Indian J. Hort. 70(4), December 2013: 491-495

Fruit drop prevention in local tangerine by growth regulators in response to application time

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ABSTRACT

The aim of the present study was to evaluate the effects of some growth regulators on local tangerine (*Citrus reticulata* Blanco) fruit abscission in late summer, and also to note the proper time of application to prevent late summer fruit drop. Trees were sprayed with different concentrations of 2,4-D (2,4-dichlorophenoxy acetic acid) and NAA (α-naphthalene acetic acid) alone or combination of of both, four times from September to December at one month interval. The combination of 20 mg l^{-1} 2,4-D + 30 mg l^{-1} NAA, 10 mg l^{-1} 2,4-D + 15 mg l^{-1} NAA and 10 mg l^{-1} 2,4-D, among other treatments, had the better effects in preventing fruit drop. Application of growth regulators during September prevented fruit drop in the month of December, which was statistically significant (α < 0.05).

Key words: Fruit abscission, citrus, auxin, tangerine.

INTRODUCTION

The so called local tangerine (*Citrus reticulata* Blanco) is an important citrus species, which grows in Jahrom region, south of Iran. It bears sweet and aromatic juicy fruits which abscise heavily while maturing on the trees. There are usually four periods of fruit abscission in local tangerine: the first is in the period of fruit set, which usually lasts for a month following full bloom also called as cleaning drop (Racsko *et al*., 11). The second period of intense fruit drop occurs at the onset of hot summer and is referred as 'June-drop' (Saleem *et al*., 13). The third period of severe and undesirable fruit drop is in late summer (from September to October) when the fruitlets are immature and yellowish in colour called as 'pre-harvest' drop (Racsko *et al*., 11). Because of heavy fruit drop, it is scientifically and economically important to control and prevent fruit drop in local tangerine.

In citrus, the balances between auxin and ethylene, determine the rate of fruit abscission (Goren, 6). At low concentrations, auxins such as NAA delays fruit abscission. However, if ethylene production by fruits has already started, application of auxin cannot delay or prevent fruit abscission (Burns, 3). It has been reported that the application of 2,4-D by preventing the development of abscission zone, will delay fruit abscission in citrus (Tumminelli *et al*., 15). There are also reports indicating that combined applications of growth regulators 2,4-D + NAA are more effective in preventing fruit abscission (Rahemi and Moghaddas, 12), while application of 2,4-D + GA_3 and 2,4-D + NAA have also been found beneficial (Almeida *et al*., 2). Abscission in citrus has been reviewed by several authers (Goren, 6; Rahemi and Moghaddas, 12; Almeida *et al*., 2; Tumminelli *et al*., 15; Saleem *et al*., 13), but rarely focused on late summer fruit abscission. In the present study, we focus on preventing late summer fruit abscission by plant growth regulators (NAA and 2,4-D) applied separately or in combination, and also to note the time of application in delaying fruit abscission in local tangerine trees.

MATERIALS AND METHODS

The experiments were carried out on 15-20 year-old local tangerine trees in an orchard located in the town of Jahrom, south of Iran, during 2008-2009. A total of 112 uniform trees were selected. Four similar branches on each tree were marked and used for the treatments. The number of fruits that dropped from each tree was recorded from May to February. Fruits on the trees were counted in each month before spraying growth regulators. Plants were sprayed with two synthetic growth regulators, α-naphthalene acetic acid (NAA) and 2,4-dichlorophenoxy acetic acid (2,4-D) for the duration of four months (September to December). Treatments were as NAA (15 and 30 mg l^{-1}), 2,4-D (10 and 20 mg l^{-1}), NAA (15 mg l^{-1}) + 2,4-D (10 mg l^{-1}) and NAA (30 mg l^{-1}) + 2,4-D (20 mg l^{-1}). Distilled water spray used as control.

The experiments were arranged in a randomized complete block design. All treatments were replicated four times. Before the application of growth regulators in each month, the number of fruits on each tree was counted and recorded. All data were subjected to

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analysis of variance and the means of the treatments were compared by Duncan and Tukey's and T-test. Statistical packages namely SPSS and SAS were used for data analysis.

RESULTS AND DISCUSSION

The numbers of fruit drops from each tree were recorded monthly from May to January. Small green fruitlets dropped heavily from May to early July known as June-drop. Two phases of severe fruit abscission in local tangerine were distinguishable: (1) from May to late June when the fruits were small and greenish; and (2) from late October to early November. The rates of fruit drops decreased in the months of August and September. However, yellowish fruitlets started to drop heavily in the months of October and November and reached a stable state from December (Figs. 1 & 2).

It has been reported that after June-drop, very little fruit drop takes place in most citrus trees (Iglesias *et al*., 7; Saleem *et al*., 13), which has been attributed to trees nutritional and carbohydrate reserve balances (Iglesias *et al*., 7). Besides June-drop, Goren (6) has pointed to a second phase of fruit drop in citrus trees which takes place from late summer to early autumn. The percent fruit abscission was recorded in the following months (Fig. 3). Spraying trees in September did not prevent fruit abscission in the following month (October) significantly (Fig. 4). The rates of fruit drop in trees sprayed with 2,4-D (10 and 20 mg l^{-1}) and with 2,4-D (20 mg l^{-1}) plus NAA (30 mg l^{-1}) in October decreased in the following month. However, statistically the differences were not significant (Fig. 5). Trees sprayed in November did not show any significant fruit drop prevention in December (Fig. 5). Applications of 10 mg l^{-1} 2,4-D alone and 30 mg l^{-1} NAA + 20 mg l^{-1} 2,4-D were more effective in preventing fruit drop than other treatments. Spraying trees with 15 mg l^{-1} NAA plus 20 mg l^{-1} 2,4-D in the month of December were more effective in preventing fruit drop, but the differences were not statistically significant (Fig. 5). The compound analysis of the treatments showed that application of NAA (30 mg l^{-1}) + 2,4-D (20 mg l^{-1}), NAA (15 mg l^{-1}) + 2,4-D (10 mg l^{-1}), and 2,4-D (10 mg l^{-1}) alone were more effective in preventing fruit abscission than other treatments (Figs. 3 & 5).

Applying NAA to prevent or delay citrus fruits abscission has been reported by other workers (Cronje *et al*., 4). Lovatt (10) has reported that the application of NAA after September in southern California orchards is not effective in delaying or preventing citrus fruit abscission. Iqbal *et al*. (8) have applied NAA as foliar spray on guava during two developmental stages: (1) 15 days after fruit set, and (2) 40 days after the first spray. They reported that NAA at 45 mg l^{-1} had the best effect in preventing fruit drop. In another study, Rahemi and Moghaddas (12) reported that two times application of NAA plus 2,4-D in January prevented pre-harvest fruit drop in February and March, in local tangerine. However, application of 10 mg l^{-1} 2,4-D alone and the combination of 2,4-D plus NAA was more effective in preventing fruit drop. Other workers have also reported that 2,4-D is effective in preventing or delaying fruit abscission (Singh *et al*., 14; Cronje *et al*., 4; Agusti *et al*., 1).

Application of 10 and 20 mg l^{-1} 2,4-D had prevented pre-harvest abscission in sweet lime (*Citrus limetta*).

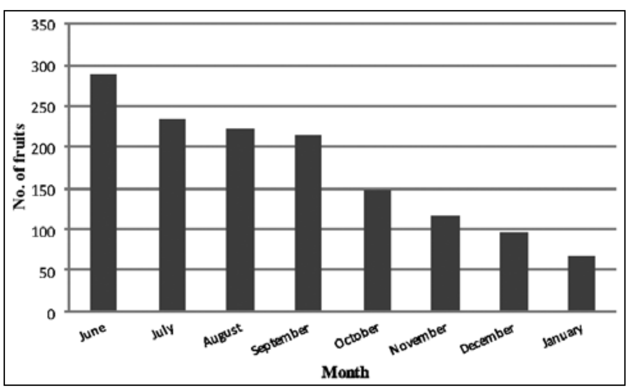

Fig. 1. Number of fruit retention on each trees in each month.

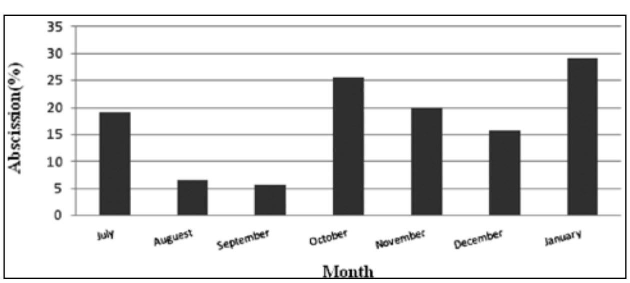

Fig. 2. Percent fruit abscission in each month in local tangerine.

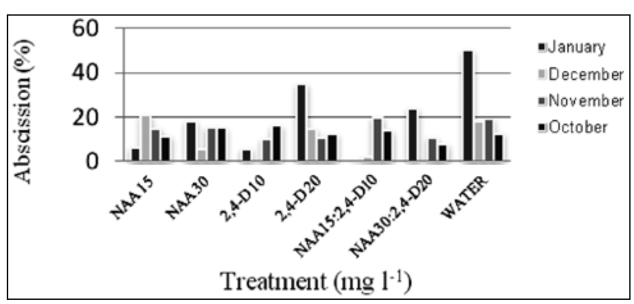

Fig. 3. Comparison of the effects of growth regulators on prevention of fruit abscission in local tangerine in different months.

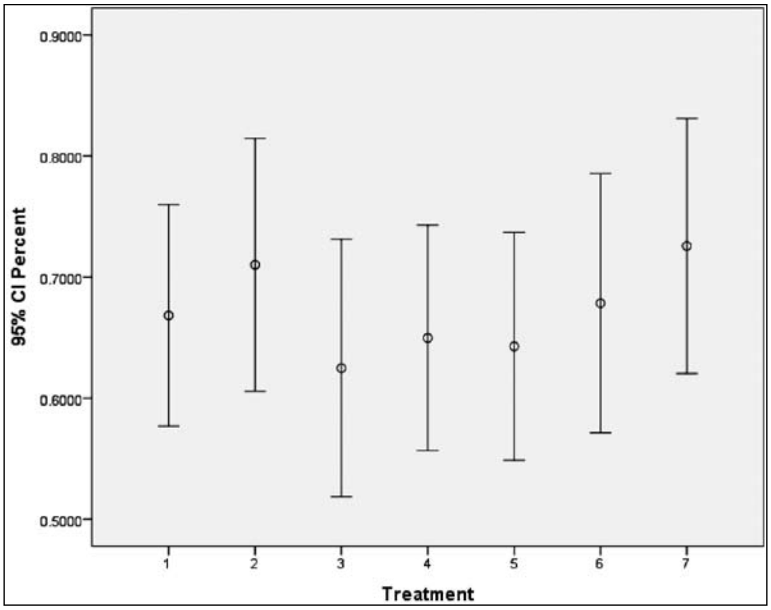

Fig. 4. Effects of growth regulators on fruit abscission. The differences are not significant (α = 0.05). 1= NAA (15 mg l^{-1}); 2 = NAA (30 mg l^{-1}); 3 = 2,4-D (10 mg l^{-1}); 4 = 2,4-D (20 mg l^{-1}); 5 = NAA (15 mg l^{-1}) + 2,4-D (10 mg l^{-1}); 6 = NAA (30 mg l^{-1}) + 2,4-D (20 mg l^{-1}); 7 = control (water).

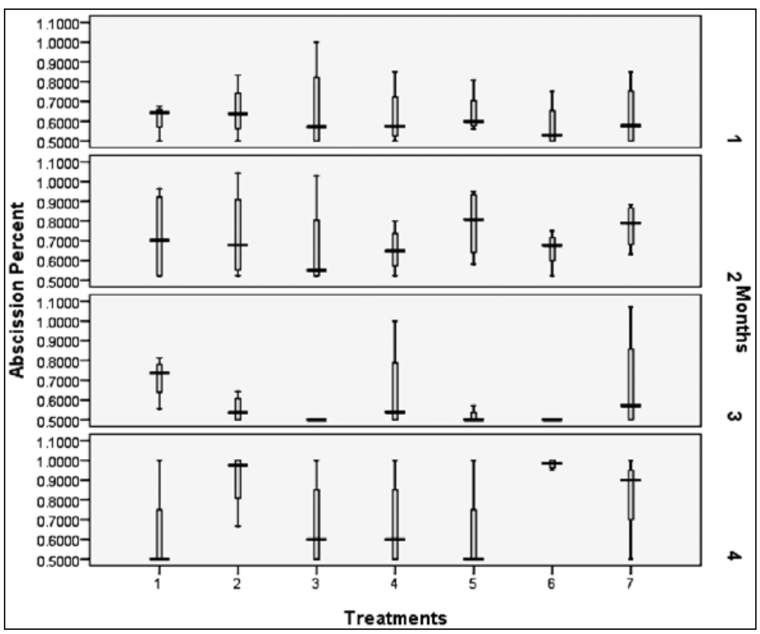

Fig. 5. Effects of growth regulators applied during four months (1-4) on fruit.

It has also been reported that application of 2,4-D from October to December has prevented pre-harvest abscission in navel orange (Lovatt, 10). Applying 20 mg l^{-1} 2,4-D from November to February, has reduced fruit abscission up to 50% through there has been general fruit drop in October for all treatments (Lovatt, 10). In contrast, Lima and Davies (9) indicated that plant growth regulators have no effects on summer - fall drop from late August through October- in navel oranges. While, Gomez-Cadenas *et al*. (5), and Saleem *et al*. (13) have earlier reported that application of plant growth regulators has not been effective in controlling or preventing undesirable fruit abscission in citrus.

In our study statistical analysis revealed that trees sprayed in September had a reduced rate of fruit abscission in December significantly. This shows that the application of NAA (30 mg l^{-1}) + 2,4-D (20 mg l^{-1}), NAA (15 mg l^{-1}) + 2,4-D (10 mg l^{-1}), and 2,4-D (10 mg l^{-1}) were more effective (Fig. 5). However, to be effective in preventing fruit abscission, growth regulators should be applied several months in advance before the process of fruit abscission starts, so that the applied growth regulators have enough time to play their roles. According to our results, plant growth regulators and time of their application do not have any effect on each other (Table 1). Time of the growth regulators application is the most important factor in preventing undesirable fruit drop, but different treatments did not show any significant differences (Table 1). Treatments from the stand points of their effects on preventing fruit abscission did not have significant differences (α = 0.05) (Fig. 5). However, the application of these growth regulators applied in different months had significant effects in preventing fruit drop (Fig. 6). Their application in the month of September prevented fruit drop in the month of December (Table 2).

Table 1. Analysis of variance for the effect of months and treatments on fruit abscission.

Source	Type III Sum of squares	df	Mean square	F	Sig.
Corrected model	1.296[a]	27	0.048	1.572	0.610
Intercept	50.493	1	50.493	1653.231	0.000
Month	0.515	3	0.172	5.625	*0.001
Treatment	0.127	6	0.021	0.695	0.6540
Month* Treatment	0.653	18	0.036	1.188	0.2890
Error	2.566	84	0.0310		
Total	54.354	112			
Corrected total	3.862	111			

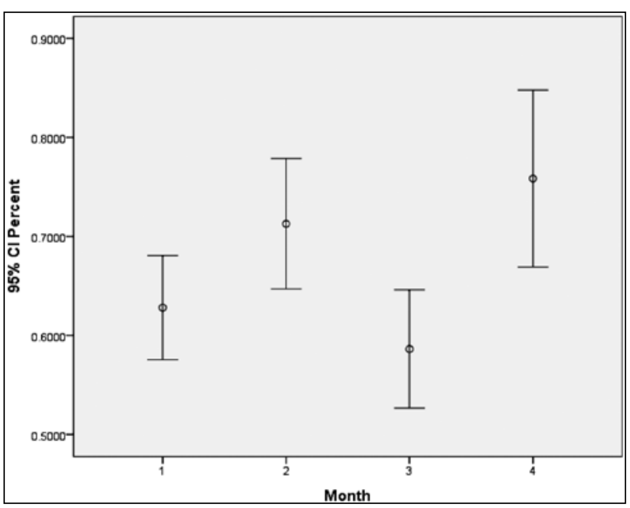

Fig. 6. Effects of time of growth regulators application on preventing fruit drop. Differences are statistically significant (P-value = 0.001) {1= September; 2 = October; 3 = November; 4 = December}.

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Table 2. Analysis of variances by Tucky's test among months, when growth regulators applied, indicating significant differences between September and December, and also between November and December. Figures shown by * are significant in decreasing abscission.

Month (I)	Month (J)	Mean difference (I-J)	Std. Error	Sig.	95% Confidence interval	
					Lower bound	Upper bound
1	2	-0.0846843	0.0470442	0.279	-0.207446	0.038077
	3	0.0417999	0.0470442	0.811	-0.080961	0.164561
	4	-0.1303449*	0.0470442	*0.033	-0.253106	-0.007584
2	1	0.0846843	0.0470442	0.279	-0.038077	0.207446
	3	0.1264842*	0.0470442	0.041	0.003723	0.249245
	4	-0.0456606	0.0470442	0.766	-0.168422	0.077101
3	1	-0.0417999	0.0470442	0.811	-0.164561	0.080961
	2	-0.1264842*	0.0470442	0.041	-0.249245	-0.003723
	4	-0.1721448*	0.0470442	*0.002	-0.294906	-0.049384
4	1	0.1303449*	0.0470442	*0.033	0.007584	0.253106
	2	0.0456606	0.0470442	0.766	-0.077101	0.168422
	3	0.1721448*	0.0470442	*0.002	0.049384	0.294906

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Received : June, 2013; Revised : September, 2013;
Accepted : November, 2013