Available online at www.sciencedirect.com
ScienceDirect
Scientia Horticulturae 114 (2007) 275–280
SCIENTIA HORTICULTURAE
www.elsevier.com/locate/scihorti

Effect of synthetic auxins on fruit development of 'Bing' cherry (*Prunus avium* L.)

Raphael A. Stern [a,*], Moshe Flaishman [b], Steve Applebaum [c], Ruth Ben-Arie [d]

[a] *MIGAL, Galilee Technology Center, P.O. Box 831, Kiryat-Shmona 11016, Israel*
[b] *Institute of Horticulture, ARO, The Volcani Center, P.O. Box 6, Bet-Dagan 50250, Israel*
[c] *Kibbutz Ortal, Golan Heights 12430, Israel*
[d] *Fruit Storage Research Laboratory, Kiryat-Shmona 10200, Israel*

Received 29 April 2007; accepted 9 July 2007

Abstract

The main cherry cultivar grown in the warm climate of Israel, 'Bing', produces relatively small fruit. Over three consecutive years (2003–2005), application of 50 mg l^{-1} 2,4-dichlorophenoxypropionic acid [2,4-DP; as its butoxyethyl ester (Power™)], 10 mg l^{-1} 3,5,6-trichloro-2-pyridyloxyacetic acid [3,5,6-TPA; as the free acid (Maxim®)], or 25 mg l^{-1} 2,4-dichlorophenoxyacetic acid (2,4-D) plus 30 mg l^{-1} naphthaleneacetic acid (NAA; 0.3% Amigo™), at the beginning of pit-hardening when fruitlet diameter was ca. 13 mm caused appreciable and significant increases in fruit size and total yield, except when the crop load was heavy. Anatomical studies revealed that the main effect of these synthetic auxins was *via* direct stimulation of fruit cell enlargement. The above auxins had no negative effect on fruit quality, either at harvest or after 1 month of storage at 0 °C, or on return yield in the following year.

Keywords: Auxins; Cherry; Fruit size; *Prunus avium* L.

1. Introduction

Small fruit size is one of the limiting factors in marketing cherry (*Prunus avium* L.) fruit (Sansavini and Lugli, 2005; Whiting and Ophardt, 2005). As consumers prefer large cherries, fruit size is a very important marketing consideration, and the economic benefits of treatments capable of improving average fruit size are potentially very high. Several techniques have been used to improve fruit size of cherry. Among them, bloom and fruit thinning have been proven to be effective (Proebsting, 1990). Whiting and Lang (2004) showed that a negative relationship exists between the ratio of fruit number to leaf area and the size of the sweet cherry fruit. However, the commercial application of chemical bloom or fruitlet thinning of sweet cherry has not yet been reported in the literature and no products are currently registered for this purpose (Byers et al., 2003; Whiting and Ophardt, 2005). Synthetic auxins may be effective in enhancing fruit growth, when applied during the second stage of fruit development (Faust, 1989; Westwood, 1993). These auxins are known for their ability to increase cell enlargement (Westwood, 1993; Arteca, 1996; Davis, 2004), thus enhancing fruit growth in certain species such as *Citrus* (Agusti et al., 1995), peach (Agusti et al., 1999; Flaishman, 2006), litchi (Stern et al., 2000), apricot (Agusti et al., 1994) and loquat (Agusti et al., 2003). In all species so far studied, synthetic auxin had the potential for increasing fruit size without inducing thinning.

In *Citrus*, peach and litchi, it was found that application of the synthetic auxin 3,5,6-trichloro-2-pyridyloxyacetic acid (3,5,6-TPA), at concentrations between 10 and 20 mg l^{-1}, considerably increased fruit size, whereas in apricot and loquat, 2,4-dichlorophenoxypropionic acid (2,4-DP) at 25–50 mg l^{-1} had the optimum effect.

Application of 2,4,5-trichlorophenoxypropionic acid (2,4,5-TP) was in commercial use, in stone fruit and litchi orchards in Israel, until its registration was withdrawn.

Since no report has been published as to the effect of synthetic auxins on fruit size of sweet cherry, the objective of this study was to evaluate the effects of some synthetic auxins on fruit development, size, maturation, quality and yield in 'Bing' sweet cherry.

* Corresponding author. Tel.: +972 4 6953508; fax: +972 4 6944980.
E-mail address: Raffi@migal.org.il (R.A. Stern).

0304-4238/$ – see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.scienta.2007.07.010

2. Material and methods

2.1. The orchards

Experiments were conducted between 2003 and 2005 on mature cherry 'Bing' trees grafted on 'Mahaleb' (*Prunus mahaleb* L.) rootstock, in three orchards:

(1) At Merom-Golan, located 900 m above sea level (a.s.l.) on the Golan Heights, where the trees were 2.5 m high, spaced at 2.5 m × 4.5 m (880 trees ha^{-1}).
(2) On the Fichman Experiment Station, located 1000 m a.s.l. on the Golan Heights, where the trees were 3.0 m high, spaced at 2.5 m × 4.5 m (880 trees ha^{-1}).
(3) At Ortal, located 1100 m a.s.l. on the Golan Heights, where the trees were 3.0 m high, spaced at 3.0 m × 5.0 m (670 trees ha^{-1}).

All orchards are located in a semi-arid area with high temperatures (ca. 35 °C max.) and low humidity (<40% RH) during the summer (May–October). Average annual precipitation (November–April) is approximately 900 mm. The soil is 0.8 m deep, and classed as a well-drained basaltic protogromosol (65% clay) on basaltic rocks. The soil pH is 7.7 with a $CaCO_3$ content of approximately 7% (w/w). The irrigation system consisted of two lateral lines per row, separated by 1.0 m, with 1.6 l h^{-1} pressure compensated in-line drippers (Netafim, Iftach, Israel) space at 0.5 m. Since yield of 'Bing' is usually low, no thinning treatments were applied.

2.2. Auxin application

Three commercial products, containing different synthetic auxins, were applied: (1) Maxim® tablets containing 10% (w/w) 3,5,6-trichloro-2-pyridyloxyacetic acid (3,5,6-TPA; Dow AgroScience, Madrid, Spain); (2) Power™, a liquid formulation containing 5% (w/v) 2,4-dichlorophenoxypropionic acid (2,4-DP butoxyethyl ester; Fine Agrochemicals, Whittington, UK); (3) Amigo™, a liquid formulation containing 0.8% (w/v) 2,4-D isopropyl ester plus 1% (w/v) naphthaleneacetic acid (NAA); Lainco, Barcelona, Spain.

The synthetic auxins were applied as foliar sprays at different concentrations at 2 l $tree^{-1}$ using a high-pressure handgun (Kibbutz Degania 15130, Israel) until run-off. A non-ionic surfactant, Triton X-100, was included in all sprays at 0.025% (v/v). Applications were made at the beginning of pit-hardening (25 days after full bloom = DAFB), when the fruitlets had reached a diameter of ca. 13 mm in all experiments. The experiments were conducted on whole trees bearing a uniform crop load according to the fruit set at that moment. Control trees, with the same crop load, were not sprayed.

The experimental design was a randomised complete block, with eight replications of one tree per treatment. In each experiment, the fruits were harvested twice based on the commercial measurement—mahogany color (Crisosto et al., 2003). At harvest, the yield from each tree was weighed and all fruit were manually sorted by diameter: small (<22 mm), medium (22–26 mm) or large (>26 mm). Semi-commercial trials were conducted in 2005 at Merom-Golan (880 trees ha^{-1}) and Ortal (670 trees ha^{-1}) using a commercial (1000 l) air-blast "spidet" sprayer (Kibbutz Degania 15130, Israel) at a rate of 1500 l ha^{-1}. In Merom-Golan, each tree received 1.7 l of the solution, while in Ortal, each tree received 2.2 l. This was a randomised complete blocks experimental design with four replicates. Each replicate consisted of 10 trees. At harvest, total yield and average fruit size were determined for all 10 trees.

2.3. Fruit growth

In Merom-Golan orchard (in 2004) and Ortal orchard (in 2005) ten 1-year-old limbs bearing one typical fruit were selected on each tree. Development of 40 fruit (10 fruit per tree × 4 trees) per treatment was monitored from the day of treatment until harvest by periodically measuring the diameter of each fruit on the selected limbs.

2.4. Fruit characteristics at harvest and after storage

Maturity at harvest and keeping quality in storage of fruit, sampled at the peak of the commercial harvest in the Merom-Golan orchard (2004), were examined for two of the auxin treatments and the control. Two representative samples of ca. 1 kg of the predominant size (26 mm) were selected from the fruit harvested from two trees in each of three replicates per treatment. For assessment of ripening, sub-samples of 10 fruit from each batch were subjected to measurement of color and extraction of the juice by squeezing in muslin for assay of soluble solid content (SSC) and titratable acidity (TA). Color readings were performed with a calibrated Minolta CR-200 chromameter, using the L^*, a^*, b^* coordinates of the CIELAB system. Chroma (C) and hue angle ($H°$) were calculated from a* and b*. SSC was measured with a digital refractometer (Atago Co. Ltd., Tokyo, Japan). Two millilitres of aliquots of the extracted juice were titrated with 0.1 M NaOH to pH 8.2 to assess TA, expressed as g malic acid equivalent 100 g^{-1} fruit flesh. For quality assessment, the remaining fruit were examined either on the same day or after storage. Stored fruit was pre-cooled to 0 °C, wrapped in polyethylene bags and held at this temperature for 3 weeks. Fruit examination consisted of sorting fruit for defects, such as decay, pitting, cracking and shrivel, in this order. Fruit that had none of these defects were considered healthy. Fruit with more than one of the defects fell into the more severe category, according the order described above.

2.5. Anatomical analysis

Cell size was measured on sections prepared from five representative fruit, uniform in size (26 mm) and color (mahogany), harvested from each treatment applied to the Merom-Golan orchard in 2004. For histological examinations, fruits were fixed in FAA solution [50% (v/v) ethanol; 10% (v/v) formaldehyde; 5% (v/v) acetic acid; 35% (v/v) H_2O] at room