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Quality and Quantity of Chemically-thinned and Hand-thinned Pear Fruit (*Pyrus communis* L.) cv. 'Conference'

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Summary

The influence of chemical and hand thinning on the quality and quantity of pear fruit (*Pyrus communis* L.) form the cv. 'Conference' was investigated at Pirsenbreg (Slovenia) in 2005, 2006 and 2007. The experiment included these four treatments: chemical thinning with NAA 8 mg l^{-1}, hand thinning 0.8 fruits cm^{-2} of trunk cross sectional area (TCSA), hand thinning 0.5 fruits cm^{-2} of TCSA and control in 2005. Because thinning with NAA 8 mg l^{-1} was insufficient, an additional treatment with NAA at 16 mg l^{-1} (NAA 16) was performed in 2006, and NAA at 20 mg l^{-1} (NAA 20) in 2007. Hand thinning 0.8 or 0.5 fruits cm^{-2} TCSA had no influence on floral density, yield efficiency or soluble solids content. Hand thinning did produce a statistically significant increase in fruit diameter and fruit weight in 2005 and 2007. Chemical thinning had a minor influence on fruit dimension (diameter, length, and weight), because the differences between control and individual chemical thinning treatments were insignificant. Chemical thinning by NAA of fruit on trees was insufficient. In 2005, we noticed a higher and statistically significant amount of soluble solids in the fruit of trees thinned with NAA 8 mg l^{-1}. Chemical thinning with NAA 8 mg l^{-1} had no influence on fruit firmness in 2005, while in 2006 and 2007 fruit firmness was higher than in the control. Chemical thinning had no negative effect on floral density, number of fruit per tree, fruit set, yield per tree, yield efficiency, crop load or total acids content.

Key words. yield – thinning – NAA – HPLC – organic acids – sugars

Introduction

To sustain and improve the profitability of commercial production of European pears, it is essentially to improve the precocity and productivity of cropping in pear orchards. To achieve these goals, the fruit grower must gain better control of flower induction and development, flower quality, pollination, fruit set, fruitlet growth and fruitlet abscission. Unfortunately, the research on developing a better understanding of these component processes in pear cropping has been limited in comparison to similar research and strategies for their control in apple (Garriz et al. 2004). Researchers have shown that, in many cases, pears react to thinning differently than apples when successfully subjected to agronomic strategies used for the latter crop (Webster 2002).

For the pear industry, regular annual crops of high internal and external quality are essential. A prerequisite for a regular annual crop is an adequate number of flowers per tree: i.e., sufficient flower bud formation in the preceding year. This can only be achieved in the case of a sufficiently small number of fruit per tree. Through its seeds, fruit has a negative effect on flower bud formation. Seed-produced hormones probably play a major role in this negative effect (Callejas and Bangerth 1997).

Fruitlet thinning is one of the most important management practices a commercial grower is required to do in order to produce high quality pears (Yuan and Green 2000a). Fruit thinning at an early stage of fruit development improves fruit size, colour and quality at harvest, while increasing return bloom the following year and thus reducing biennial bearing (Yuan and Green 2000b). For a high quality crop, a sufficient number of leaves per fruit must be present in order to ensure good development. Normally, a reduction in the number of fruit per tree by thinning is necessary, since too many flowers per tree set fruit (Wertheim 2000). The thinning of flowers and fruit prevents the development of some fruit, often allowing the remainder to become larger and more marketable (Dennis 2002). Pear fruitlet thinning performed by hand is a costly operation, seriously limiting crop profitability. Successful thinning with chemicals would significantly reduce the cost of production and lead to larger marketable yields (Dussi et al. 2008).

Post-bloom application of NAA (naphthaleneacetic acid) is cultivar specific and may, in addition to causing fruit abscission, show unwanted side effects (for example leaf damage and inhibited growth of shoots (Widmer and Stadler 2007)). Varying response among cultivars can be directly associated with their differing sensitivities to NAA (Garriz et al. 2004). NAA is known to stimulate ethylene synthesis in plants. Applications of NAA or other synthetic auxins delays apple fruit abscission, even though fruit ethylene production and fruit softening are increased at ripening. Increased expression of genes and enzyme activity associated with cell wall degradation are

concomitant with increased ethylene production (LI and YUAN 2008). Weather conditions are greatly involved in the effect of chemical thinners. Leaf uptake of NAA increases with temperature and is better at low light intensities. The role of humidity is disputed (BLACK et al. 1995).

In our climatic conditions, the 'Conference' cultivar is biennial bearing, with high yield in "on"-years and very low yield in "off"-years. The aim of our research was to investigate the effect of NAA and hand thinning on fruit size, external and internal quality and quantity of the 'Conference' pear cultivar. The 'Conference' cultivar is a high yielding cultivar, which produces many small fruit, if it is not thinned.

Material and Methods

Plant material

The study was conducted on 22-year-old 'Conference' pear trees (*Pyrus communis* L.) on quince MA rootstock, growing on sandy loam and trained to spindle, during the 2005, 2006 and 2007 growing seasons at the commercial orchard in Pirsenbreg (Slovenia). The trees were spaced 3.9 × 1.5 m, the height of the tree was 3.5 m. The experiment included these treatments: unsprayed control; hand thinning to 0.8 fruits cm^{-2} of TCSA (trunk cross-sectional area) (hand thinning 1); hand thinning to 0.5 fruits cm^{-2} of TCSA (hand thinning 2); and NAA at 8 mg l^{-1} (IsagroItalia S.p.A., Segrate-Milano, Italy) (NAA 8) in 2005, 2006 and 2007. An additional treatment of NAA at 16 mg l^{-1} (NAA 16) was added in 2006, and NAA at 20 mg l^{-1} (NAA 20) was added in 2007. We sprayed with NAA thinner on 12th May 2005 [24 days after full bloom (DAFB)], on 10th May 2006 (20 DAFB), and on 26th April 2007 (18 DAFB), at 9–10 mm of fruit diameter. Temperatures at the beginning and end of spraying with NAA thinner were 12 to 16 °C in 2005, 18 to 24 °C in 2006 and 18 to 20 °C in 2007; humidity was 77 to 58 % in 2005, 51 to 46 % in 2006 and 80 to 77 % in 2007. For the hand thinning treatments, we removed redundant fruit proportionately over the whole tree to balance the number of fruit to TCSA after "June drop" (2005 Jun. 27, 2006 Jun. 24 and 2007 Jun. 25). The experiment was arranged as a random design with three trees in four repetitions (12 trees per treatment). The same treatments were applied to the same trees in each of the three years. The orchard was managed according to standard commercial practice for integrated fruit production (i.e. pruning, spraying, irrigation, etc.) (MINISTRY OF AGRICULTURE, FORESTRY AND FOOD 2007). Physical characteristics such as floral density, fruit set, fruit weight (g), fruit diameter and length (mm), number of fruit per tree, yield per tree, yield efficiency, crop load and firmness were determined, and chemical analyses (soluble solids content (SSC; %), individual sugars and organic acids) were carried out. Forty fruit from each treatment were used for chemical and physical analysis. Trunk diameters were measured 20 cm above the graft union each year in spring before budbreak and in autumn after harvest, from which the trunk cross-sectional areas (TCSA) were calculated. The number of flower clusters per tree was counted before flowering prior to treatment. Fruit weight, diameter and length, the number of fruit per tree, yield per tree, and fruit firmness were determined at harvest (2005 Sep. 07, 2006 Sep. 11 and 2007 Sep. 08), and chemical analyses (soluble solids content levels (SSC), individual sugars and organic acids) were carried out after harvest. Fruit were harvested at commercial maturity on the basis of SSC, firmness and starch scale. Fruit set is the number of fruit per 100 flower clusters. Yield efficiency (kg fruits cm^{-2} of TCSA) was calculated using the ratio of yield to autumn TCSA. Floral density was calculated using the number of flower clusters divided by the spring TCSA of the tree. Crop load was calculated as the number of fruit divided by the autumn TCSA. Soluble solids content was determined in the juice of each fruit using a digital refractometer (model WM-7, Atago, Tokyo, Japan) at 20 °C. Firmness was measured with a digital penetrometer (model 53205, T.R. Turoni SRL, Forli, Italy) with an 8-mm-diameter plunger for each fruit (measured on four sides of each fruit).

Chemical analysis

The sugars (glucose, fructose, sucrose and sorbitol) and organic acids (citric, malic, shikimic and fumaric) were analyzed in the fruit by HPLC. For the HPLC analyses, 10 g of fresh fruit were used. The tissue samples were increased in volume to 40 ml with bidistilled water, homogenized with Ultra-Turrax T-25 (Ika-Labortechnik) and clarified by centrifugation at 4200 rotations min^{-1} for 15 min. Before injection into the column, samples were filtered through a 0.45 μm Macherey-Nagel filter. Samples of 20 μl of extract were used for the HPLC analysis of sugars and organic acids (HUDINA and STAMPAR 2006). A Thermo Separation Products HPLC system (Riviera Beach, Florida, USA; pump model P1000; auto sampler model AS1000) was used. The solute elution was monitored by using the refractive index (Shodex-71RI model).

Analysis of the sugars was performed isocratically, using an Aminex – HPX 87C column (Bio Rad Laboratories, Hercules, California) at 85 °C and a flow rate of 0.6 ml min^{-1}, with bidistilled water used as the eluent. Organic acids were analysed using an Aminex – HPX 87H column (Bio Rad Laboratories, Hercules, California) at 65 °C with a flow rate of 0.6 ml min^{-1}. A UV detector was used with a wavelength set at 210 nm. For the mobile phase, 4 mM H_2SO_4 was used.

Chemical standards of the carbohydrates and organic acids were obtained from Fluka Chemical (New York, US), except for the malic acid, which originated from Merck Chemicals (Darmstadt, Germany).

Statistical analysis

One-way analysis of variance (ANOVA) and HSD Tests at $P < 0.05$ were used for statistical analysis. The statistical software package (Statgraphics Plus 4.0; Manugistics Inc., Rockville, MD, USA) was used to perform the analysis.

Results and Discussion

The results for floral density, number of fruit per tree and fruit set are shown in Table 1. The average floral density showed no statistically significant difference in the first two years of the experiment. There were also no statistically

Table 1. Floral density, number of fruit per tree, and fruit set for 'Conference' pear in response to thinning treatments in 2005, 2006 and 2007.

Treatment[z]	Floral density (no. cm^{-2} TCSA)				Number of fruit per tree				Fruit set (%)			
	2005	2006	2007	Sig. Year	2005	2006	2007	Sig. Year	2005	2006	2007	Sig. Year
Control	1.42 a	1.09 a	4.34 ab	**	514.3 c	208.8 a	221.0 b	***	251 b	101 a	52 a	***
Hand thinning 1	1.73 a	0.99 a	2.36 a	***	226.0 ab	172.6 a	184.0 ab	***	134 ab	98 a	70 a	***
Hand thinning 2	1.49 a	0.92 a	4.62 ab	**	165.7 a	143.2 a	98.8 a	*	87 a	77 a	64 a	NS
NAA 8	1.63 a	0.72 a	4.79 ab	***	408.0 bc	137.0 a	157.2 ab	NS	196 ab	96 a	83 a	NS
NAA 16		0.94 a	5.41 b	***		126.8 a	158.8 ab	NS		109 a	54 a	*
NAA 20			5.74 b				208.6 ab				63 a	

[z] Control: not thinned; Hand thinning 1: 0.8 fruits cm^{-2} of TCSA; Hand thinning 2: 0.5 fruits cm^{-2} of TCSA; NAA 8: NAA 8 mg l^{-1}; NAA 16: NAA 16 mg l^{-1}; NAA 20: NAA 20 mg l^{-1}.
a–c: Means in the same column followed by the same letter are not significantly different by Tukey's HDS (P<0.05).
Sig. Year: significance between year; NS: not significant; *: significant at P<0.05; **: significant at P<0.015; ***: significant at P<0.001

significant differences between the control and hand thinning, and between the control and thinning with NAA during the experiment.

The 'Conference' cultivar is a high yielding cultivar. The trees were thinned successfully by hand in 2005; because the number of fruit per tree under the hand thinning treatments was statistically significantly lower than for the control, in spite of a very similar floral density. In the next two years, (2006 and 2007) neither chemical nor hand thinning didn't have an influence on the number of fruit per tree, except for hand thinning 2 in 2007. Furthermore, chemical and hand thinning also had no influence on the fruit set percentage, except for hand thinning 2 in 2005. A drop in the number of flower or fruit depends on hormonal changes in the abscission zone situated in the pedicel base (Wertheim 2000). Cultivars differed in sensitivity, and recommended concentrations of thinner also vary (McArtney and Wells 1995). Within each cultivar, reaction to thinning varies from year to year as well, partly depending on the degree of fruit set (Wertheim 1978). NAA thinning did not reduce yield per tree to the 'Harrow sweet' cv. and had no negative effect on fruit set, yield efficiency, or crop load in any of the years (Hudina and Stampar 2009).

We found differences between the years, which can be attributed to weather conditions. During the 2005 growing season, temperatures were medium (17.0 °C), precipitation was high (670 mm), and sunshine duration was low (1260 h). In 2006, high temperatures (17.6 °C), low precipitation (607 mm) and high sunshine duration (1303 h) were observed during the growing season. In 2007, high temperatures in May (17.3 °C) and June (21.1 °C), low precipitation in April (9 mm) and then high precipitation (106 mm in May, and 91 mm in June and July) and high sunshine duration during the growing season (1405 h) were observed. The weather conditions before, during and after NAA application affect uptake and, possibly, transport or breakdown (Black et al. 1995). Hudina and Stampar (2009) reported that weather conditions influenced thinning with NAA in the cultivar 'Harrow Sweet'. This could be attributed to the temperature, as suggested by data from a trial with 'Conference' (Wertheim 2000). Auxins thin apple and pear variably (McArtney and Wells 1995; Ferree 1996). We found no differences in yield per tree between treatments, except in 2005 (Table 2). Yield per tree was significantly lower in both hand thinnings in 2005. Despite the lack of statistically significant differences between control and hand thinning in yield per tree for 2006 and 2007, hand thinned fruit were heavier and bigger than those in the control.

Yield efficiency differed among the observed years. In 2005 it was from 0.15 to 0.28 kg cm^{-2} TCSA, in 2006 from 0.11 to 0.16 kg cm^{-2} TCSA and in 2007 from 0.24 to 0.42 kg cm^{-2} TCSA. We noticed no significant differences between the control and hand thinning, or between the control and NAA thinning in yield efficiency.

In the first year of the experiment, hand thinning produced a lower crop load, but in the next two years hand thinning had no effect on crop load. Thinning with NAA had no negative effect on crop load.

Hand thinning resulted in a statistically significant increase in fruit diameter and fruit weight (except in 2006), while there were no significant differences in fruit length (Table 3). Thinning large numbers of trees by hand is neither practical nor economically efficient. Therefore, thinning flowers or fruit by chemicals is customary (Wertheim 1997). Chemical thinning had a minor influence on fruit dimensions (diameter and length), since the differences between the control and individual treatments by chemical thinning were not significant.

Soluble solids content differed among the observed years (Table 4). Chemical and hand thinning showed no influence on soluble solids content in fruit at harvest. With hand thinning, fruit firmness did not decrease because the difference between the control and hand thinning treatments was not statistically significant in the observed years, except in 2007. There were also no differences between the control and the NAA 16 and NAA 20 treatments. Significant differences were noticed only between the control and the NAA 8 treatment in 2006 and 2007.

The content of individual sugars in the fruit differed among years and treatments. The content of individual sugars and organic acids was measured in pear fruit at harvest in 2006 and 2007. For the hand thinning

Table 2. Yield per tree, yield efficiency, and crop load for 'Conference' pear in response to thinning treatments in 2005, 2006 and 2007.

Treatment[z]	Yield per tree (kg)				Yield efficiency (kg cm^{-2} TCSA)				Crop load (no. cm^{-2} TCSA)			
	2005	2006	2007	Sig. Year	2005	2006	2007	Sig. Year	2005	2006	2007	Sig. Year
Control	51.5 b	28.0 a	28.4 a	**	0.24 ab	0.16 a	0.39 a	***	2.55 b	1.09 a	3.12 ab	**
Hand thinning 1	27.8 a	27.1 a	24.8 a	**	0.23 ab	0.15 a	0.42 a	***	1.21 a	0.99 a	1.50 a	*
Hand thinning 2	26.3 a	23.1 a	16.0 a	NS	0.15 a	0.11 a	0.24 a	NS	0.87 a	0.92 a	1.41 a	NS
NAA 8	43.3 ab	21.9 a	22.3 a	NS	0.28 b	0.14 a	0.40 a	***	2.31 b	0.72 a	3.68 b	***
NAA 16		20.2 a	21.2 a	NS		0.12 a	0.37 a	**		0.94 a	2.82 ab	
NAA 20			27.9 a				0.42 a				3.12 ab	

[z] Control: not thinned; Hand thinning 1: 0.8 fruits cm^{-2} of TCSA; Hand thinning 2: 0.5 fruits cm^{-2} of TCSA; NAA 8: NAA 8 mg l^{-1}; NAA 16: NAA 16 mg l^{-1}; NAA 20: NAA 20 mg l^{-1}.
a–b: Means in the same column followed by the same letter are not significantly different by Tukey's HDS (P<0.05).
Sig. Year: significance between year; NS: not significant; *: significant at P<0.05; **: significant at P<0.015; ***: significant at P<0.001.

Table 3. Mean diameter, length and weight of 'Conference' pear fruit in response to thinning treatments in 2005, 2006 and 2007.

Treatment[z]	Fruit diameter (mm)				Fruit length (mm)				Fruit weight (g)			
	2005	2006	2007	Sig. Year	2005	2006	2007	Sig. Year	2005	2006	2007	Sig. Year
Control	55.8 a	63.3 a	61.9 a	***	90.3 ab	99.7 a	90.3 a	*	114.0 a	162.6 a	139.2 a	***
Hand thinning 1	61.4 b	67.7 b	66.1 b	***	95.2 bc	107.1 a	97.4 ab	***	144.7 b	189.4 ab	173.3 bc	***
Hand thinning 2	63.8 b	67.1 b	66.4 b	***	97.4 c	105.7 a	98.0 ab	***	151.7 b	192.4 ab	180.0 bc	***
NAA 8	55.7 a	66.8 ab	65.3 ab	*	85.2 a	106.3 a	101.1 ab	**	107.7 a	190.0 ab	167.2 bc	***
NAA 16		66.5 ab	67.5 b	NS		101.3 a	104.4 b	NS		197.1 b	186.1 c	NS
NAA 20			64.0 ab				92.8 ab				158.7 ab	

[z] Control: not thinned; Hand thinning 1: 0.8 fruits cm^{-2} of TCSA; Hand thinning 2: 0.5 fruits cm^{-2} of TCSA; NAA 8: NAA 8 mg l^{-1}; NAA 16: NAA 16 mg l^{-1}; NAA 20: NAA 20 mg l^{-1}.
a–c: Means in the same column followed by the same letter are not significantly different by Tukey's HDS (P<0.05).
Sig. Year: significance between year; NS: not significant; *: significant at P<0.05; **: significant at P<0.015; ***: significant at P<0.001

Table 4. Soluble solids content and firmness of 'Conference' pear in response to thinning treatments in 2005, 2006 and 2007.

Treatment[z]	SSC (%)				Firmness (N cm^{-2})			
	2005	2006	2007	Sig. Year	2005	2006	2007	Sig. Year
Control	9.8 a	12.0 b	14.8 ab	***	60 a	51 a	43 a	***
Hand thinning 1	10.4 ab	11.3 ab	15.5 b	***	60 a	53 ab	43 a	***
Hand thinning 2	10.5 ab	11.9 ab	14.9 ab	***	59 a	54 ab	48 b	***
NAA 8	10.6 b	11.9 ab	13.8 a	***	59 a	56 b	48 b	***
NAA 16		9.7 a	14.5 ab	***		54 ab	47 ab	***
NAA 20			15.0 b				46 ab	

[z] Control: not thinned; Hand thinning 1: 0.8 fruits cm^{-2} of TCSA; Hand thinning 2: 0.5 fruits cm^{-2} of TCSA; NAA 8: NAA 8 mg l^{-1}; NAA 16: NAA 16 mg l^{-1}; NAA 20: NAA 20 mg l^{-1}.
a–b: Means in the same column followed by the same letter are not significantly different by Tukey's HDS (P<0.05).
Sig. Year: significance between year; NS: not significant; *: significant at P<0.05; **: significant at P<0.015; ***: significant at P<0.001

treatments with 0.8 fruits cm^{-2} TCSA, we noticed higher amounts of glucose, sucrose and sorbitol compared to the control in 2006. In 2007, no significant differences were found (Table 5). For hand thinning 2 (0.5 fruits cm^{-2} of TCSA), sucrose content was lower than in the control, but not significantly. The content of sorbitol, glucose and fructose was higher compared to the control; only for fructose in 2007, we found a significantly higher amount. The NAA 16 treatment had a statistically significantly higher content of individual sugars in 2006, while in 2007 the differences were not significant. We noticed higher amounts of glucose and sucrose, and lower content levels of fructose in 2007 compared to 2006. The main product of photosynthesis and the primary transported carbohydrate of the genus *Pyrus* is the alcohol sugar sorbitol, representing 60–90 % of all carbohydrates that are being transported from leaves to other parts of the plants (Loesher 1987). Most sorbitol transformed to fructose in fruit, and the rest to glucose and sucrose. In the final stages of ripening, sucrose is slowly hydrolyzed and transformed to glucose and fructose (Seymour et al. 1993).

The year, cultivar and other factors have a greater influence on the individual sugar content than thinning (Hudina and Stampar 1999, 2000, 2005). The content of individual sugars changes during the growing season, and varies according to the stage of maturity (Hudina et al. 2007). The individual sugar content (except sorbitol) in pears of the 'Conference' cv. depends on the year more than on chemical thinning because the results vary among the years (Table 5). Chemical and hand thinning had no influence on individual organic acids content (Table 6). Total levels of sugars and organic acids content also differ among the observed years. Chemical thinning had no influence on total sugars and organic acids content, which means that with chemical thinning we caused no decrease in internal fruit quality (Table 7). Hand thinning to 0.8 fruits cm^{-2} TCSA had no significant influence on total acids and total sugars content, except in 2006. Hand thinning to 0.5 fruits cm^{-2} TCSA also had no significant influence on total sugars and total acids content. It was only total acids content in 2007 that differed significantly between the control and hand thinning 2.

Table 5. Glucose, fructose, sucrose and sorbitol content of 'Conference' pear fruit in response to thinning treatments in 2006 and 2007.

Treatment[z]	Glucose (g kg^{-1} FW[y])			Fructose (g kg^{-1} FW)			Sucrose (g kg^{-1} FW)			Sorbitol (g kg^{-1} FW)		
	2006	2007	Sig. Year	2006	2007	Sig. Year	2006	2007	Sig. Year	2006	2007	Sig. Year
Control	2.99 a	7.92 a	***	22.34 ab	13.77 a	NS	9.30 a	34.26 ab	***	13.76 a	15.93 a	***
Hand thinning 1	5.45 c	7.61 a	***	28.93 b	14.98 ab	***	13.85 b	36.19 ab	***	19.24 b	16.17 a	NS
Hand thinning 2	3.37 a	8.34 a	***	25.80 ab	20.30 c	*	9.26 a	19.06 a	NS	15.27 a	21.44 a	NS
NAA 8	3.55 ab	8.95 a	***	20.89 a	18.47 bc	***	8.81 a	47.60 b	***	12.88 a	19.04 a	NS
NAA 16	4.69 bc	8.75 a	***	40.59 c	16.12 ab	***	15.80 b	42.79 b	***	22.77 c	20.90 a	NS
NAA 20		8.32 a			16.36 abc			38.35 ab			20.46 a	

[y] FW: fresh weight
[z] Control: not thinned; Hand thinning 1: 0.8 fruits cm^{-2} of TCSA; Hand thinning 2: 0.5 fruits cm^{-2} of TCSA; NAA 8: NAA 8 mg l^{-1}; NAA 16: NAA 16 mg l^{-1}; NAA 20: NAA 20 mg l^{-1}.
a–c: Means in the same column followed by the same letter are not significantly different by Tukey's HDS (P<0.05).
Sig. Year: significance between year; NS: not significant; *: significant at P<0.05; **: significant at P<0.015; ***: significant at P<0.001

Table 6. Organic acids (malic, citric, fumaric, shikimic) content of 'Conference' pear fruit in response to thinning treatments in 2006 and 2007.

Treatment[z]	Malic acid (g kg^{-1} FW[y])			Citric acid (g kg^{-1} FW)			Fumaric acid (mg kg^{-1} FW)			Shikimic acid (mg kg^{-1} FW)		
	2006	2007	Sig. Year	2006	2007	Sig. Year	2006	2007	Sig. Year	2006	2007	Sig. Year
Control	3.19 ab	3.31 a	**	0.38 a	0.02 a	*	0.68 ab	0.33 ab	***	3.59 a	11.00 ab	***
Hand thinning 1	3.11 a	3.28 a	*	0.36 a	0.07 a	**	0.60 a	0.27 a	NS	4.03 a	8.00 a	***
Hand thinning 2	3.56 ab	5.81 b	***	0.47 a	0.15 a	*	0.68 ab	0.47 ab	NS	3.44 a	11.00 ab	**
NAA 8	3.45 ab	4.60 ab	NS	0.42 a	0.17 a	***	0.76 b	0.41 ab	***	4.04 a	15.00 ab	*
NAA 16	3.64 b	4.60 ab	NS	0.48 a	0.20 a	***	0.62 a	0.84 b	***	4.15 a	17.00 b	**
NAA 20		4.88 ab			0.25 a			0.60 ab			14.00 ab	

[y] FW: fresh weight
[z] Control: not thinned; Hand thinning 1: 0.8 fruits cm^{-2} of TCSA; Hand thinning 2: 0.5 fruits cm^{-2} of TCSA; NAA 8: NAA 8 mg l^{-1}; NAA 16: NAA 16 mg l^{-1}; NAA 20: NAA 20 mg l^{-1}.
a–b: Means in the same column followed by the same letter are not significantly different by Tukey's HDS (P<0.05).
Sig. Year: significance between year; NS: not significant; *: significant at P<0.05; **: significant at P<0.015; ***: significant at P<0.001

Table 7. Total sugars and organic acids content of 'Conference' pear fruit in response to thinning treatments in 2006 and 2007.

Treatment[z]	Total sugars (g kg^{-1} of FW[y])			Total acids (g kg^{-1} of FW)		
	2006	2007	Sig. Year	2006	2007	Sig. Year
Control	48.40 a	71.88 ab	***	3.58 ab	3.34 a	*
Hand thinning 1	67.48 b	74.95 ab	NS	3.48 a	3.36 a	NS
Hand thinning 2	53.71 a	69.14 a	NS	4.03 ab	5.97 b	**
NAA 8	46.13 a	94.05 b	**	3.88 ab	4.79 ab	NS
NAA 16	83.85 c	88.57 ab	**	4.12 b	4.81 ab	NS
NAA 20		83.49 ab			5.15 ab	

[y] FW: fresh weight
[z] Control: not thinned; Hand thinning 1: 0.8 fruits cm^{-2} of TCSA; Hand thinning 2: 0.5 fruits cm^{-2} of TCSA; NAA 8: NAA 8 mg l^{-1}; NAA 16: NAA 16 mg l^{-1}; NAA 20: NAA 20 mg l^{-1}.
a–c: Means in the same column followed by the same letter are not significantly different by Tukey's HDS (P<0.05).
Sig. Year: significance between year; NS: not significant; *: significant at P<0.05; **: significant at P<0.015; ***: significant at P<0.001

Conclusion

Hand thinning to 0.8 or 0.5 fruits cm^{-2} TCSA had no statistically significant influence on floral density, yield efficiency or soluble solids content. Hand thinning caused a statistically significant increase in fruit diameter and fruit weight (except in 2006). Chemical thinning had a minor influence on fruit dimensions (diameter and length), since differences between the control and individual treatments by chemical thinning were not significant. Chemical thinning with NAA 8 mg l^{-1} reduce yield per tree from 16 % in 2005 to 22 % in 2006 and 2007, and NAA 16 mg l^{-1} reduce yield per tree from 25 % in 2007 to 28 % in 2006. In 2005, we noticed a statistically significantly higher amount of soluble solids for thinning with NAA 8 mg l^{-1}. Chemical thinning with NAA 8 mg l^{-1} had no influence on fruit firmness in 2005, while in 2006 and 2007 fruit firmness was higher than in the control. Other NAA treatments had no influence on fruit firmness. Chemical thinning had no negative effect on floral density, fruit number per tree, fruit set and yield per tree, yield efficiency, crop load or total acids content. Hand thinning requires intensive labour and has high costs, while chemical thinning can result in unpredictable results, as well as being dependent on the weather factor. To improve recommendations and thinning results, more work is needed to elucidate the exact influence of temperature, humidity, their interaction, and concentration on the action of the various chemical fruit thinning compounds. Chemical thinning of pear is a complex technological procedure. Apart from weather conditions, a cultivar's sensitivity to various chemical thinners and their concentrations also influences thinning success. In our experiment, we noticed the distinctive effect of one individual year. The effect of various chemical thinning compounds on pears is cultivar specific; therefore, we cannot generalize the thinning results obtained for the specific cultivar to other cultivars.

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