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ORIGINAL ARTICLE

Effects of Naphthalene Acetic Acid and Carbaryl on Fruit Thinning in 'Kinnow' Mandarin Trees

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KEYWORDS

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ABSTRACT: Several fruit trees including some cultivars of citrus tend to develop irregular bearing. Fruit thinning has been used for hundreds of years to manipulate blooming and crop load to improve the alternate bearing process. Frequently, combination sprays of two or more chemical thinners are used in various fruit trees and the thinning responses were additive and more effective than individual compounds. In this study, we investigated the effects of Naphthalene acetic acid and carbaryl alone and in combination in thinning of 'Kinnow' mandarin (*Citrus reticulata* Blanco) trees. Some characteristics such as fruit weight, diameter and volume, total soluble solid (TSS), titrable acidity (TA), TSS/TA, vitamin C and peel thickness were measured prior to harvest for 2010 and 2011 as a complete randomized block design with 13 treatments and four replications. Results showed that the application of NAA and carbaryl alone in June drop stage of fruit growth increased fruit thinning percentage, TSS of fruit juice, fruit weight, volume, diameter and length. These chemical thinners improved fruit size significantly by increasing the leaf/fruit ratio. Combination sprays could not effectively thin fruits than individual chemicals and thus had no effect on fruit size. Fruit characteristics such as TA, ascorbic acid, TSS/TA ratio and peel thickness were not affected by our treatments.

INTRODUCTION

Fruit thinning is to remove excessive flowers or fruitlets from fruit trees and is one of the most effective methods to improve fruit size, color and quality and increases the return bloom in the following year, thereby reduces

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biennial bearing [1]. For this purpose, several techniques have been tried such as hand thinning, chemical and hormone thinning [2, 3]. Since 1930s, a variety of chemical thinning agents and primarily plant growth regulators (PGRs) have been investigated for safety and efficiency. These compounds are typically applied at specified stage of fruit development and either damage some of the blossoms or cause some of the fruitlets to drop from the tree [2]. Many trials had proved the effectiveness of these PGR alone or in combination with mandarins and their hybrids such as 'Ellendale' and 'Dancy' bb , 'Michal', 'Wilking' and 'Murcott' [4], 'Imperial'[5]. Spray application of NAA (Naphthalene acetic acid) applied about June drop have been effective in reducing crop load, reducing alternate bearing and improved fruit size and quality in various species and cultivars [3, 6, 7] . The effect of NAA for fruit thinning depends on factors such as time of application, concentration, environmental and tree conditions as well as cultivar [8].

Effects of carbaryl (Sevin) as a fruit thinner are recognized in most fruit trees. Its action is relatively a little affected by concentration and time of application [3]. 'Kinnow' mandarin is a hybrid seedy cultivar that refers to growth in several countries because of the high tolerance against high temperature, high yields and its attractive quality [9].

Because NAA is relatively expensive, thus, the objective of this experiment was to evaluate the effects of NAA and carbaryl (Sevin) alone in compared with their mixtures as a thinning agent for 'Kinnow' mandarin trees to decrease the application of NAA.

MATERIALS AND METHODS

Plant materials and treatments

The study was conducted in a commercial orchard in Fars Province (Fasa) in Iran, containing mature 14-year-old 'Kinnow' mandarin trees grafted on sour orange rootstock. Trees are planted 7m×7 m apart with drip irrigation. In spring (June drop stage), 39 trees similar in size, vigor and crop load and four branches on each tree selected and were labeled for thinning, fruit drop and fruit quality evaluation. A complete randomized block design was used with 13 treatments and four replications. Treatments consisted of distilled water (control), NAA at 300, 350, 400 and 450 mg/l, carbaryl (Sevin) at 500, 1000, 1500 and 2000 mg/l, NAA plus carbaryl (mixed treatment) at 3+150, 6+300, 12+600 and 24+1200 mg/l respectively. Trees were sprayed when the fruit diameter was about 1-1.5 cm at third of Jun in two consecutive years (2010-2011). Spray treatments were applied to the canopy until run off.

Fruits on the trees were counted just before treatment, two weeks after treatment and finally at harvest time.

Evaluation of fruit characters

Measured parameters concluded of: Fruit weight, diameter and volume, total soluble solid (TSS), titrable acidity (TA), TSS/TA, vitamin C and peel thickness prior to harvest for 2010 and 2011. Fruit samples consisted of ten fruits/trees (replication). Fruits were sectioned equatorially and the juice was extracted by hand. TSS was determined with hand-held refractometer (MASTER-T, Atago CO., Japan) and TA was measured by titration of a 10 ml fruit juice with 0.3125 N NaOH. Ascorbic acid was determined with using the Indophenol titration method [10].

Data were analyzed by Statistical Analyzed System, version 9.1 (SAS Institute, USA). Means differences were determined by LSD test ($P \leq 0.05$).

RESULTS

All the physical characters of fruits except fruit shape were affected by thinner agents. The average fruit weight was higher in 300, 350 and 400 mg/l NAA treatments as well as in 1000 and 1500 mg/l sevin in compare to the control treatment (Figure 1). The highest

fruit volume was at 400 mg/l NAA treatments and this was significantly affected by all thinning treatments except sevin (500) and mixture treatments (Figure 1).

The average fruit diameter was significantly higher than control at all treatments except the first three mixtures (Figure 2). Trees thinned with sevin (1000) treatment had the highest fruit length (Figure 2), but the ratio of length to diameter was similar in all of treatments (Figure 3).

The TA content of fruits was similar in all treatments but TSS content was significantly affected by all thinning treatments (Figure 5). The maximum ratio of TSS/TA of fruits was observed at NAA (350) treatment and it was similar for other treatments and control (Figure 5).

The highest content of fruits ascorbic acid (41.86 mg/100ml) was found at NAA (350) treatment but the difference between treatments and the control was not significant (Figure 6).

Thinning percentage was not affected by sevin (500) and mixture treatments in compare to the control but other treatments thinned significantly the fruitlets (Figure 4). Effects of low and high concentrations of both compounds were small and it seems that the moderate concentrations were more effective.

Peel thickness of fruits had the highest value (4.23 mm) at sevin (500) treatment and the lowest (3.42 mm) at NAA+sevin (12+600). However only the lowest value was difference significantly, compare to the control (Figure 7). Peel percentage had the highest (33.53 %) and the lowest value (28.45 %) at sevin (500) and NAA+sevin (12+600) treatments respectively but only the highest value was difference significantly compare to the control (Figure 7).

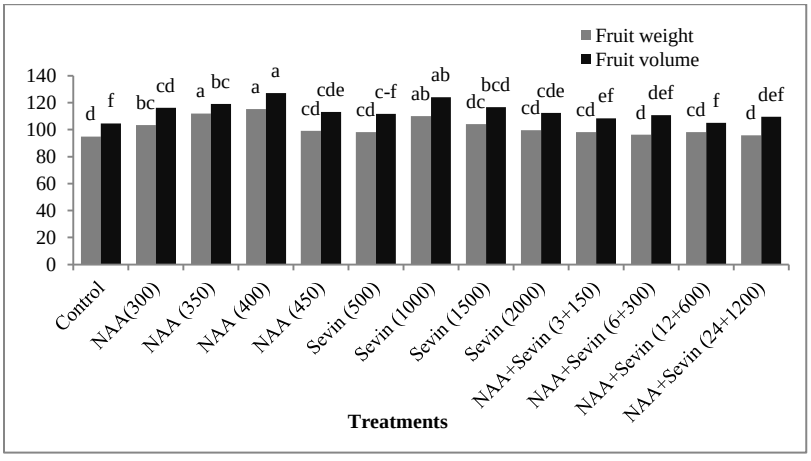

Figure 1. Effects of chemical thinning on fruit weight (g) and fruit volume (cm^3) in 'Kinnow' mandarin trees

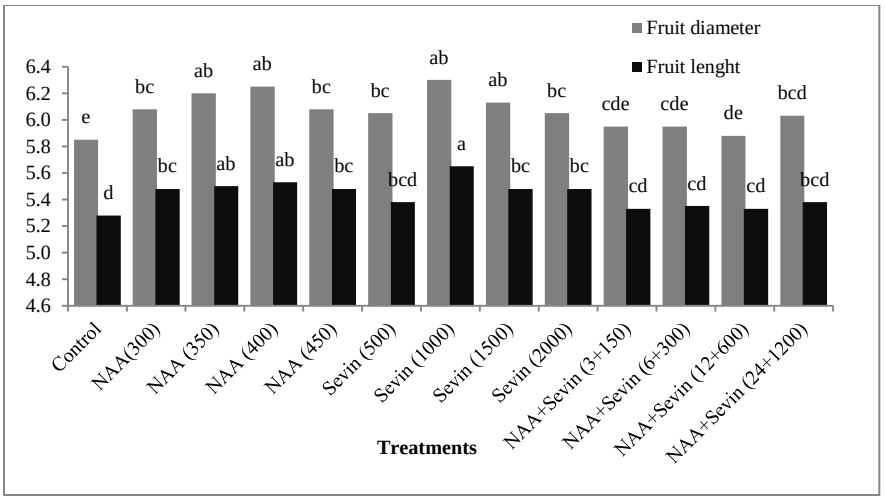

Figure 2. Effects of chemical thinning on fruit diameter (cm) and fruit length (cm) in 'Kinnow' mandarin trees

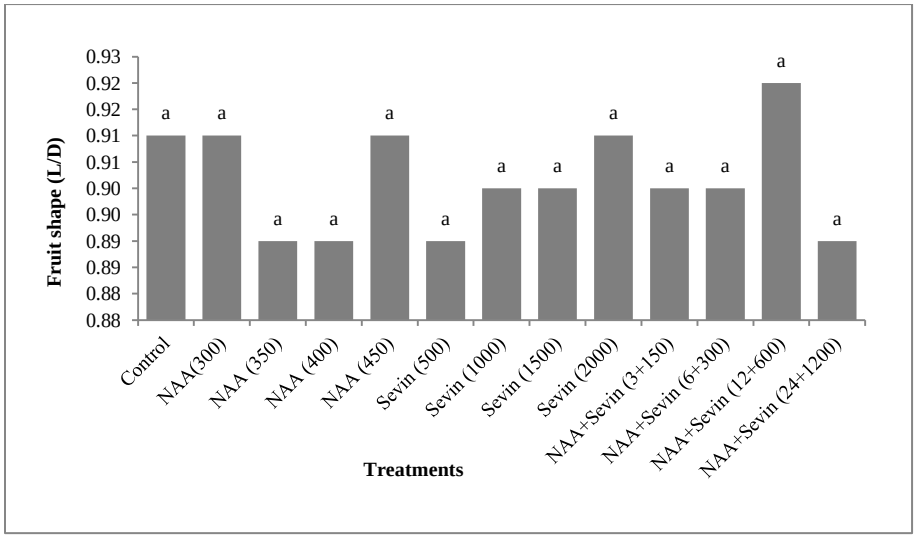

Figure 3. Effects of chemical thinning on fruit shape (L/D) in 'Kinnow' mandarin fruits

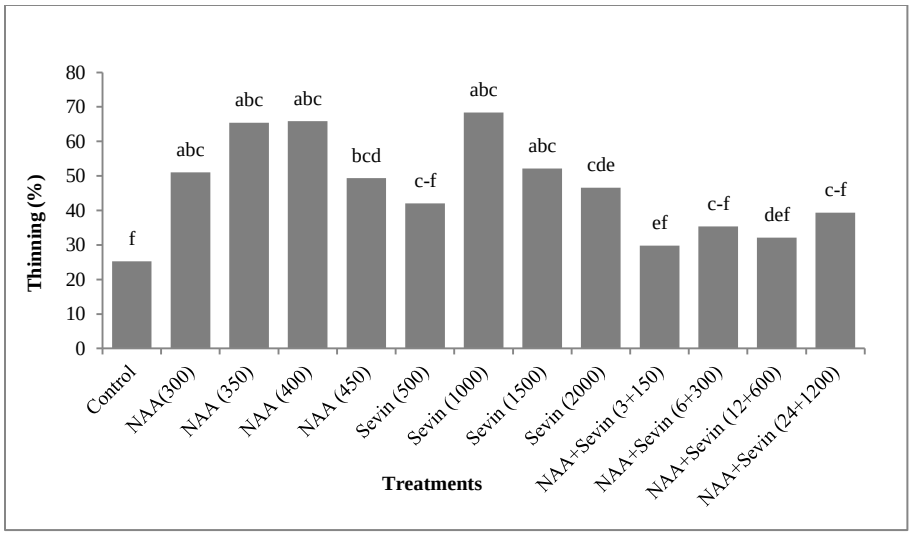

Figure 4. Effects of chemical thinning on fruit thinning (%) in 'Kinnow' mandarin trees.

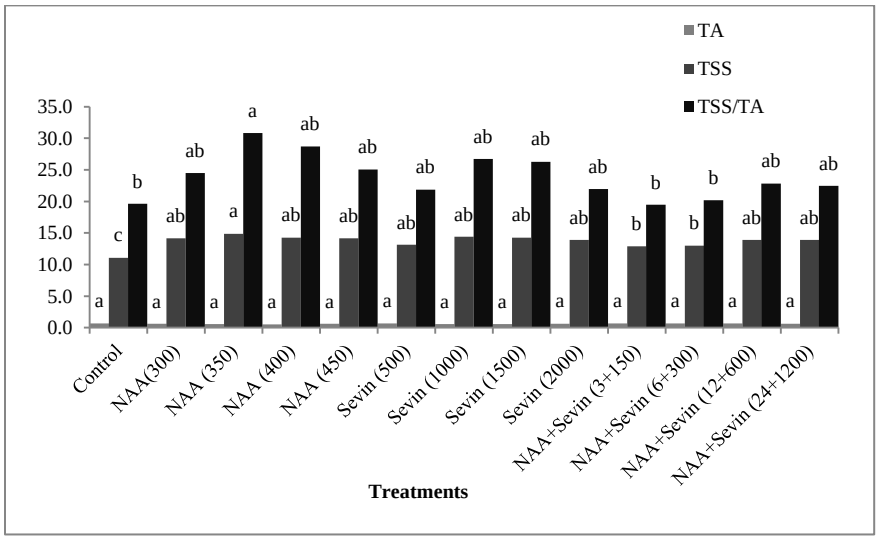

Figure 5. Effects of chemical thinning on TA (mg/100 ml), TSS (%) and TSS/TA in 'Kinnow' mandarin fruits

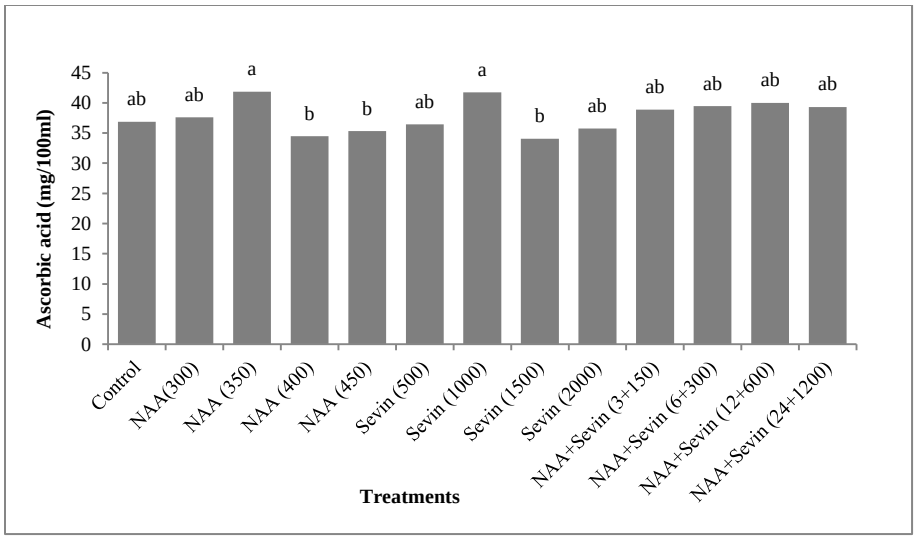

Figure 6. Effects of chemical thinning on ascorbic acid (mg/100 ml) in 'Kinnow' mandarin fruits

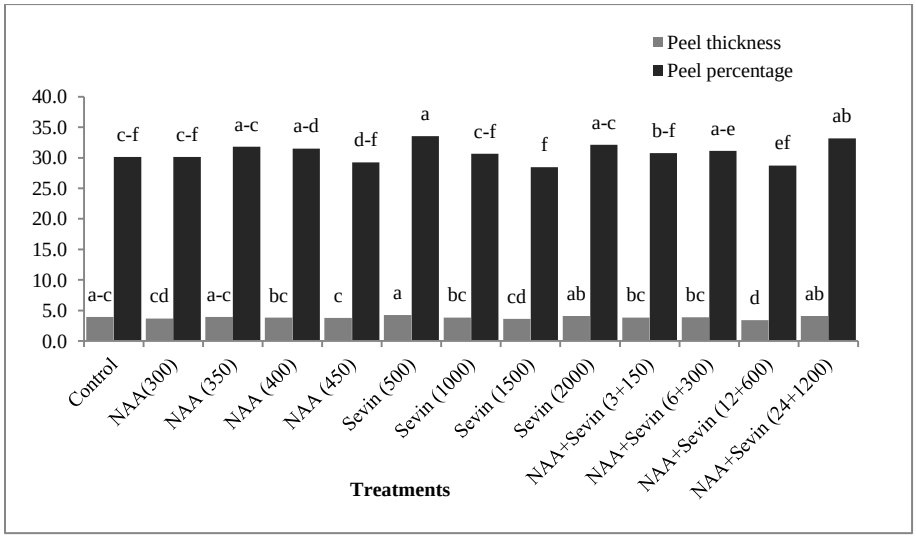

Figure 7. Effects of chemical thinning on peel thickness (mm) and peel (%) in 'Kinnow' mandarin fruits

DISCUSSION

In this study, fruit weight, volume, diameter and length increased by NAA treatment and thus improved fruit growth. On the other hand, these treatments increased fruit juice Tss and thinning percentage of trees. The effects of synthetic auxins such as NAA on fruit growth are well documented [1, 11-13]. It seems that auxins dependence on the time of application, effect on fruit growth by two mechanisms: a) thinning of fruits and reduce the crop load and b) direct effect on fruit growth by increase in cell division and cell elongation in fruit tissue [11, 14]. The mode of action of NAA for fruit drop is not clearly understood however two theories have been accepted for the mode of action of this chemical thinner: a) possible role of this compound via

phloem transport of hormones and photosynthates in and out of fruit and b) NAA effects causing by ethylene realize in the tissue [14]. Reduction in crop load increase leaf/fruit ratio and consequently less competition for available photo-assimilates and this leads to increase fruitlet growth rate [15].

Sevin treatments (except with 500 mg/l) increased significantly thinning percentage and TSS ratio of fruit juice and consequently fruit growth indexes (fruit weight, volume diameter and length) compared with control. It could be argued that the thinning activity of carbaryl changed the leaf / fruit ratio so that there were more leaves to support fruit growth. Although the mode of action of carbaryl is not clear however two hypotheses accepted for this a) the influx of metabolites in fruitlets and thus decreasing the growth and abscission ultimately or b) by activity the existing sinks, increase competition and reduced metabolite flow into the fruitlets [14].

These findings have been confirmed by some studies that showed that the relationships between fruitlet growth rate and amount of crop load were very subtle and a change on any of these parameters affected the others [3, 11]. All treatments (NAA and carbaryl alone) that decline fruit numbers in on year, increased fruit set in the next year (off year) (data not shown). Average fruit TA, ascorbic acid, TSS/TA ratio and peel thickness were similar for all treatments.

In this study, the effect of NAA in combination with carbaryl on fruit thinning and fruit growth rate was not different in comparison to each other alone as well as controls. Combination treatments only increased TSS of fruit juice rather than control. These results agree with previous reports [16, 17] that showed that when applied mixture of NAA and carbaryl, greater thinning effects of this mixture decrease compared to each other alone.

CONCLUSIONS

Reducing the number of fruit per tree by chemical thinners, increases the relative amount of leaf areas per fruit and hence the availability of photo-assimilates for the remaining fruits. This also improve flower bud induction and return bloom in ‘Kinnow’ mandarin trees and leads to more constant annual yields but this not true for combination of these two compounds with these concentrations.

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