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RESPONSE OF EARLY GRAND PEACH TO CHEMICAL THINNING; ETHREL, GIBBERELLIC ACID AND UREA. I. YIELD AND FRUIT QUALITY

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ABSTRACT

The results of the two successive seasons of 1997 and 1998 revealed that chemical thinning with gibberellic acid (GA_3), urea at pre-bloom stage and ethrel at post-bloom stage of Early Grand peach trees significantly reduced yield but increased fruit weight.

In general, the three thinning treatments significantly increased both total soluble solids and vitamin "C". As for juice acidity, it was increased by GA_3, decreased by ethrel and was not affected by urea treatments.

As for fruit firmness, data showed that ethrel reduced firmness in the meanwhile, it increased total soluble pectin. On the other hand, both GA_3 and urea treatments produced firmer fruits as a result of reducing the total soluble pectin significantly.

It was also found that total chlorophyll was significantly decreased with ethrel treatments and increased with both GA_3 and urea treatments. In addition, carotene and anthocyanin were increased by ethrel and were not affected by both GA_3 and urea treatments.

Data of the present study showed that chemical thinning caused a general increase in total sugars, while total phenols were affected by ethrel only.

INTRODUCTION

The highly fruit setting clearly observed in peach trees is considered to be the main reason in producing a lot of small size fruits with low or poor quality. The ultimate objective of peach fruit growers is to obtain both the highest regular crops and the best fruit quality. Fruit thinning is done to reduce limb breakage, increase fruit size and improve its colour and quality, to stimulate floral initiation for next year's crop and to increase the effectiveness of pest control program. Growers could increase the economic efficiency of peach production if reliable chemical thinning agents were available (Daniel, 1988). Hand thinning is one of the most expensive task (Mizelle and Westberry, 1989). Thinning agents could, also, optimize the physiological efficiency of peach trees by reducing flower and fruit density early, when fruit size is increased by thinning with the least reduction of tonnage.

Chemical thinning of some peach cultivars was evaluated by Duarte and Jauregui (1990) (with ethephon), Southwick *et al*.(1995) (with gibberellic acid) and Zilkah *et al*. (1988) (with urea).

Recently, increased marked pressures to maximize fruit size and minimize labor costs have dramatically increased the need for chemical thinning agents for peaches. Therefore, the present investigation aimed to study the effect of ethrel, gibberellic acid and urea on fruit thinning of "Early Grand" peach after being applied at pre- and post-bloom stages.

MATERIALS AND METHODS

The experiment was conducted during 1997 and 1998 growing seasons on 8-year old peach cv. Early Grand on Nemagard rootstock, growing in loamy sand soil at commercial orchard located at El-Nobaria, Behera Governorate. The trees were as uniform as possible, planted at 5x5 meters. The orchard was drip irrigated by using 2x4 liter h^{-1} emitters per tree. Nutrients were applied via fertigation. Irrigation was provided daily for 4 h during each season (~10 February to 15 October). The irrigation hours were increased by one hour every 15 days till the beginning of July and then decreased by 1 hour every 15 days till October, according to local irrigation regime. The experimental trees were sprayed with water (control), 50, 100, 150 ppm of gibberellic acid (GA_3), 2, 3 and 4% urea at pre-bloom stage (18 January) or 25, 50 and 100 ppm ethrel (2-chloroethyl phosphonic acid) at the post-bloom stage (18 February). Each plot included one tree and each treatment was replicated four times in a randomized block design. Four branches per tree were used to calculate the percentage of fruit drop.

In both seasons, the yield was recorded at 22^{nd} of April of each treatment as number of fruits per tree and yield weight was estimated by multiplying number of fruits x average weight of fruit.

Twenty mature fruits (full fruit growth) of each treatment were taken to determine the fruit characteristics including seed, pulp and average of fruit weight. Fruit firmness was determined by Magness and Taylor (1925) pressure tester using a 5/16 plunger. Two readings were taken on the flesh of each fruit after peeling. In fruit juice; total soluble solids (T.S.S) were determined using a hand refractometer.

Acidity was estimated as malic acid and vitamin C content was determined using 2,6-dichlorophenol indophenol dye according to the A.O.A.C. (1980). Peel chlorophyll and carotene (mg/100g fresh weight) were colourimetrically determined according to the procedure outlined by Wensttein (1957). Anthocyanin was determined (mg/100 g fresh weight) according to Rabino *et al*.(1977). Sugars content was determined according to the procedures outlined by Malik and Singh (1980). Total soluble pectin was determined according to McComb and McCready (1952) Total phenols were determined according to A.O.A.C. (1980).

The obtained data throughout the two studied growing seasons were statistically analyzed using the analysis of variance (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

I. Yield :

Regarding the effect of spraying Early Grand peach trees with ethrel, GA_3 and urea on yield, the data presented in Table (1) indicated that all treatments reduced yield as number of fruits and kilogram per tree than the untreated trees (control). In both experimental seasons, spraying trees with ethrel at 50 and 100 ppm, GA_3 treatments (50, 100 and 150 ppm) caused a significant decrease in yield as compared with untreated trees, except for ethrel at 50 ppm for yield as kg/tree in the first season.

As for urea treatments, significant differences were found for the highest two concentrations (3 and 4%) as compared with untreated trees in 1997 and 1998 seasons. These results agreed with those reported by Vitagliano *et al*.(1985), Zilkah *et al*.(1988), Durner *et al*.(1990), Modie (1990),Muthoo *et al*.(1997) and Abdel-Hamid (1999) working on peach.

Ethrel (ethylene-releasing agent) is known to be an effective thinner in several fruit crops (Muthoo *et al*., 1997). Likewise, GA_3 may influence abscission by stimulating the formation of abscission layer or altering the amount of auxin in the tissue which, in turn, affects abscission by increasing ethylene formation (Burg, 1973). Also, Lewis and Varner (1970) reported that the hormone may increase the activity of certain enzymes such as cellulase, pectinase and alpha-amylase. So, the above mentioned interpretation could explain the reduction in fruit set in the present study resulting from the abscission of flowers sprayed with GA_3 at pre-bloom.

On the other hand, urea treatments produced low yield in both seasons, with significant differences between 3 and 4% concentrations compared with control. The reduction in total yield with urea treatments might be attributed mainly to the higher fruit abscission with urea treatments, and this may be due to their damaging effect on flowers. This result agreed with those found by Abdel-Hamid (1999) working on Florida Prince peach.

II. Fruit drop (%) :

Data in Table (1) showed that the foliar application of Early Grand peach trees with the three chemical thinners caused an increase in the percentage of fruit drop as compared with untreated trees (control). In both seasons of study, spraying trees with ethrel at 50 and 100 ppm, GA_3 treatments (50, 100 and 150 ppm) and the highest two concentrations of urea (3 and 4%) caused significant increase in fruit drop percentage, compared with untreated trees (control). These results are in line with those reported by Khalil *et al*.(1990), Modie (1990) and Southwick *et al*.(1995) working on peach cultivars.

III. Fruit Quality :

1. Physical parameters :

Fruit, pulp and seed weight

The present results in Table (1) revealed the influence of thinning treatments on fruit, pulp and seed weight during the two seasons. Comparing with the control, a gradual increment was found in both fruit and pulp weight by increasing ethrel, GA_3 and urea concentrations in both seasons. Differences were significant between the control and the two high concentrations of ethrel, GA_3 in the two seasons, and urea in the first season. While, in the second season, significant differences were found between the three urea treatments and control. These results are in line with those obtained by Bay-Kam (1984), Vitagliano *et al*.(1985), Forlani *et al*.(1986), Byers (1989) and Muhammad *et al*.(1996) working on peaches.

Results in Table (1), also, showed that, in both experimental seasons, the three chemical thinners caused an increase in seed weight as compared with control. With a closer view, results showed that significant increase was found in the highest ethrel treatment (100 ppm) in both seasons and significant differences were also found for the highest two GA_3 concentrations (100 and 150 ppm) and the highest urea concentration (4%) in the first season. While in the second season, significant increase was found for the highest concentration of GA_3 (150 ppm) and the highest two concentrations of urea (3 and 4%) as compared with untreated trees (control).

2. Chemical parameters :

a) Total soluble solids (TSS) :

Investigating the effect of the chemical thinners on fruit chemical parameters, it is obvious from the data presented in Tables (2 and 3) that the three ethrel treatments and the highest GA_3 concentration caused a significant increase in TSS compared with the control. These results agreed with those reported by Hassan *et al*.(1987) and Muthoo *et al*. (1997). Data in Tables (2 and 3), also, showed that, in both seasons, urea treatments caused a slight increase in TSS, but differences were not big enough to be significant as compared with control. These results are in agreement with those reported by Abdel-Hamid (1999) working on peach.

In general, increasing the percentage of TSS in all treatments rather than the control may be due to the starch hydrolysis as a result of synthesis of alpha-amylase (Jones and Armstrong, 1971).

b) Acidity :

Data in Table (2) showed that the foliar application of the three chemical thinners differentially acted in fruit juice acidity comparing with the control. Increasing the GA_3 concentration caused an increase in juice acidity. Differences were significant between the control and GA_3 at the highest two concentrations (100 and 150 ppm). These results may be attributed to the effect of GA_3 treatment in delaying fruit maturation as described by Muhammad *et al*.(1996). Also, these results agreed with Jonson and Handley (1989). Releasing organic and amino acids from protein and carbohydrate synthesis may explain the increase in fruit acidity at all GA_3 treatments (Evins and Varner, 1972).

As for the effect of the different ethrel treatments, it is quite evident from the data of both experimental seasons that ethrel caused a significant decrease in juice acidity as compared with the control. These results can be attributed to the effect of ethrel on promoting ripenning (Ezz and Kassem, 1999).

On the other hand, the three urea treatments did not affect juice acidity as compared with the control. These results agreed with Abdel-Hamid (1999) working on peach.

c) Vitamin C :

Data of the present investigation (Tables 2 and 3) showed that vitamin C increased in the fruit juice with increasing ethrel, GA_3 and urea concentrations. Significant differences were only found in the highest concentration of both ethrel and GA_3 compared with the control. Such results agreed with those of Bana *et al*.(1986) working on Red Delicious apple.

d) Fruit firmness and total soluble pectin :

Data in Tables (2 and 3) showed that using ethrel as chemical thinner on Early Grand peach trees caused a significant decrease in fruit firmness compared with the control at harvest. These results agreed with those found by Sims *et al*.(1974) and Khalil *et al*. (1990).

As for GA_3 application, data indicated that the three GA_3 concentrations caused a significant increase in fruit firmness, as compared with the control, except at the lowest GA_3 concentration (50 ppm) in the first season. These results are in line with those obtained by Saeid and Khalil (1993), Southwick and Frits (1995) and Muhammad *et al*.(1996).

Regarding urea treatments, data of both seasons, also, showed that fruit firmness was slightly increased as compared with the control. These results are in line with those found by Zilkah *et al*.(1988) working on peaches and nectarines.

It is clear from the data in Tables (2 and 3) that fruit firmness reflected the effect of the three chemical thinner treatments on the total soluble pectin of Early Grand fruits at harvest. The observation of the data of the present investigation revealed that the three ethrel treatments increased total soluble pectin of the peach fruits compared with the control at harvest in both seasons. These results agreed with those reported by Klein *et al*.(1990) working on Anna and Granny Smith apples.

Data in Tables (2 and 3), also, indicated that the three GA_3 applications caused a significant decrease in total soluble pectin. Significant differences were only found between the highest two concentrations and control in the second season. These results may be attributed to the effect of GA_3 in delaying ripening as confirmed by Sims *et al*.(1974).

Regarding the effect of urea application on the fruit total soluble pectin, the data showed that urea caused a decrease as compared with the control but this decrease was not big enough to be significant. These results are in line with those of Abdel-Hamid (1999) working on Florida Prince peach.

e) Total chlorophyll, carotene and anthocyanin :

Data in Tables (2 and 3) showed that, in both seasons of study, total chlorophyll was significantly decreased with the highest two ethrel concentrations (50 and 100 ppm). These results agreed with Mussini *et al*.(1985) working on different apple varieties.

Data, generally, showed that the three GA_3 treatments increased total chlorophyll, but the increase was not big enough to be significant. This may be attributed to the effect of GA_3 in delaying maturation and destruction of chlorophyll. These results agreed with those reported by Meheriuk *et al*.(1996).

As for urea treatments, it is clear that, in both seasons of study, significant increase in total chlorophyll was found in urea-treated peach fruits as compared with the control. These results are confirmed by Zilkah *et al*.(1988) working on peach.

The change in colour, includes destruction of chlorophyll, revelation of pigments previously masked and synthesis of new pigments (Murphey and Dilley, 1988). It was evident from the data presented in Table (1) that the ethrel treatment greatly improved colouration of Early Grand peach fruit. In both experimental seasons, the three ethrel foliar applications caused a significant increase in carotene and anthocyanin in comparison with the control, except for the lowest concentration (25 ppm) in the second season in the anthocyanin. The present results are in accordance with those reported by Sims *et al*.(1974) and Corelli and Coston (1991) working on peach, and Sansavini *et al*.(1980) working on apple. The major red pigment of apple is a soluble anthocyanin called eyamidin-3-galactoside. The synthesis of anthocyanin in several plant tissues is influenced by phenylalanine ammonia lyase (PAL). Tan (1979) reported that Pal activity was affected by light, growth regulators, inhibition of RNA and protein synthesis.

As for the effect of the different GA_3 and urea treatments on both carotene and anthocyanin, data in both experimental seasons showed that no significant differences were found between treated and untreated fruits. These results are confirmed by Casper and Taylor (1989) and Byers (1990) when spraying peach trees with GA_3, and when chemical thinning of some peach cultivars was evaluated by Zilkah *et al*.(1988) and Abdel-Hamid (1999) with urea.

f) Total phenols :

Results of the present investigation, in the two seasons, showed that using the foliar applications on Early Grand peach trees with ethrel as a chemical thinner caused a significant decrease of total phenols in peach fruits. No significant differences were found with both other chemical thinners; GA_3 and urea. These results agree with those reported by Paulson *et al*.(1980) working on peaches.

g) Total sugars :

Data of the present study showed that all chemical thinner treatments caused a general increase in total sugars in both seasons. With a closer view, significant increase was found between the three ethrel treatments and the highest GA_3 treatment as compared with the control. These results are in line with those reported by Zilkah *et al*. (1988), Durner *et al*.(1991), Modie (1990) and Muthoo *et al*.(1997) working on peaches and nectarines.

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إستجابة ثمار الخوخ صنف إيرلى جراند للخف بالإيثريل وحمض الجبريليك واليوريا:

1- المحصول وجودة الثمار

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أوضحت نتائج موسمى الدراسة 1997، 1998 أن الخف الكيماوى لثمار الخوخ إيرلى جراند بإستعمال حمض الجبريليك واليوريا قبل الإزهار وبالإيثريل بعد الإزهار أدى إلى نقص معنوى فى المحصول وزيادة معنوية فى وزن الثمار.

وبصفة عامة فإن المعادلة بالمواد الثلاث أدت إلى زيادة معنوية فى المواد الصلبة الذائبة الكلية وفيتامين ج. وقد زادت حموضة العصير زيادة معنوية بالمعاملة بحمض الجبريليك وقلت نتيجة المعاملة بالأيثريل ولم تتأثر من المعاملة باليوريا.

وبالنسبة لصلابة الثمار فقد أوضحت النتائج أن الأيثريل قلل من صلابة الثمار وزاد من البكتين الكلى الذائب. أما المعاملة بحمض الجبريليك واليوريا فقد زادت صلابة الثمار عن طريق تقليل البكتين الكلى الذائب معنوياً.

وقد قل الكلوروفيل الكلى بالثمار معنوياً نتيجة لمعاملة الإيثريل وزاد نتيجة لمعاملتى حمض الجبريليك واليوريا. علاوة ذلك فقد زاد الكاروتين والانثوسياسين نتيجة لمعاملة الإيثريل ، بينما لم يتأثر نتيجة لمعاملتى حمض الجبريليك واليوريا.

كذلك أوضحت نتائج هذه الدراسة أن مواد الخف الثلاث بصفة عامة زادت من السكريات الكلية بالثمار بينما تأثرت الفينولات الكلية نتيجة لمعاملة الإيثريل فقط.

Table (1): Effect of ethrel, gibberellic acid and urea as chemical thinners on yield, percentage of fruit drop and physical parameters of Early Grand peach in 1997 and 1998 seasons.

Treatments	1997 season						1998 season					
	No. of fruits /tree	Yield /tree (kg)	Fruit drop (%)	Average fruit weight (g)	Pulp weight (g)	Seed weight (g)	No. of fruits /tree	Yield /tree (kg)	Fruit drop (%)	Average fruit weight (g)	Pulp weight (g)	Seed weight (g)
Control	457	35.55	14.60	77.80	67.68	10.12	496	37.51	16.83	75.63	65.62	10.10
Ethrel 25 ppm	438	34.65	18.78	79.12	68.40	10.72	436	33.50	20.10	76.95	66.70	10.25
Ethrel 50 ppm	399	33.48	19.69	83.90	72.65	11.25	395	32.72	22.36	82.83	71.71	11.12
Ethrel 100 ppm	357	31.46	21.88	88.11	75.16	12.95	357	31.38	28.02	87.91	75.14	12.77
GA_3 50 ppm	302	25.04	33.92	82.93	71.58	11.35	299	24.22	39.72	80.99	69.47	11.52
GA_3 100 ppm	271	22.98	40.70	84.82	72.07	12.75	280	23.49	43.55	83.90	72.00	11.90
GA_3 150 ppm	252	21.51	44.86	85.36	72.39	12.97	259	21.95	47.78	84.74	72.09	12.65
Urea 2%	410	33.33	18.20	81.30	70.29	11.01	399	33.08	20.56	82.91	71.75	11.16
Urea 3%	345	29.57	24.51	85.71	73.87	11.84	326	27.50	34.27	84.35	71.95	12.40
Urea 4%	322	27.98	29.54	86.90	74.87	12.03	309	26.55	37.70	85.98	73.39	12.59
$L.S.D_{0.05}$	48.50	4.01	4.08	5.91	4.30	1.83	98.1	4.69	4.17	5.68	5.82	1.98

Table (2): Effect of ethrel, gibberellic acid and urea as chemical thinners on fruit quality of Early Grand peach in 1997 season.

Treatments	TSS (%)	Acidity (%)	V. C (mg/ 100 L)	Total sugars (%)	Total phenols (%)	Total soluble pectin (%)	Firmness (pounds /inch^2)	Total chlorophyll mg/100 g	Total carotene mg/ 100 g	Anthocyanin mg/100 g
Control	11.04	1.01	18.62	7.59	97	1.57	14.31	7.30	2.80	14.21
Ethrel 25 ppm	12.40	0.86	18.81	8.20	85	1.70	13.80	6.60	3.30	16.80
Ethrel 50 ppm	12.77	0.82	18.90	8.35	83	1.75	13.01	6.30	3.80	16.74
Ethrel 100 ppm	12.82	0.78	19.94	8.64	81	1.74	12.89	6.10	4.00	17.31
GA_3 50 ppm	11.22	0.99	18.66	7.83	93	1.42	14.75	7.50	3.00	14.16
GA_3 100 ppm	11.03	1.17	18.87	7.79	95	1.40	16.89	7.60	2.70	14.11
GA_3 150 ppm	12.11	1.19	19.98	8.68	98	1.37	16.01	7.80	2.80	14.00
Urea 2%	11.34	1.00	18.65	7.61	89	1.54	14.35	8.20	3.10	13.96
Urea 3%	11.25	1.04	18.72	7.74	89	1.57	14.41	8.30	2.80	14.09
Urea 4%	11.15	1.01	18.74	7.98	90	1.59	14.66	8.30	2.70	14.17
$L.S.D_{0.05}$	1.00	0.15	1.30	0.59	8.73	0.13	0.49	0.80	0.40	2.21

Table (3): Effect of ethrel, gibberellic acid and urea as chemical thinners on fruit quality of Early Grand peach in 1998 season.

Treatments	TSS (%)	Acidity (%)	V. C (mg/ 100 L)	Total sugars (%)	Total phenols (%)	Total soluble pectin (%)	Firmness (pounds /inch^2)	Total chlorophyll mg/100 g	Total carotene mg/ 100 g	Anthocyanin mg/100 g
Control	10.52	0.95	17.49	6.25	95	1.51	14.16	7.00	2.50	13.38
Ethrel 25 ppm	11.85	0.82	18.20	7.86	84	1.70	13.62	6.40	3.10	15.11
Ethrel 50 ppm	11.64	0.78	18.62	8.01	83	1.73	13.44	6.10	3.70	16.04
Ethrel 100 ppm	12.00	0.70	18.70	8.58	80	1.80	12.20	5.90	3.90	16.32
GA_3 50 ppm	10.60	0.97	18.65	6.78	92	1.49	15.95	7.40	2.70	13.73
GA_3 100 ppm	10.94	1.11	18.68	6.89	90	1.33	15.91	7.30	3.00	13.89
GA_3 150 ppm	11.55	1.13	19.10	7.52	98	1.29	15.98	7.60	2.90	13.96
Urea 2%	10.78	0.92	17.55	6.94	87	1.49	14.42	7.90	2.70	13.65
Urea 3%	10.84	0.96	17.64	7.31	89	1.45	14.56	8.10	3.00	13.72
Urea 4%	10.43	0.95	17.40	7.48	91	1.45	14.50	8.00	3.00	14.22
$L.S.D_{0.05}$	1.03	0.12	1.200	1.25	8.32	0.16	0.52	0.71	0.60	1.78