Mitteilungen Klosterneuburg 57 (2007): 176-179

Short Communication

Flower thinning with sweet cherry (*Prunus avium* L.): A first year field study

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*Effects of the chemical flower thinning agent ammonium thiosulfate (8.82 g/l and 17.64 g/l) on the fruit of three cherry (*Prunus avium *L.) cultivars - 'Blaze Star', 'Samba', 'Techlovan' - were measured. Parameters analysed were crop load, fruit size, fruit weight, soluble solids, pH-values and the content of anthocyanins. Significant reduction in crop load was assessed by chemical flower thinning, fruit size and fruit weight, however, were not significantly increased. The content of soluble solids and the pH-value were significantly affected by application of the thinning agents.*

Key words: Cherry, flower thinning, ammonium thiosulfate, fruit quality, 'Blaze Star', 'Samba', 'Techlovan'

Sweet cherry (*Prunus avium* L.) is commercially cultivated in temperate climatic regions for local and national markets. For the production of high quality fruit with at least 20 mm of diameter and adequate colouring as defined in EC regulations (COMMISSION REGULATION 214/2004 OF THE EUROPEAN UNION OF THE 6TH OF FEBRUARY 2004 LAYING DOWN THE MARKETING STANDARDS FOR CHERRIES) intensive horticultural management is required. Fruit thinning is a well recognized strategy and has been successfully applied in a variety of fruits (e.g. apples, peaches, apricots (COSTA and VIZZOTTO, 2000)). Fruit thinning effects through flower reduction cause increased fruit sizes, improved fruit quality, prevention of alternate bearing and balancing of the fruit-to-shoot ratio, leading to an increase in assimilates in fruit and shoots (LINK, 2000), whereas excessive fruit set may result in small fruit size and low quality, breakage of branches, exhaustion of reserves and reduced cold hardiness (WEBSTER and SPENCER, 2000). Field study research on flower or fruit thinning with sweet cherries is in the beginning and published studies indicate the complexity of physiological and genetic interactions and difficulty of data interpretation. HANGARTER (2006) showed reduced yield and increased fruit sizes (application of 5% ammonium thiosulfate (ATS)), whereas WIDMER et al. (2006) did not find improved fruit sizes despite of a reduction of fruit set after the treatment with ATS (0.9%). Work on the molecular background of cherry fruit abscission has greatly increased the knowledge on fruit set and development of cherry fruit (e.g. BLANUSA et al., 2005).

Though fruit thinning is an often used management strategy, the multiple interacting elements affecting fruit formation in the field need to be assessed. Timing, technique and the degree of thinning are key factors for developing a thinning strategy. A first field study was performed in a sweet cherry plantation employing a flower thinning strategy to address the questions (1) whether flower thinning can be achieved with sweet cherries employing ATS; and (2) if flower thinning affects the fruit size of three sweet cherry cultivars.

Material and methods

Plant material

Three cultivars 'Blaze Star' (sterility alleles S_4'S_6, self-fertile), 'Samba' (S_1S_3, partially self-fertile) and 'Techlovan' (S_3S_6, self-sterile) were employed. All varieties are grafted on 'GiSelA 5'- rootstocks, were planted in

2003 and trained in a spindle system with shifted centreline with distances between rows of 4.5 m and distances between trees of 2.5 m.

Experimental design

Besides one control three treatments were performed and repeated four times resulting in a total of 48 trees randomly placed:

I) Thinning with water,
II) Thinning with ammonium thiosulfate (ATS) at 8.82 g/l (low; equals 0.9 %)
III) Thinning with ammonium thiosulfate (ATS) at 17.64 g/l (high, equals 1.8 %)
IV) control (no treatment).

Each tree was treated at two branches of the same age and of each treated branch 100 flowers were analysed. The treatments were applied with a hand sprayer (April, 24th, 2006; 10 a.m.; 13 °C; relative humidity of 50 %) onto the fully opened flowers. Assessment of winter frost injuries on 400 randomly chosen flowers of each cultivar showed no significant differences among or within the cultivars 'Samba' (4.00%) and 'Techlovan' (4.00%). The variety 'Blaze Star' (0.00%) did not show frost symptoms and significantly differed from the two other varieties.

Harvest and fruit quality assessment

Harvest of fruit of 'Blaze Star' and 'Samba' occurred 60 days, of 'Techlovan' 63 days after anthesis. Fruit were hand-picked and stored at 2 to 3 °C for three days until the beginning of laboratory tests. The effect of natural abscission (June drop) was estimated by comparing the yield of the control versus the originally counted quantities of flowers. The amount of fruit formed of the originally counted flowers ('yield') was measured (at each trial branch) by counting total numbers of fruit. Fruit size was determined by the cross-diameter of 10 randomly chosen fruit per tree, and fruit weight was determined from ten randomly chosen cherries per tree. Total soluble solids (°Bx) were analysed with five randomly chosen fruit per tree with a digital refractometer (Atago digital refractometer PR-101 Palette). The pH-value was determined with ten randomly chosen fruit using a digital penetration pH-meter (one puncture per fruit, Unicam 9450 pH-meter). For spectrometric analysis ten randomly selected cherries per tree were cored, squeezed with a hand squeezer and the pulp was separated from the juice in a strainer and stored at -20° C for six weeks. The pre-frozen juices were defrosted at +4 °C and extracted with 5% propanoic acid (99%) in methanol (⩾99.95%) for 15 minutes in an ultrasonic bath prior to centrifugation (15 min at 6000 rpm). The concentration of cyanidine equivalents as an index for the total content of anthocyanins was assessed by measuring absorption of the supernatant at 528 nm in three replications against cyanidinchloride (M = 322.7 g/mol; 5%) using a Unicam UV/Vis spectrometer (UV 2). The statistical analyses were conducted with SPSS 12.0 for windows (SPSS Inc., Chicago, USA) executing univariate variance analysis applying the multiple range test of Duncan or t-tests. The data of the fruit weight and size were subjected to correlation analysis of Pearson.

Results and discussion

ATS induced flower thinning

A single ATS application showed significant effects on flower thinning with all cultivars tested. The high ATS treatment induced the best thinning efficiency in two of the three cultivars tested (Table 1). Additionally strong cultivar specificity could be assessed. 'Samba' and 'Techlovan' did not show significant differences between the two ATS treatments. A significant effect of the treatment with water could only be assessed in 'Blaze Star'. The total yield (number of fruit formed out of the originally counted flowers) of the control treatment (showing the influence of the natural fruit fall) varied among the cultivars as did the efficiency of the flower thinning treatments. The control variant of 'Blaze Star' developed the highest number of fruit after June drop (44.25% of the originally counted flowers), whereas 'Samba' produced 21.25% and 'Techlovan' only 14.22% of the originally counted flowers. One possible reason for the high percentage of coulure may be a shortage of insects for pollination. Self-fertile 'Blaze Star' was not that much affected as the self-sterile variety 'Techlovan'.

Effect of flower thinning on fruit size and fruit weight

Effects of each of the treatments on fruit size (diameter) and fruit weight are shown in Table 1. Fruit size and fruit weight were significantly correlated as expected ($r = 0.994$; $p = 0.01$). Fruit sizes of 'Blaze Star' were not significantly affected by any treatment; 'Samba' produced fruit sizes ranging from 23.64 mm (high ATS) to 24.38 mm (low ATS). 'Techlovan' produced the biggest fruit sizes possibly due to the excessive June drop. Concerning the fruit size both ATS treat-

Table 1: Yields, size, weight, total soluble solids and pH-values of three sweet cherry cultivars

	Blaze Star		Samba		Techlovan	
	Yield (amount of fruits in % of the originally counted flowers)					
Control	44.25 b		21.25 cd		14.22 f	
Water-treatment	33.00 a		31.13 d		8.25 ef	
ATS 8.82 g/l	45.13 b		16.00 c		4.75 e	
ATS 17.64 g/l	27.63 a		16.88 c		2.27 e	
	Size (mm)	Weight (g)	Size (mm)	Weight (g)	Size (mm)	Weight (g)
Control	21.03 i	5.82 j	24.24 k	8.10 l	25.36 m	9.02 o
Water-treatment	19.50 g	4.83 j	24.33 k	8.46 l	26.07 mn	9.53 o
ATS 8.82 g/l	20.44 hi	5.39 j	24.38 k	8.45 l	26.80 n	10.61 o
ATS 17.64 g/l	20.09 gh	5.24 j	23.64 k	8.00 l	26.82 n	9.94 o
	°Brix	pH	°Brix	pH	°Brix	pH
Control	15.02 pq	4.03 s	14.77 t	4.07 x	15.18 z	4.09 öü
Water-treatment	14.37 p	4.04 s	15.76 uv	3.91 y	20.21 ä	4.10 ü
ATS 8.82 g/l	15.29 q	4.02 rs	16.13 v	3.96 y	16.98 z	4.09 öü
ATS 17.64 g/l	15.55 q	3.97 r	15.10 tu	3.91 y	*)	4.00 ö

Values with different letters within the same column per characteristic per cultivar (a-b; c-d; e-f; i-h; j; k; l; m-n; o; p-q; r-s; t-v; x-y; z-ä; ö-ü) are significantly different ($P < 0.05$), *) too less fruit for analysis

ments of 'Techlovan' differed significantly from the control, but concerning weight there was no significant difference among all treatments of this cultivar. Additionally to these results one has to consider, that the effects of flower thinning on fruit quality may be greatly affected by the timing of thinning. Since the stage of bloom often varies among trees within one orchard and even within trees, timing is critical if optimum results should be obtained (Dennis, 2000). Especially for early ripening cherries timing is crucial. Furthermore ATS-induced leaf damages may have affected fruit sizes through reduced leaf areas limiting photosynthetic activity (Widmer et al., 2006). If the treatment is applied or active during the main period of cell division, negative effects on cell numbers and consequently fruit size will occur. Therefore the timing of the thinning treatment is crucial for the efficiency (Hangarter, 2006) and the success of the treatment depends on climatic conditions, flowering strategy and the cultivar's growth stage. Any experimental approach employing different cultivars and even larger plantation plots need to be carefully evaluated. In the presented experiment we chose a later time for application presuming that fertilization of flowers has occurred prior to the application.

Effect of flower thinning on fruit quality parameters

The contents of total soluble solids (°Bx) were significantly affected by flower thinning in all cultivars (Table 1). The high ATS treatment had stronger effects with 'Blaze Star', whereas the low ATS treatment affected more the soluble solids content in 'Samba'. This indicates cultivar specificity which was also reflected in a significant cultivar-treatment interaction pertaining total acidity which was significantly reduced after flower thinning treatments (Table 1) in all cultivars tested.
The increased content of total soluble solids may be due to the reduced crop load and better support of fruit with water, nutrients and assimilates (Costa and Vizzotto, 2000), though this hypothesis needs critical evaluation, since controversial results concerning fruit size and soluble solids are reported. For instance Wells and Bukovac (1978) noted that fruit size, soluble solids content and fruit colour in plum (variety: 'Stanley') were negatively correlated with increasing fruit loads. On the other hand, Link (2000) reported, that increased sugar contents in fruits were not related to reduced fruit size. The study of Serrano et al. (2005) with cherry fruit confirms our results indicating accumulation of malic acid (e.g.), while in other stone fruits (plum, peach, apricot, nectarine) acidity decreased during fruit development and ripening (Drake and Fellman, 1987). In our study the amount of free acids was higher after thinning, while the pH values were decreased. Poll et al. (2003) assumed that the high concentrations of total acids are due to low fruit-to-leaf ratios, possibly due to decreased inter-fruit competition.
No effect of flower thinning could be assessed on the anthocyanin contents though the darker cultivar 'Techlovan' contains a significantly higher amount of antho-

cyanin than the two other varieties (data not shown). Anthocyanin content is mainly affected by the genotype and the environmental conditions (e.g. irradiation) rather than by physiological parameters. This assumption is confirmed by KELLER et al. (2005) in their study on the effect of cluster thinning on three deficit-irrigated *Vitis vinifera* cultivars indicating strong influence of the seasonal conditions on the anthocyanin accumulation with 'Cabernet Sauvignon' but independence of cluster thinning. Anthocyanin content in fruit is also affected by inter-annual differences as indicated in a study on grapes (ORTEGA-REGULES et al., 2006).

Future perspectives

Flower thinning with sweet cherry seems to be a promising strategy for applied horticultural management. As with any chemical thinning agent effects are hard to predict and basic work has to be done to elucidate the morphological and molecular effects of thinning agents to the flower (pollen tube development) and fruit. Besides the entire tree physiology needs to be involved in terms of vegetative sink competition, shading effects and hormone metabolisms. Further studies are underway to repeat field work and bioassay flower-fruit-quality interaction in sweet cherries.

Acknowledgements

We are thankful to Prof. Dr. J. WÜNSCHE (University of Hohenheim, Germany) for helpful comments to an earlier version of the manuscript and we thank Dr. J. BALAS (University for Natural Resources and Life Sciences, Vienna) for assistance in photometric measurements. We highly appreciated the assistance of our field crew at the experimental station. This work contributes in part to the master's thesis of K. SCHOEDL.

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Received June 5, 2007