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RESPONSE OF 'SWELLING' PEACH TO CHEMICAL THINNING IN COMPARISON WITH HAND THINNING

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ABSTRACT

Hand thinning of "Swelling" peach [*Prunus persica* (L.) Batch] was compared with chemical blossom thinning using ammonium thiosulfate (ATS) + Topsin, urea + Topsin, and urea, or Topsin individually during the 1999/2000 and 2000/2001 seasons with regard to some vegetative characters, yield, and some fruit quality characters. In both seasons, hand thinning induced the least significant shoot growth increment, percentage of fruit retention, fruit firmness, and fruit acidity; while it gave the highest significant values of leaf area, yield (in terms of weight and number of fruits per tree), and fruit weight, size, polar and equatorial diameter, colour flesh thickness, and total soluble solids (TSS) content. Blossom thinning with ATS + Topsin followed hand thinning in all the measured characters, but it was significantly inferior to hand thinning in yield, as weight and number of fruits, and fruit TSS, significantly higher than hand thinning in shoot growth increments and fruit firmness, and not significantly different from hand thinning in, at least, one of the two seasons in the remaining characters. The other blossom thinning treatments were inferior to hand thinning, regarding all above-listed characters. The applied thinning treatments had no significant effect on leaf chlorophyll readings.

INTRODUCTION

Peach [*Prunus persica*l (L.) Batsch] trees require hand fruit thinning to reach optimal size. Early hand thinning usually gives the best results with regard to regular cropping, yield of marketable fruits, and economic value of the crop but this method is usually too costly and thus is impractical for growers (Link and Blanke, 1998; Basak and Michalczuk, 1999). For instance, hand thinning of apple trees cvs. Gala, Lobo, Glster, and Elaster and of peach trees cvs. Florda Prince, Swelling, Loadel, Cresthaven, and Redhaven at different stages of flowering or pre-pit hardening (for peach) reduced fruit set and increased yield and fruit size, weight, firmness, and sugar content, with a reduction in fruit acidity as compared with chemical thinning or no thinning (Byers and Marini, 1994; Bootsma, 1995; Southwick *et al.*, 1995; Abdel-Hamid, 1999; Basak and Michalczuk 1999, Mahamoud, 2001).

Graf (1997) used urea sprays at 3-4% for thinning apple trees. Treatments increased fruit size and yield without causing any injury. Likewise, Abdel-Hamid (1999) applied urea at 3 or 5% to 'Florda Prince' peach at full bloom. Urea treatment, compared with unthinning, decreased fruit set and number of fruits, increased fruit drop, fruit weight, total yield, total soluble solids (TSS), and total acidity. It has been indicated by Szafran *et al* (1998) that trees with reduced nitrate reductase activity in flowers at the pink bud stage, caused by exposure to certain environmental stresses, were more sensitive to chemical thinning by urea

Ammonium thiosulphate (ATS) applied alone or in combination with other chemicals to apple trees cvs. Cox's Orange Pippin and Breaburn at 3.7 g l^{-1} (Irving *et al.*, 1989), Fuji on M. 26 (Andrews and Collier, 1995), Elstar at 0.5-2.0% (Balkhoven-Baart, 1997a), and Queen Cox and Royal Gala on M.9 at 10 or 15 g l^{-1} at full bloom (Webster and Spencer, 1999) enhanced fruit size as compared with unthinning. ATS at 1.5% applied once or twice to plum trees at full bloom caused flower scorching and this was reflected in the lowest yield. However, average fruit weight and fruit sugar and acid contents were highest (Balkhoven-Baart, 1997b).

ATS applied at 2% reduced the number of fruits per peach tree to 45 and 42% of non-ATS-treated trees on a per tree and per trunk cross-sectional-area basis, respectively. ATS caused excessive bloom thinning, but combining it with some fungicides, including Topsin M 70 (thiophanate methyl), did not cause further increase in the number of burned blooms over ATS alone, while, Topsin did not cause phytotoxicity to shoots. It was concluded that using combination of ATS and fungicides is a safe practice (Olein *et al.*, 1995).

According to Greene *et al.* (2001), ATS 55% applied at the rate of 35 to 45 l ha^{-1} (14.8-18.9 fed^{-1}) was the most effective material for blossom thinning and reducing fruit set of 'Garnet Beauty' and 'Red Haven' peaches. It reduced the need for hand thinning by 80%. The reduction in crop load resulted in significant increases in fruit size. It has been indicated (Ju *et al.*, 2001) that the mode of action of ATS is to burn off flower stigmas and styles; consequently, preventing pollination.

Most post-bloom chemical thinners act either through their effect on hormone levels, or by influencing carbohydrate distribution among rapidly developing fruits. However, all post-bloom hormone-type thinners are ineffective on peaches. Consequently, application of caustic thinners during bloom is the only effective method to reduce peach fruit load (Greene *et al.*, 2001). Chemicals used successfully include sulfacarbamide, endothall, pelarogonic acid, and ATS (Fallahi, 1997; Byers, 1999).

The objective of this study was, therefore, to compare the effect of some locally-available chemical blossom thinners with hand thinning on foliage characteristics, yield, and fruit quality characters of peach cv. Swelling.

MATERIALS AND METHODS

This investigation was conducted during the 1999/2000 and 2000/2001 seasons at a private farm (El-Marwa farm, Km 76, Cairo/Alexandria desert road) on "Swelling" peach trees.. The eight-year-old trees, which were budded on 'Nemaguard' peach rootstock and planted 4 x 6 m apart, were growing in sandy soil under drip irrigation system and received similar cultural practices.

Trees were sprayed at full bloom (4 March , 2000 and 10 March , 2001 in the 2 seasons, respectively) with the following solutions: Ammonium thiosulfate (ATS)at 1g l^{-1} + Topsin M (thiophanate methyl) at 0.8 g l^{-1} , urea at 0.5 g l^{-1} + Topsin M at 0.8 g l^{-1}, urea at 0.5 g l^{-1}, and Topsin M at 0.8 g l^{-1}. Control trees were hand-thinned about 14 days after fruit set, leaving about 15 cm between adjacent fruits.

Foliage measurements included shoot growth increments (SGI) during the current fruiting season in both years [SGI = (Shoot length on july 1st -Shoot length on April 1st)*100/shoot length on April 1st]. leaf chlorophyll content expressed as SPAD readings using a chlorophyll meter (model SPAD 502 ; Minolta Corporation. N J. USA) during mid-August of 2000 and 2001 seasons, and leaf area using a leaf area meter (model C/203 Area Meter, CID, Inc. USA) at the same dates. Measurements also included the percentage of fruits retained till maturity of those initially set. Yield data were recorded in terms of both weight and number of fruits per tree. Fruit quality characters were recorded on 15 fruits per experimental unit and included fruit weight, size. polar diameter, equatorial diameter. firmness as measured by Advanced Force Gauge RH13, UK colour measured subjectively as the approximate percentage of coloured fruit surface, flesh thickness, TSS content, and titratable acidity.

A randomized complete block design was used with 3 replicates. Each experiment unit consisted of 1 tree. Data obtained were subjected to statistical analysis according to Gomez and Gomez (1984), and treatment means were compared using the LSD test

RESULTS

Vegetative characters

The applied thinning treatments had significant effects on shoot growth increments and leaf area, but not on leaf chlorophyll SPAD readings (Table 1) Shoot growth increments

Table (1): Effect of hand and chemical blossom thinning treatments on shoot growth increments, leaf chlorophyll, and leaf area.

Treatments [a]	Shoot growth increments (%)	Leaf chlorophyll (SPAD reading)[b]		Leaf area (cm^2)	
	2001	2000	2001	2000	2001
Hand thinning (Control)	65.1	41.6	40.8	45.3	49.5
ATS + Topsin	108.8	45.3	44.0	40.7	44.3
Urea + Topsin	104.0	44.2	44.0	34.7	43.3
Urea	119.4	47.8	44.8	33.8	41.7
Topsin	142.6	44.5	44.5	30.7	41.2
L.S.D. at 5%	19.5	N.S	N.S	7.7	2.2

a ATS = Ammonium thiosulphate.
b Using a chlorophyll meter (model SPAD 502, Minolta Corporation, NJ, USA).

Were significantly the lowest (65.1%) with hand thinning and significantly the highest (142.6%) with Topsin treatment. while ATS + Topsin and urea treatments resulted in intermediate values. Meanwhile, hand-thinning induced the largest significant leaf area, while Topsin treatment had the smallest leaf area followed by ATS + Topsin treatment in both seasons, but it was not significantly different from the hand thinning treatment in the 2000 season.

Yield

Table (2) showed that percentage of retained fruits and yield (in terms of weight and number of fruits per tree) were significantly affected by the thinning treatments. Hand thinning resulted in the least significant percentage of retained fruits and the highest significant yield (in terms of *weight or number of fruits per tree)*; while urea, Topsin, and urea + Topsin treatments gave the highest significant percentage of retained fruits and the least significant yield per tree. ATS + Topsin treatment occupied an intermediate position between hand thinning and the other chemical thinning treatments with respect to all 3 measurements.

Fruit quality characters

Fruit weight, size, polar and equatorial diameters, and colour were highly significant with hand thinning while Topsin treatment reduced their values significantly (Table 3). However, combining ATS with Topsin resulted *in the second highest values in the above-listed characters* and there was in-significant difference between ATS + Topsin treatment effect and that of hand thinning treatment in , at least, one of the two seasons. Likewise, the Topsin treatment was not significantly different from the remaining chemical thinning treatments, viz., urea + Topsin and urea, with regard to their effect on fruit *weight, size, and dimensions in*, at least, one of the two seasons. Meanwhile, fruit colour was significantly better (higher percentage colouring of fruit surface) in the following descending order: urea + Topsin > urea> Topsin.

Table (2): Effect of blossom hand and chemical thinning treatments on *fruit retention and yield of 'Swelling' peach.*

Treatments	Retained fruits (%)		Yield		
			kg/tree		No. fruits/tree
	2000	2001	2000	2001	2001
Hand thinning (Control)	53.1	52.4	70.8	90.9	702.0
ATS + Topsin	59.3	58.1	54.8	66.6	558.8
Urea + Topsin	71.0	69.4	38.5	50.2	435.0
Urea	77.4	77.6	29.1	37.9	340.2
Topsin	79.5	82.9	33.9	42.4	410.0
L.S.D. at 5%	7.5	6.2	5.6	7.5	36.2

ATS = Ammonium thiosulphate.

Concerning fruit firmness, Topsin treatment gave the highest values, while hand thinning significantly gave the lowest. The other chemical thinning *treatments produced fruits having a significant decreasing order of firmness* as follows: Urea > Urea + Topsin > ATS + Topsin.

Table (3): Effect of hand and chemical blossom thinning treatments on external fruit quality characters.

Treatments	Weight (g)		Size (cm^3)		Polar diameter (cm)		Equatorial diameter (cm)		Firmness ($lb/inch^2$)		Colour (%)	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Hand thinning (Control)	100.8	129.6	102.5	136.1	5.5	6.0	5.7	6.3	14.2	14.3	85 0	83.3
ATS + Topsin	98.1	119.2	94.9	125.9	5.2	5.8	5.5	6.2	15.2	15.5	80 0	80.0
Urea + Topsin	88.5	115.3	89.9	118.7	4.9	5.7	5.5	5.9	18.8	17.4	75.0	75.0
Urea	85.1	110.7	86.3	113.7	4.5	5.6	5.3	5.9	20.3	19.7	65.0	66.7
Topsin	84.7	105.8	81.3	108.8	4.3	5.4	5.1	5.7	21.1	20.7	60.0	61.7
L.S.D at 5%	10.6	10.0	8.6	10.9	0.3	0 1	0.1	0.2	0.6	0.9	3.5	3.4

ATS = Ammonium thiosulphate.

Fruit thinning treatments significantly effected fruit TSS content and titratable acidity in both seasons, while they affected flesh thickness in the first year only (Table 4). Hand thinning resulted in significantly the highest values of fruit flesh thickness and TSS content, while Topsin treatment gave the least values. Meanwhile, the other chemical thinning treatments were in the following decreasing order with regard to both characters: ATS + Topsin >Urea + Topsin > Urea. However, they were not always significantly different from each other or from the other two thinning treatments. An opposite trend was obtained for fruit titratable acidity, as it was significantly decreased, in both seasons, in the following order: Topsin > urea > urea + Topsin > ATS + Topsin > hand thinning.

Table (4): Effect of hand and chemical blossom thinning treatments on *internal fruit quality characters.*

Treatments	Flesh thickness (cm)		TSS (%)		Titratable acidity (%)	
	2000	2001	2000	2001	2000	2001
Hand thinning (Control)	2.1	2.3	11.2	14.0	0.39	0.14
ATS + Topsin	1.9	2.2	10.5	13.5	0.44	0.16
Urea + Topsin	1.8	2.2	10.5	13.2	0.47	0.24
Urea	1.8	2.1	10.0	12.5	0.60	0.28
Topsin	1.7	2.1	10.0	12.0	0.70	0.33
L.S.D. at 5%	0.1	N.S.	0.2	0.2	0.02	0.01

ATS = Ammonium thiosulphate.

DISCUSSION

Although fruit retention (as percentage of fruits initially set) was much higher with chemical thinning treatments than with hand thinning, fewer number of fruits per tree were harvested from the chemical thinning treatments (Table 2), indicating that these treatments were highly effective in inducing early flower drop and, consequently, most of the stored organic compounds in these treatments were directed towards subsequent shoot elongation (Table 1). Meanwhile, with higher number of retained fruits per tree in the hand thinning treatment, reserved metabolic products were mostly directed towards the relatively larger number of developing fruits than in the chemical thinning treatments; hence, growth increments were smaller. This relationship between shoot growth increments (Table 1) and number of developing fruits (Table 2) was also evident among the various chemical thinning treatments.

As leaf area followed a trend opposite to that of shoot growth (Table 1), it appears that the increased shoot growth was at the expense of leaf area enlargement. This reduced leaf area in the chemical thinning treatments probably contributed to their reduced yield (Table 2) , fruit weight, size, dimensions, colour (Table 3), flesh thickness, and TSS content (Table 4).

The lack of treatments' effect on leaf chlorophyll SPAD readings in this experiment (Table 1) was probably due to the very well-balanced nutrition program and excellent care given to peach trees in the private farm in which this experiment was conducted, which had evidently masked any treatment effect on the intensity of leaf greenness, if there had been any.

In spite of greater fruiting load encountered with hand thinning, as compared with chemical thinning (Table 2), the former treatment probably provided the developing fruits with a steady supply of photosynthate, i.e., provided a better balance of source/sink relationship. The smaller shoot increments and the larger leaf area in the hand thinning treatment (Table 1) ensured abundant supply of photosynthate to the developing fruits as compared with the chemical thinning treatments in which a larger portion of photosynthate, produced by smaller-size leaves, was directed towards increasing shoot growth.

Though no records were made for light penetration within tree canopy, the small shoot growth increments induced by the hand thinning treatment probably provided better light penetration than in the chemical thinning treatments, i.e., trees in the latter treatments could have been suffered from some shading. This is in line with previous research conducted on different deciduous fruit trees. Marini and Marini (1983) and Marini and Sowers (1990) indicated that light penetration and shade affected net photosynthesis of peach leaves. Also, photosynthetic characteristics of apple (Barden, 1974) and peach (Kappel and Flore, 1983) leaves were influenced by exposure to diverse light environments. Shading reduced apple fruit size and quality (Jackson *et al.*, 1971, 1977; Seeley *et al.*, 1980;Morgan *et al.*, 1984). Also, redness and soluble solids content (SSC) of 'Bing' cherries increased logarithmically with photosynthetic photon flux densities (PPFD) (Patten and Proebsting, 1986). Peach fruits from tree tops, where PPFD is greatest, were redder and had a higher SSC than fruits harvested with similar ground colour from the tree interiors (Marini, 1985). Peach fruit quality was also affected by shade during final swell of fruit growth (Marini *et al.*, 1991).

The significant improvement of external and internal fruit quality characters with hand thinning (Table 3 and 4) could be also due to the better distribution of fruits along shoots with respect to their feeding leaves, as compared with a random distribution of fruits imposed by chemical thinning. According to Greene *et al.* (2001), blossom thinners did not thin uniformly on the tagged limbs. There were some areas of the limb that set less than optimal number of fruit, thus fruit were spaced more than 15 cm apart, whereas other areas were set heavier and required more hand thinning, specially where fruits were clustered. This factor can not be over emphasized regarding source/ sink relationship considering that peach trees are often characterized by an inefficient distribution of photosynthates to fruit compared to vegetative growth (Walsh *et al.*, 1989).

Though a negative relationship was found between fruit weight and fruit number per tree in 4 peach cvs of different maturity stages (Johnson and Handley, 1989) contrary to the results of this study (Table 2), this relationship likely depends on the even distribution of fruits within limbs.

A negative relationship was observed in this study between percentage of fruit retention and total number of fruits harvested per tree (Table 2). Though Topsin, urea and Topsin + urea treatments were efficient blssom thinners, their enhancement of fruit retention (Table 2), in spite of their enhancement of shoot growth and suppression of leaf area (Table 1), probably resulted in the poorer fruit size, colour development, and, consequently, higher fruit firmness and acidity and lesser TSS content (Table 3 and 4) compared with the hand thinning treatment, considering that fruits of all treatments were harvested at the same date, i.e. fruits of the hand thinning treatment were probably in a slightly more advanced stage of maturity when harvested than those of the chemical thinning treatments.

The poor fruit quality induced by the Topsin treatment in this study (Tables 3 and 4) could be due to it's phototoxicity to both flowers and young leaves at a critical stage of development. This phototoxic effect of Topsin on tree metabolism was eliminated when it was combined with ATS. According to Olien *et al.* (1995), combining ATS with bloom-applied fungicides, including Topsin M, is a safe practice. In the present study, the ATS + Topsin treatment was the second best, in all respects, after hand thinning (Tables 1-4). According to Greene *et al.* (2001), using ATS as a blossom thinner resulted in 80% reduction in the need for hand thinning in 2 peach cvs. This reduction in hand thinning following blossom thinner use can be a significant saving in labor cost and the need for labor.

Differences among treatments were more pronounced when farm-sales of size-graded fruits were taken into consideration. During the course of this study, farm-gate pric ranged between LE 0.8 to 2.5 /kg fruits, depending on fruit size, expressed as weight, as follows: LE 0.8 for fruits weighting 70 - < 80 g, LE 1.0 for 80 - < 90 g, LE 1.25 for 90 - <100 g, L.E. 1.50 for 100 - <110 g, LE 2.0 for 110 - < 120 g, and LE 2.5 for ≥ 120 g. Meanwhile, cost of various thinning treatments per tree was as follows: hand thinning: LE 1.700, ATS + Topsin: LE 0.600, urea + Topsin: LE 0.546, Urea: LE 0.002, and Topsin: L.E. 0.544. When yield data in kilograms per tree (Table 2) and average fruit weight (Table 3) were used in determining fruit sales per tree, results after deduction of thinning cost were as presented in Table 5, indicating higher returns from the hand thinning treatment, followed by the ATS + Topsin treatment in both seasons.

Table (5): Fruit sales per 'Swelling' peach tree subjected to different thinning treatments and based on fruit yield (Table 2) and average fruit weight (Table 3), taking into consideration farm-gate price of size-graded fruit, and after deduction of treatments , cost.

Treatments	Fruit sale (LE/tree)	
	2000	**2001**
Hand thinning (Control)	106.2	227.25
ATS + Topsin	68.5	133.2
Urea + Topsin	38.5	100.4
Urea	29.1	75.6
Topsin	33.9	63.6

Results obtained in this study are in agreement with those obtained by Byers and Marini (1994), Link and Blanke (1998), Basak and Michalczuk (1999), Abdel-Hamid (1999), and Mahmoud (2001) concerning the superiority of hand thinning of peach trees with regard to fruit size, weight, firmness, sugar content, and acidity as compared with chemical thinning. Our results also confirm previous research concerning the effectiveness of urea (Abdel-Hamid, 1999) and ATS (Olien *et al.*, 1995; Greene *et al.*, 2001) as peach blossom thinners.

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استجابة صنف الخوخ سويلنج للخف الكيميائى مقارنة بالخف اليدوى

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قورن الخف اليدوى لصنف الخوخ سويلنج بالخف الكيميائى باستعمال ثيو سلفات الأمونيوم مع التوبسن ، واليوريا مع التوبسن ،واليوريا منفردة، والتوبسن منفرداً خلال موسمى ١٩٩٩/٢٠٠٠ ، و ٢٠٠٠/٢٠٠١، فيما يتعلق بتأثير المعاملات على بعض الصفات الخضرية، والمحصول ، والصفات الثمرية الهامة. وفى كلا الموسمين ، كانت معاملة الخف اليدوى الأقل معنويا فى معدل النمو الخضرى، وفى نسبة بقاء الثمار العاقدة، وصلابتها، ومحتواها من الحموضة، بينما كانت هى الأعلى معنويا فى مساحة الورقة، والمحصول سواء أكان على صورة وزن الثمار أم عددها لكل شجرة، ومتوسط وزن الثمرة، وحجمها وقطرها القطبى والاستوائى ، وسمك لحمها، ومحتواها من المواد الصلبة الذائبة الكلية. وقد جاءت معاملة الخف بثيوسلفات الأمونيوم مع التوبسن الثانية فى الترتيب بعد الخف اليدوى فى كل الصفات المقاسة ، وكانت أقل منها جوهريا فى محصول الثمار المقدر بصورتى الوزن والعدد لكل شجرة، ومحتوى الثمار من المواد الصلبة الذائبة الكلية، كما كانت أقل من معاملة الخف اليدوى جوهرياً فى معدل النمو الخضرى، وصلابة الثمار، بينما لم تختلف عنها جوهريا– فى موسم واحد على الأقل – فى الصفات المتبقية. أما معاملات الخف الكيميائى الأخرى : التوبسن، واليوريا، والتوبسن مع اليوريا فقد أعطت أقل النتائج ؛ فكانت على نقيض الخف اليدوى فيما يتعلق بجميع الصفات المبينة أعلاه. هذا ، بينما لم تؤثر معاملات الخف معنويا على محتوى الأوراق من الكلوروفيل.