Middle Eastern and Russian Journal of Plant Science and Biotechnology ©2008 Global Science Books

'Hayward' Kiwifruit Characteristics as Affected by Naphthalene Acetic Acid and Girdling

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ABSTRACT

In order to study the effect of NAA application and girdling on quantitative and qualitative characteristics of 'Hayward' kiwifruit and the probable effect of naphthalene acetic acid (NAA) on fruit thinning, the present research was performed. Twenty uniform vines were selected for uniformity of age and trunk diameter with all fruiting laterals intact. Shoots including leaves and fruits were sprayed with 0, 25, 50, 75 or 100 mg l^{-1} NAA to the point of run off. In each vine, half of the experimental canes were girdled and the other half left intact. NAA, especially at 50 and 75 mg l^{-1}, increased fruit criteria such as weight, length and width. Girdling increased fruit weight significantly, especially when combined with NAA. NAA did not have any thinning effect. Total soluble solids were significantly reduced as a result of NAA treatment, however girdling increased total soluble solids (TSS). Highest vitamin C content was obtained with combined NAA + girdling.

Keywords: *Actinidia deliciosa*, fruit weight, synthetic auxin, vitamin C

INTRODUCTION

Fruit size is one of the major factors that determines the marketability of kiwifruit and price of the fruit. Many studies have been conducted in the case of thinning and its effects on final fruit weight and yield of kiwifruit trees (Snelgar *et al*. 1986; Lahav *et al*. 1989; Samanci 1997; Thakur and Chandel 2004). Although hand thinning has a positive effect on fruit size, fruit number and yield however, decrease significantly and thus has to be done as early as possible (Snelgar *et al*. 1986). Cases have been reported in which thinning practices did not significantly affect fruit weight (Samanci 1997). Consequently, only removal of small fruits with no competitive ability is advised. Thinning is only recommended on high-yielding cultivars with small fruits such as 'Bruno' and 'Allison' (Lahav *et al*. 1989; Thakur and Chandel 2004).

In general, access to a technique which can increase fruit size without affecting harvested fruit numbers, is necessary and profitable.

To achieve this purpose, the positive effect of CPPU (a synthetic cytokinin compound) application has been reported but contradictory results exist on the manner and intensity of this chemical compound's effectiveness (Woolley *et al*. 1991; Patterson *et al*. 1993; Antognozzi *et al*. 1993, 1997; Cruz-Castillo *et al*. 1997, 1999, 2002). It is not quite clear whether an increase in size of treated fruits is as a result of increased cell division, cell elongation or both; however, since CPPU is a cytokinin-like compound, it is expected that most of its effect is due to increased cell division, as reported by Cruz-Castillo *et al*. (1997, 1999, 2002). Chouliaras and Gerascapoulos (1997) also reported that application of seaweed extract (a cytokinin-like activity compound) resulted in the marked increase in final fruit size and mean fruit weight of kiwifruit by increasing sink capacity of the fruits.

Thakur and Chandel (2004) stated that NAA application at petal fall increased fruit size and yield of 'Allison' kiwifruit but that high concentrations of NAA (200 mg l^{-1}) was phytotoxic to the vines and resulted in 7.75% fruit drop and partial defoliation.

The positive effect of girdling on fruit size and yield is well documented for grape, peach, nectarine, citrus, mango, avocado, olive and persimmon. Girdling-induced increase in fruit size is most probably caused by improved supply of photosynthates to the developing fruits (Goren *et al*. 2004).

Thus, this study was conducted in order to study the combined effects of NAA application and girdling on quantitative and qualitative characteristics of 'Hayward' kiwifruit and its probable effect on fruit thinning.

MATERIALS AND METHODS

The study was carried out in 2006-2007 on 13-year-old vines of kiwifruit cv. 'Hayward' in Mazandaran province in Iran. On each vine, uniform canes with the same number of determinate and indeterminate fruiting laterals, were selected, and leaf to fruit ratios adjusted to 2:1 in all experimental canes. This ratio was maintained by removing any shoot regrowth as they appeared. The experiment was as a factorial in a complete randomized design, having ten treatments with 4 replicates. NAA was used at five concentrations (0 (distilled water), 25, 50, 75 and 100 mg l^{-1}), 3 weeks after petal fall and half the treated canes on each vine were girdled by removing a 5 mm strip of bark around the base of each cane, while the other half were left intact.

When required, the girdles were recut to prevent reconnection of the phloem. Fruits were harvested at commercial maturity. Criteria measured after harvest were length, width, weight and volume of fruits considered as quantitative traits, while vitamin C content and total soluble solids concentration (TSS) were measured for qualitative characteristics. TSS and ascorbic acid content were determined by a digital refractometer (ATAGO. Tokyo) and indophenol titration method, respectively. All data were subjected to statistical analysis using MSTATC and means were compared using Duncan's new multiple range test.

Received: 29 July, 2008. Accepted: 20 August, 2008.

Short Communication

Table 1 Effect of NAA and girdling on quantitative and qualitative characteristics of kiwifruit 'Hayward'.

NAA concentration (mgl^{-1})	Length (cm)	Width (cm)	Weight (g)	Volume (cm^3)	Vitamin C content (mg/100 cc)	Total soluble solids (%)
Girdled cane						
0	7.01 d	5.15 e	90.06 d	84.96 d	65.24 bc	7.05 cd
25	8.15 abc	5.86 cd	145.14 abc	140.00 abc	65.12 bc	8.05 bc
50	8.50 a	6.13 bc	162.00 a	154.38 a	73.63 bc	8.17 abc
75	8.51 a	6.50 a	162.23 a	156.25 a	94.44 a	9.26 a
100	8.26 ab	6.17 b	152.58 ab	146.75 ab	79.20 b	8.93 ab
Non-girdled cane						
0	6.92 d	5.05 e	85.26 d	80.54 d	60.71 c	8.03 bcd
25	7.87 bc	5.88 cd	128.95 c	124.00 c	68.35 bc	6.80 d
50	8.03 bc	6.04 bc	139.63 bc	134.00 bc	76.56 bc	7.13 cd
75	8.05 bc	6.07 bc	144.80 abc	135.00 bc	75.24 bc	7.10 cd
100	7.76 c	5.75 d	128.93 c	122.33 c	71.25 bc	7.03 cd

The mean values within a column followed by the same letters are not significantly different at 5% level using Duncan's new multiple range test.

RESULTS AND DISCUSSION

As shown in **Table 1**, NAA treatments significantly improved all of the fruit quantitative characteristics when compared with the control, especially 75 and 100 mg l^{-1} NAA treatments, which, when combined with girdling, significantly improved fruit length, weight and volume. Girdling alone had no significant profitable effect. NAA treatments at the concentrations used had no thinning effect and did not cause fruits to drop.

Table 1 shows also that 75 mg l^{-1} NAA combined with girdling produced fruits with greatest amount of vitamin C content. Furthermore, these fruits had higher TSS compared with untreated (control) TSS, which was slightly reduced by the use of NAA alone.

It is clear from the results that NAA treatments significantly improved fruit quantitative characteristics. The positive effect of this synthetic auxin is similar to that reported by other authors using 2,4-DP (another synthetic auxin) applied on mandarins (Agusti *et al*. 1994) and NAA application on kiwifruit 'Allison' (Thakur and Chandel 2004). This means that NAA increases fruit sink strength and causes to produce bigger fruits with more dry weight and water content.

The low leaf: fruit ratio (2: 1) that was observed on each experimental cane might be the reason for non-significant effectiveness of girdling on fruit quantitative characteristics. Though in another study, Lai *et al*. (1989) with ^{14}C-tracer studies showed that a minimum leaf: fruit ratio (2: 1) was required to support optimum fruit growth in 'Hayward', without import of carbohydrate from other parts of the vine.

At all NAA concentrations, girdling improved fruit quantitative characteristics and its effectiveness increased at higher concentrations (50, 75 and 100 mg l^{-1}). This finding confirms the positive effect of girdling through increased supply of available carbohydrate for fruits that was previously reported by Goren *et al*. (2004), and also improved assimilate uptake with increased plant growth regulator concentrations.

These data suggest that final fruit growth is limited by its sink strength and by severe competition for photosynthate from other sinks such as replacement canes and the root system (Snelgar *et al*. 1986).

The results reported here agree with the findings of others (El-Otmani *et al*. 1993; Agusti *et al*. 1994; Thakur and Chandle 2004), i.e. that application of NAA did not have any effect on fruit drop. This lack of response with respect to fruit thinning following the application of NAA may be attributed to insensitivity of the abscission zone to this growth regulator.

In non-girdled treatments, NAA applications at different concentrations reduced TSS, but this effect was not significant. Richardson *et al*. (1997) stated that cultural techniques which increase fruit size, such as plant nutrition or the application of growth regulators, decreases TSS through a dilution effect; however, all concentrations of NAA in girdling application increased TSS. This finding, confirms the positive effect of girdling on this qualitative aspect of fruit characteristics, through increasing supply of available carbohydrates for fruits.

Application of 75 mg l^{-1} NAA combined with girdling produced fruits that had highest vitamin C content in comparison with other treatments. No explanation could be provided. In general, from the aspect of treatments effects on all quantitative and qualitative fruit characteristics, this treatment was the best.

It can be concluded that with regard to girdling, there are limitations that should be considered. Damage or even the deaths of trees are occasionally observed. Girdling-induced damage is more pronounced in cases where the trees are weak and are grown under unfavorable conditions. In order to reduce tree injury, girdling is recommended on healthy, vigorous trees. These trees need adequate irrigation, fertilization, disease and pest control (Cohen 1984). As reported earlier (Cohen 1984; Fernandez-Escobar *et al*. 1987; Villiers 1990), girdling the whole tree (the trunk or all main branches) can result in adverse effects on the roots as root starvation. So, it is recommended that girdling may be done only on some branches, and not the trunk.

In general, application of NAA is an effective means of improving the fruit quality especially when combined with girdling, however further work must be done to confirm this findings.

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