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EFFECT OF SOME GROWTH REGULATORS AND BORIC ACID ON YIELD AND FRUIT QUALITY OF CLEMENTINE MANDARIN *"Citrus reticulata"*

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ABSTRACT: This study was carried out to investigate the effect of spraying Clementine Mandarin trees with 10&20 ppm of gibberellic acid (GA) , 20&30 ppm of 2,4 – D and 100&200 ppm of boric acid at full bloom stage on yield and fruit quality.

It was noticed that both GA_3 treatments , as well as , the boric acid treatment at 200 ppm significantly increased the percent of fruit set, fruit retained after June drop and mature fruits (yield). In the same time, 30 ppm 2, 4-D and 100 ppm boric acid slightly, but not significantly, increased the percent of fruit set.

As for the fruit shape, it may be, generally concluded that the fruit set under the effect of gibberellic acid, 2,4-D and boric acid were more elongated (width / length ratio) than that of control. Concerning fruit that of quality, the 2,4-D and boric acid treatments slightly increased, TSS% and decreased vitamin C fruit content. On the contrary it was noticed that GA_3 delayed fruit maturity and decreased TSS%.

INTRODUCTION

Clementine Mandarin fruits are known with their excellent eating characteristics and attractive appearance due to their deep orange rind color. On the other side Clementine trees suffer from alternate bearing habit, poor fruit set percentage mainly due to flower self incompatability and low fruit yield. Many previous studies were performed to increase the percentage of fruit set, consequently the fruit yield in different citrus sp., through application of some growth regulators such as 2,4-D and GA as well as boric acid (**Garcia *et al.*, 1992; Garcia-Papi and Martinez, 2003; Room and Ranjit, 2003 and El-Otmani *et al.*, 2004**).

In addition, **Rajbir *et al.*, (2007)** reported that boron deficiency acts as a physiological barrier leading to flower incompatability, hence cause low percentage of fruit set.

Therefore, the target of the present study is to overcome the problem of low fruit set percentage a well as to increase the yield of Clementine Mandarin throw application of GA, 2,4-D or boric acid.

MATERIALS AND METHODS

The present study was conducted for two years 2003 and 2004 on 16 years old Clementine Mandarin trees budded on sour orange rootstock grown at a private orchard located in Delengat-Behera Governorate. The trees are cultivated on sandy loam calcareous soil and received similar normal cultural practices. Treatments of the experiment were done on three replicates, each replicate contained one tree.

The treatments are:

1- Control : The trees were received foliar spray with tap water at full bloom. (One treatment) .

2- Spraying GA-solution using the commercial salt that is known with "Berelex" as foliar spray at full bloom with concentrations 10 and 20 ppm. Agral was added to GA solution as wetting agent at concentration 0.1%, (two treatments) .

3- Spraying 2, 4 -D (2,4 - dichlorophenoxy acetic acid) as foliar spray at full bloom at concentrations 20 and 30 ppm. Agral 0.1% was also added to the solution, (two treatments).

4- Foliar spray with boric acid solution (8% B) at concentration 100 and 200 ppm, plus Agral 0.1% at full bloom, (two treatments).

Measurements:

1- Fruit set%: flowers on four main branch / tree were counted one week before bloom. Three days after a complete fruit set, the fruits / branch were counted.

$$\text{fruit set \%} = \frac{\text{Total fruits per branch}}{\text{Total number of flowers per branch}} \times 100$$

2- Number and percentage of fruit retained / main branch at fruit maturity stage were determined .

Percentage of fruit retained was calculated according to the equation:

$$\frac{\text{Number of retained fruits at maturity / branch}}{\text{Number of fruit set / branch}} \times 100$$

fruit maturity was adjusted according to **(Jimenez *et al.*, 1990).**

3- The yield / tree : was estimated throw the following equation:
Estimated yield / tree = Number of fruits / branch X Number of branches / tree X fruit weight at maturity.
4- Physical characteristics of fruit: the following parameters were measured:
Fruit length (cm), fruit width (cm), fruit shape (W/L), fruit weight (gm), Number of seeds / fruit and juice percentage (fr. wt.) per fruit%.
5- Biochemical fruit characteristics: the following parameters were measured: TSS%, Total acidity%, TSS / Acid ratio and vitamin C content (mg / 100 gm juice).
A complete randomize block design was used to analyze the variance **(Snedecor and Cochran, 1980).**

RESULTS AND DISCUSSION

1- Fruit set:

It is obvious in Table (1) that the treatments with GA_3 (10 and 20 ppm) showed the highest number of fruit set and percentages in comparison to that of other treatments including control, while the two 2,4-D treatments and 100 ppm of boric acid treatment recorded the lowest values among all treatments.

Talon *et al.*, (1992) reported that low fruit set in Mandarin cultivars was linked to low gibberellin content in the developing ovaries. In addition, gibberellin was shown to increase sink strength in ovaries and enhance assimilate export to the developing fruits of Navel orange **(Mauk *et al.*, 1986)**. Differences in fruit set (number and percentage) at 20 ppm GA_3 and all other treatments were significant.

2- Number and percentage of retained fruits at maturity:

Table (1) clearly showed that the two GA_3 treatments and 200 ppm boric acid gave higher significant number of retained fruits / branch than that of control in both studied seasons.
Treating with GA_3 at 20 ppm showed the maximum number of fruits retained per main branch among all other treatments, while treatments with 2,4-D (20 and 30 ppm) as well as boric acid at 100 ppm showed a minimal number of retained fruits/branch in comparison to other

treatments. **El-Otmani *et al.*, (2004)** stated that GA_3 enhanced early fruit growth stages, which resulting in delaying or ceasing the early fruit drop and caused an increase in final fruit retention.

Table (1): Effect of some growth regulators and Boric acid on fruit set, fruits retention and estimated yield of Clementine Mandarin trees (2003 and 2004 seasons).

2003

Treatment	No. of treated flowers / branch	No. of branches	Fruit set / main branch		Fruit retention / branch at maturity		Fruit wt. (g.)	Estimated Yield / tree (kg)
			No.	%	No.	%		
Control	527	6	180	34.0	57	31.6	62.4	21.3
GA_3 10ppm	507	5	355	70.0	138	38.9	73.0	51.7
GA_3 20ppm	521	5	391	75.1	142	36.3	71.4	51.5
2,4-D 20ppm	492	5	207	42.1	115	55.5	70.1	41.4
2,4-D 30ppm	512	5	205	40.0	115	56.1	70.4	41.1
B.acid 100ppm	522	5	198	38.0	116	58.6	82.0	47.6
B.acid 200ppm	497	5	323	65.0	125	38.7	64.8	40.5
L.S.D at 0.05	N.S	N.S	20.5	6.8	13.1	2.9	2.4	4.1

2004

Control	522	6	187	35.8	62	33.2	63.0	23.4
GA_3 10ppm	518	5	364	70.3	138	37.9	73.0	50.6
GA_3 20ppm	498	5	380	76.3	146	38.4	71.4	52.1
2,4-D 20ppm	510	5	408	48.4	116	28.4	70.9	41.1
2,4-D 30ppm	489	5	200	40.9	114	57.0	70.4	40.2
B.acid 100ppm	507	5	234	46.2	117	50.0	82.3	48.1
B.acid 200ppm	511	5	292	57.1	130	44.5	64.8	42.1
L.S.D at 0.05	N.S.	N.S	31.5	6.3	10.2	3.2	2.4	4.3

Regarding the percentage of retained fruits / branch, the results in Table (1) indicated that all treatments gave higher fruit retention percentage than that of control. However, 2,4-D at 20 or 30 ppm and boric acid at 100 ppm gave higher percentages of retained fruits than other treatments or control except that of 2,4-D at 20 ppm in the second season. It seemed that the low number of fruit set in the three mentioned treatments led to a reduction of the competition between fruits in obtaining sufficient assimilate which consequently led to a reduction of the fruit drop. Thus the percentages of retained fruits increased by application of 2,4-D 20 & 30 ppm or boric acid 100 ppm.

These results were in the same line with those reported by others who found that application of growth regulator such as GA_3 at 10, 15 or 25ppm enhanced fruit set and increased yield of Clementine. In addition, **Mauk *et al.*, (1986)** concluded that GA_3 acts principally in preventing the abscission of fruitlets with aborting embryos. Concerning the boric acid treatments, the results in this study agreed with those reported by **Room and Ranjit (2003) and Rajbir *et al.*, (2007)** working on Mandarin, who stated that the deficiency of boron is a physiological barrier to fertilization, since boron stimulates pollen germination and pollen tube growth, as well as the formation of plant auxins that lead to encourgement of sucrose translocation to fruits.

3-The estimated yield /tree:

Table (1) showed that estimated yield/tree significantly increased by all treatments than the control. The two GA_3 treatments and to less extent boric acid at 100 ppm gave the most increase in estimated yield than other treatments.

The significant increase in estimated fruit yield after spraying with GA, 10 or 20 ppm was due to the significant increase in both fruit weight and number of retained fruit per branch. Thus gibberellin application decreased the fruit drop and increased the fruit weight. Gibberellin was shown to increase sink strength in ovaries and enhance assimilate export to the developing fruit **(Mauk *et al.*, 1986). Garcia-Papi and Martinz (2003)** reported that sprayed GA_3 increased translocation of minerals from leaves to the growing fruit.

4- Physical characteristics of fruits:

4-1. Fruit weight:

The data illustrated in Table (2) showed that fruit weight of Clementine Mandarin significantly increased by all experimented treatments than that of control in both studied seasons. Boric acid at 100 ppm as well as GA_3 at 10 or 20 ppm showed the maximum values of fruit weight in the two seasons when compared with other treatments. These results were agreement with those obtained by **El-Otmani *et al.*, (2004)** who found that growth regulators increased fruit weight than control.

4-2. Seed / fruit:

It is obvious from data in Table (2) that all fruits which treated with

Gibberellic acid or 2,4-D were completely set parthenocarpic. Beside, the self-incompatabilty of the variety Clementine Mandarin shared to some extent in occurring the seedlessness of the fruits specially when no pollens other than its own were available. **Talon *et al.*, (1992)** came to similar conclusion.

Table (2): Effect of some growth regulators and Boric acid on the number of seeds per fruit, fruit dimensions, fruit shape and fruit weight of Clementine Mandarin trees (2003 and 2004) seasons.

2003

Treatment	No. of Seeds / fruit	Fruit Dimentions Fruit width (cm)	Fruit length (cm)	Fruit shape W / L	Fruit No. /tree	Fruit weight (g)
Control	3.9	5.4	4.5	1.1	342	62.4
GA_3 10ppm	0.0	4.7	5.3	0.9	690	73.0
GA_3 20ppm	0.0	4.6	5.2	0.9	710	71.4
2,4-D 20ppm	0.0	4.5	5.3	0.9	575	70.1
2,4-D 30ppm	0.0	4.5	5.3	0.9	575	70.4
B.acid 100ppm	6.2	4.5	4.9	0.9	580	82.0
B.acid 200ppm	7.7	4.6	5.1	0.9	625	64.8
L.S.D at 0.05	1.3	0.2	0.2	0.03	14.5	2.4

2004

Control	4.1	5.5	4.4	1.2	372	63.0
GA_3 10ppm	0.0	4.6	5.2	0.9	690	73.0
GA_3 20ppm	0.0	4.5	5.2	0.9	730	71.4
2,4-D 20ppm	0.0	4.5	5.2	0.9	580	70.9
2,4-D 30ppm	0.0	4.7	5.3	0.9	570	70.4
B.acid 100ppm	6.6	4.5	5.0	0.9	585	82.3
B.acid 200ppm	8.9	4.5	4.9	0.9	650	64.8
L.S.D at 0.05	1.9	0.2	0.2	0.02	10.1	2.4

As can be seen in Table (2) that all fruits produced from trees previously treated with boric acid were completely seeded. The presence of seeds indicates that boric acid treatments appeared to help in overcoming the self-incompatabilty barrier through promoting pollen germination and tube growth and also, stimulating fertilization process in the ovaries. **Rajbir *et al.*, (2007)** came to similar conclusion.

4-3. Fruit dimentions and shape:

It is obvious from Table (2) that the fruits from trees that were previously treated with GA_3, 2,4-D or boric acid were more elongated than those of control. Fruits were more nicked with GA_3 or 2,4-D rather than with boric acid treatments **(Barros, 1992)**. As can be seen in table

(2), all treatments produced elongated fruits in comparison to those of control. Differences among all treatments and control were significant.

5- Biochemical fruit characteristics:

It is clear from Table (3) that juice per fruit percentage were the highest with 20 ppm GA_3, this was true in both seasons. In the same time no significant difference in juice acidity percentage among the different treatments in both seasons was noticed.

Table (3): Effect of some growth regulators and Boric acid on fruit quality of Clementine Mandarin trees (2003 and 2004 seasons).

Treatment	2003				
	Juice per fruit %(fr.wt.)	TSS%	Total acidity (Citric acid) (g.) /100 (g.) of juice	TSS / acid ratio	Vit. C mg. / 100 g. juice
Control	39.9	13.4	0.9	13.7	45.7
GA_3 10ppm	42.0	12.7	0.9	14.1	43.1
GA_3 20ppm	46.0	12.5	0.9	14.0	42.5
2,4-D 20ppm	44.0	13.8	0.9	16.0	41.7
2,4-D 30ppm	43.0	13.6	0.8	16.2	41.9
B.acid 100ppm	39.5	13.5	0.8	16.4	41.8
B.acid 200ppm	40.2	13.7	0.8	17.1	41.2
L.S.D at 0.05	3.2	N.S.	N.S.	2.3	2.0
	2004				
Control	40.1	13.5	0.9	14.7	47.2
GA_3 10ppm	41.1	12.8	0.9	14.4	44.0
GA_3 20ppm	44.2	12.6	0.9	13.7	43.1
2,4-D 20ppm	43.6	13.8	0.9	16.3	41.2
2,4-D 30ppm	42.9	13.6	0.8	16.6	40.9
B.acid 100ppm	41.9	13.7	0.8	17.1	42.8
B.acid 200ppm	40.0	13.8	0.8	16.7	42.0
L.S.D at 0.05	2.9	N.S.	N.S.	2.4	3.1

As for the total soluble solids, the data revealed that treated trees with 2,4-D and boric acid gave higher values of TSS% than control, while the two GA_3 treatments gave the lower values. This was true in both seasons. The 20 ppm 2,4-D treatment recorded the highest TSS%. The reverse was with the 20 ppm GA_3 treatment. It was noticed that differences were not significant in both seasons of study.

Concerning the total acidity (citric acid) in fruit juice, the data in both seasons generally cleared that, the GA_3 treatments and 2,4-D at 20 ppm recorded the highest percentage, while the reverse was true with 100, 200 ppm boric acid and 30 ppm 2,4-D treatment. In the same time,

differences among treatments in the percentage of total acids in fruit juice were insignificant.

The TSS/acid ratio was significantly higher with both boric acid treatments than with GA_3 treatments. This was true in both seasons of study, while 2,4-D treatments gave intermediate ratio. The differences in TSS/acid ratio. between boric acid treatments and control were significant.

Regarding vitamin C content in fruit juice, the data in both seasons showed that the control and GA_3 treatments recorded the highest vitamin C content in fruit juice, while 200 ppm boric acid and 20 ppm 2,4-D recorded the lowest V.C. fruit content. Other treatments gave intermediate values of V.C. fruit content. All differences among treatments were not enough to be significant.

These results were in the same line with those obtained by **(El-Otmani *et al.*, 2004)** on Clementine, who found that, juice content% per fruit and ascorbic acid were increased, while TSS / acid ratio were significantly decreased in fruits treated by GA_3.

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الملخص العربي

تأثير الرش ببعض منظمات النمو وحمض البوريك على المحصول وجودة ثمار اليوسفى الكليمانتين.

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تهدف هذه الدراسة إلى معرفة تأثير رش أشجار اليوسفى الكليمانتين بتركيزات ١٠و ٢٠ جزء فى المليون من الجبرالين و ٢٠, ٣٠ جزء فى المليون 2, 4 - D و ١٠٠و ٢٠٠جزء فى المليون من حمض البوريك أثناء الإزهار الكامل على المحصول وجودة الثمار. وقد أوضحت النتائج أن كلا من معاملتى الجبريلين وحمض البوريك بتركيز ٢٠٠ جزء فى المليون زادت من عقد الثمار وكذلك عدد الثمار المتبقية بعد تساقط يونية وكمية المحصول الناتج وفى الوقت نفسه أدت معاملة الـ ٣٠ جزء فى المليون2, 4 - D , ١٠٠ جزء فى المليون حمض البوريك إلى زيادة نسبة الثمار العاقدة أما فيما يتعلق بشكل الثمار فقد كانت الثمار العاقدة بعد الرش بالمعاملات سابقة الذكر مستطيلة عن الثمار الأخرى الناتجة من الكنترول. وأظهرت النتائج أيضا أن الثمار المعاملة بالـ 2, 4 - D أو حمض البوريك زاد محتواها من المواد الصلبة الذائبة وقل محتواها من فيتامين ج قليلا كما قلت الحموضة وكان العكس فى الثمار المعاملة بالجبرالين.