Data also indicated that, spraying trees with KNO₃ at 4% gave the lowest significant values for T.S.S % comparing with other treatments. Anyhow, the differences between all treatments were low to be significant. A similar trend was obtained with navel orange (Ibrahim, *et al.* 1994 and Abel El-Rahman, 2005). On the other hand, (Mostafa and Saleh 2006) found that T.S.S content in the fruit juice increased with potassium sprays on Balady mandarin trees.

Acidity percentage

Table (10) reflects that trees sprayed with GA₃ 50 ppm had the highest significant acidity for Washington navel orange fruits in the first season, while, trees treated by potassium nitrate treatments gave the maximum acidity for their fruits in the second seasons especially with higher concentration. Meanwhile, the

other treatments scored the intermediate significant values in this regard for two seasons. These results are in the same line with those obtained by (Ibrahim, *et al.*, 1994) who found that total acidity were no significant effected by GA₃ treatment. Also, (Erner, *et al.* 1993) reported that trees spraying with KNO₃ increased juice acidity on Shamouti and Valencia oranges.

T.S.S acid ratio

It is evident from Table (10) that T.S.S acid ratio did not show any obvious trend in the first and second season. Concerning the time of foliar spraying, the results indicated that trees sprayed at second time (fruit diameter from 1.5-2.0 cm) recorded the highest significant values for T.S.S. acid ratio with KNO₃ 2% followed by GA₃ 100 ppm + 0.5% urea on Washington navel orange fruits than the other times of applications in the first season (2008). While, GA₃ 100 ppm + 0.5% urea gave the highest significant values for T.S.S. acid ratio in (second application and first application) respectively in the second season (2009). Also, it could be noticed that, the differences between all treatments were high to be significant.

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Table (7) Fruit diameter and length of Washington navel orange trees as affected by gibberellic acid and potassium nitrate during 2008 and 2009 seasons.

Treatments(T)	Fruit diameter (mm)								Fruit length (mm)							
	2008, Season				2009, Season				2008, Season				2009, Season			
	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)
Control	75.6abc	75.6abc	75.6abc	75.6A	79.6abcd	79.6abcd	79.6abcd	79.6AB	79.65a	79.65a	79.65a	79.65A	81.8abc	81.8abc	81.8abc	81.8BC
GA ₃ 50ppm	77.3abc	74.4abc	71.43 c	74.38A	79.6abcd	80.99abc	83.44a	79.6AB	81.46a	79.19a	80.90a	80.52A	81.2abc	84.88ab	83.1abc	83.1ABC
GA ₃ 100ppm	75.2abc	74.4abc	74.2abc	74.62A	82.95ab	82.50ab	82.69ab	82.71A	79.58a	81.28a	77.56a	79.47A	85.11ab	85.56a	85.94a	85.54A
GA ₃ 50ppm+0.5%urea	74.9abc	76.6abc	73.6abc	75.00A	81.48ab	81.53ab	82.54ab	81.5AB	79.04a	80.57a	79.54a	79.72A	82.7abc	82.1abc	82.1abc	82.3BC
GA ₃ 100ppm+0.5%urea	74.4abc	72.33bc	74.2abc	73.62A	80.2abcd	81.40ab	82.54ab	81.4AB	79.32a	78.47a	79.39a	79.20A	83.4abc	84.75ab	84.2abc	84.1AB
KNO ₃ 2%	72.6abc	77.6abc	79.85a	76.68A	75.38cd	79.5abcd	80.38abc	78.40B	77.67a	80.56a	83.42a	80.55A	79.38c	82.4abc	81.3abc	81.02C
KNO ₃ 4%	78.91ab	77.4abc	75.4abc	77.25A	80.58abc	79.6abcd	77.36bcd	79.16B	80.96a	80.94a	82.48a	81.46A	81.5abc	82.6abc	80.38bc	81.5BC
KNO ₃ 6%	77.0abc	77.1abc	77.1abc	77.06A	79.3abcd	78.4abcd	79.3abcd	78.99B	79.77a	79.43a	82.46a	80.55A	82.5abc	81.5abc	81.5abc	81.85BC
Mean (Time)	75.73A	75.68A	75.15A		79.24A	80.42A	80.85A		79.68A	80.07A	80.68A		82.21a	83.21a	82.55a	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table (8) Fruit size and Peel thickness of Washington navel orange trees as affected by gibberellic acid and potassium nitrate during 2008 and 2009 seasons.

Treatments(T)	Fruit size (ml)								Peel thickness (mm)							
	2008, Season				2009, Season				2008, Season				2009, Season			
	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)
Control	248i	248i	248i	248FG	296g	296g	296g	296E	4.46i	4.46i	4.46i	4.46D	4.10g	4.10g	4.10g	4.10C
GA ₃ 50ppm	275d	250i	250i	258.3D	346abcd	330bcde	332bcde	336BC	3.49p	3.61O	3.79n	3.63H	3.90i	3.70k	3.10O	3.57G
GA ₃ 100ppm	260g	250i	242j	250.7F	320cdef	310efg	320cdef	316.7D	3.85m	4.83d	4.28j	4.32G	3.27m	3.63L	4.03h	3.64F
GA ₃ 50ppm+0.5%urea	255h	270e	236k	253.7E	300fg	325cdef	320cdef	315D	3.99L	4.63g	4.65g	4.42E	3.10O	3.15no	3.20n	3.15H
GA ₃ 100ppm+0.5%urea	240jk	252hi	248i	246.7G	320cdef	317defg	330bcde	323.3CD	4.9bc	4.11k	4.06k	4.35F	3.60L	3.84j	3.70k	3.71E
KNO ₃ 2%	285c	270e	265f	273.3C	335bcde	350abc	345abcd	343.3AB	4.71f	4.87bcd	4.53h	4.70C	4.10g	4.20f	3.80j	4.03D
KNO ₃ 4%	290b	270e	270e	276.7B	330bcde	360ab	350abc	346.7AB	4.29j	5.10a	4.84cd	4.74B	3.70k	4.30e	4.44d	4.15B
KNO ₃ 6%	295a	275de	275d	281.6A	360ab	338abcd	368a	355.3A	4.77e	4.66fg	4.92b	4.78A	4.60b	4.51C	5.80a	4.97A
Mean (Time)	268.5A	260.6B	254.3C		325.9A	328.3A	332.6A		4.31C	4.53A	4.44B		3.80C	3.93B	4.02A	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table (9) Juice weight and T.S.S percentage in Washington navel orange fruits as affected by gibberellic acid and potassium nitrate during 2008 and 2009 seasons.

Treatments(T)	Juice weight (%)								T.S.S (%)							
	2008, Season				2009, Season				2008, Season				2009, Season			
	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)
Control	56.0efg	56.0efg	56.0efg	56.0C	53.7hijk	53.7hijk	53.7hijk	53.7C	10.5abc	10.5abc	10.5abc	10.5ABC	11.00a	11.00a	11.00a	11.00A
GA ₃ 50ppm	59.7bc	61.3ab	62.73a	61.2A	51.9k	56.5efg	54.4ghij	54.3C	10.5abc	10.abcd	10.5abc	10.3ABC	10.5ab	10.5ab	10.00ab	10.3ABC
GA ₃ 100ppm	61.3ab	60.0bc	58.1cde	59.8B	55.3fghi	54.9fghi	53.4ijk	54.5C	10.0abcd	11.00a	10.0abcd	10.3ABC	11.00a	11.00a	10.00ab	10.67AB
GA ₃ 50ppm+0.5%urea	60.0bc	63.40a	55.3fgh	59.6B	56.1def	52.8jk	53.4ijk	54.4C	9.8bcd	9.50cd	10.25abc	9.86BC	10.5ab	9.50b	10.25ab	10.08BC
GA ₃ 100ppm+0.5%urea	56.7defg	53.3hi	56.9def	55.7C	52.9jk	53.9hijk	56.0efg	54.3C	11.00a	10.83ab	10.0abcd	10.61A	11.00a	10.5ab	10.5ab	10.67AB
KNO ₃ 2%	56.3efg	55.1fgh	54.4gh	55.3C	55.7efgh	57.7cde	60.9ab	58.1B	11.00a	10.3abc	10.0abcd	10.42AB	10.5ab	11.00a	10.8ab	10.77AB
KNO ₃ 4%	58.0cde	51.6lj	56.8def	55.5C	59.4zbc	62.5a	62.5a	61.5A	10.0abcd	9.7cd	9.50cd	9.73C	10.0ab	9.50b	9.80ab	9.77C
KNO ₃ 6%	59.7bc	50.41j	58.8cd	56.3C	59.4bc	58.6cd	59.7bc	59.2B	11.00a	9.00d	10.0abcd	10.0ABC	9.90ab	10.0ab	10.5ab	10.13BC
Mean (Time)	58.47A	56.39C	57.38B		55.65B	56.32AB	56.74A		10.48A	10.10A	10.09A		10.55A	10.38A	10.36A	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table (10) Acidity percentage and T.S.S / Acid ratio in Washington navel orange fruits as affected by gibberellic acid and potassium nitrate during 2008 and 2009 seasons.

Treatments(T)	Acidity (%)								T.S.S / Acid ratio							
	2008, Season				2009, Season				2008, Season				2009, Season			
	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)	Full Bloom (Time1)	Fruit diameter from 1.5-2.0cm (Time2)	(Time1) + (Time2)	Mean(T)
Control	1.07efg	1.07efg	1.07efg	1.07CD	0.96fg	0.96fg	0.96fg	0.96B	9.81d	9.81d	9.81d	9.81C	11.5ef	11.5ef	11.5ef	11.5CD
GA ₃ 50ppm	1.25a	1.16c	1.22ab	1.21A	0.84ijk	0.84ijk	0.79k	0.82D	8.40j	8.6hij	8.61ij	8.55F	12.5cd	12.5cd	12.66c	12.55B
GA ₃ 100ppm	1.07efg	1.12cde	1.14cd	1.11B	0.92gh	0.88hij	0.96fg	0.92C	9.35ef	9.82d	8.8ghij	9.31D	12.0de	12.5cd	10.42h	11.63C
GA ₃ 50ppm+0.5%urea	1.08ef	1.05fg	1.14cd	1.09BC	0.99ef	0.84ijk	0.89hi	0.91C	9.1efg	9.1efg	9.0fgh	9.05E	10.61h	11.3fg	11.5ef	11.15D
GA ₃ 100ppm+0.5%urea	1.09def	0.96i	1.07efg	1.04E	0.82k	0.73L	0.83jk	0.79E	10.1cd	11.28b	9.35ef	10.24B	13.41b	14.38a	12.65c	13.48A
KNO ₃ 2%	1.12cde	0.86j	0.96i	0.98F	1.08ab	1.07abc	1.0def	1.05A	9.82d	11.92a	10.41c	10.72A	9.72i	10.27h	10.8gh	10.26E
KNO ₃ 4%	0.96i	1.09def	0.96i	1.00F	1.10a	0.99ef	1.0cde	1.04A	10.4bc	8.9ghi	9.90d	9.74C	9.09j	9.60ij	9.62ij	9.44F
KNO ₃ 6%	1.17bc	0.99hi	1.02gh	1.06DE	1.1abcd	1.04bcde	1.1abcd	1.05A	9.40e	9.1efg	9.81d	9.43D	9.47ij	9.58ij	9.52ij	9.52F
Mean (Time)	1.10A	1.04C	1.07B		0.97A	0.92B	0.94B		9.55B	9.81A	9.46B		11.03B	11.45A	10.08B	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

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