

## Comparison of different crop regulation methods for organically grown apples (cultivar 'Pinova' and 'Elstar')

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### Abstract

*Over a period of three years (2009-2011) different thinning methods and compounds were tested at three different sites. At two sites the same trees were observed over three seasons, strength of thinning was adapted to the intensity of flowering depending on the reaction of the trees. At different field trials with the cultivar 'Pinova' and 'Elstar' thinning by hand was compared to thinning with the Darwin rope thinner and to lime sulphur. Using the Darwin rope thinner showed the best results for 'Pinova'. Lime sulphur also reduced the remaining time necessary for thinning by hand, but not as efficient as the rope thinner.*

**Keywords:** thinning, apples, organic, rope thinner, lime sulphur

### Introduction

In organically grown apple orchards thinning is an important tool to help the tree to regulate its yields, to achieve a good fruit quality and to avoid alternating bearing. In recent years different methods of thinning were tested (Eis *et al.* 2008, Weibel *et al.* 2008). In spring 2009 a research project „Increasing of crop safety and optimizing of crop loading of organic grown pome fruit“ (FuE 2806OE197) started, founded by the „Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft“. The aim is to examine different possibilities for securing yield and optimizing crop load in organically grown apples and pears. The project is a cooperation between the research facilities LVWO Weinsberg, DLR Rheinpfalz and ÖON Jork.

### Material and Methods

Trial 1 was carried out on an organic apple orchard at the fruit experimental station of LVWO Weinsberg. In all three years (2009-2011) the same trees of the variety 'Pinova' planted in spring 2003 at a spacing of 1.2 x 3.5 m (crown height 2.3 m) were observed (10 trees per treatment, each tree was counted as replication). In spring the number of blossom clusters per tree was counted. In May/June all trees were thinned by hand (except of untreated control) and adjusted to an average amount of 110-130 apples per tree. Time for thinning was stopped. Number of apples removed by hand was counted and time saving for thinning by hand was computed. At harvest number, weight and quality of fruits were determined for each tree. In 2009 8 different treatments were carried out, in 2010 three new and in 2011 two further treatments were added (table 1). The Tree-Darwin rope thinner (Fruit-Tec) was used at three different BBCH flower stages: pink bud (57), flowers forming a hollow ball (59) and 40-50 % of flowers open (64-65). Lime sulphur and sunflower oil were applied with a tunnel sprayer using a spray volume of 800 l water per ha. Additional pruning was done in 2009 and 2011 to reduce the number of blossom clusters.

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Table 1: Thinning treatments at Weinsberg, 'Pinova' 2009 - 2011.

Treatment	Application / Dosage 2009	Application / Dosage 2010	Application / Dosage 2011
untreated control			
thinning by hand 1			
rope thinner 1 BBCH 57	200 U/min, 8 km/h	-	220 U/min, 6 km/h
rope thinner 1 BBCH 59	220 U/min, 8 km/h	-	220 U/min, 6 km/h
rope thinner 1 BBCH 64-65	220 U/min, 8 km/h	180 U/min, 8 km/h	220 U/min, 6 km/h
lime sulphur	3 x 30 l/ha + 1,5 l/ha Bioblattmehltaumittel	1 x 30 l/ha	3 x 30 l/ha
additional pruning	✓	not necessary	✓
foliar fertilizer 1 (Wuxal Aminoplant)	1 x 15 l/ha	1 x 20 l/ha	1 x 20 l/ha
thinning by hand 2			
rope thinner 2 BBCH 64-65		180 U/min, 8 km/h	220 U/min, 6 km/h
rope thinner 2 + lime sulphur		180 U/min, 8 km/h + 1 x 30 l/ha	220 U/min, 6 km/h + 1 x 25 l/ha
Sunflower oil + TS-forte			3 x 25 l/ha + 2 l TS-forte
Sunflower oil + Rimulgan			3 x 25 l/ha + 2,4 l Rimulgan

Trial 2 at Klein-Altendorf was on-farm placed in an organic orchard within two rows of 'Pinova' (1.0 x 3.0 m). Thinning by hand was compared to thinning with lime sulphur (600 l water/ha), as well as to mechanical thinning by the Darwin rope thinner (table 2). The tested treatments have been replicated four times with seven to nine trees per testing plot. Five trees per plot have been evaluated (20 trees per variant). In April blossom clusters per tree were counted. After treatment the trees have been adjusted to an average amount of 100-110 apples/tree. Number of apples removed by hand was counted and time saving for thinning by hand was computed under presumption that removing one apple per tree needs one hour per ha (2500 trees/ha). At harvest yield (kg) and amount of fruits/tree were recorded.

Table 2: Thinning treatments at Klein-Altendorf, 'Pinova' 2009 - 2011.

Treatment	Application / Dosage
thinning by hand	
rope thinner BBCH 59	200 U/min, 8 km/h
rope thinner BBCH 63-64	200 U/min, 8 km/h
lime sulphur	3 x 30 l/ha

Trial 3 was carried out in an organic 'Elstar'-orchard (planted 1998, 1.0 x 3.5 m) at the fruit growing station ESTEBURG (Jork). Thinning by hand, lime sulphur (1000 l water/ha) and mechanical thinning by Darwin rope thinner with different rotations were compared (table 3). Due to a large variety of flowering intensity the trial was repeated every year with new sample trees. Only trees with high flowering rate were chosen to assess the fundamental effect of each thinning method. In spring the intensity of flowering per tree was rated on a scale from one to nine (1=no flowers, 6=optimal). The treatments were replicated four times with ten trees per replication. Three trees per replication have been evaluated. In opposite to Weinsberg and Klein-Altendorf trees weren't thinned by hand after treatment

(except for 2009). Only the trees of the treatment thinning by hand have been adjusted to an average amount of 110 apples per tree after June drop.

Table 3: Thinning treatments at Jork, 'Elstar' 2009 - 2011.

Treatment	Application / Dosage 2009	Application / Dosage 2010	Application / Dosage 2011
untreated control			
thinning by hand	after june drop	after june drop	after june drop
rope thinner BBCH 58-59	240 U/min, 8 km/h	230 U/min, 8 km/h (BBCH 61)	250 U/min, 8 km/h
rope thinner BBCH 65 (A)	240 U/min, 8 km/h BBCH 63-64 (A)	250 U/min, 8 km/h	250 U/min, 8 km/h
rope thinner BBCH 65 (B)	210 U/min, 8 km/h BBCH 63-64 (B)	230 U/min, 8 km/h	230 U/min, 8 km/h
rope thinner BBCH 65 (C)	270 U/min, 8 km/h BBCH 63-64 (C)	270 U/min, 8 km/h	270 U/min, 8 km/h
rope thinner BBCH 67	240 U/min, 8 km/h	230 U/min, 8 km/h	250 U/min, 8 km/h
lime sulphur (BBCH 65-66)	3 x 30 l/ha (BBCH 61, 65-66)	3 x 30 l/ha	3 x 30 l/ha

## Results

### Trial 1

Regarding the quality (figure 1) and yield (table 4) within the tested treatments over all three years, rope thinner 1 at BBCH 59 (64 kg/tree) and BBCH 64-65 (61 kg) had the highest yield, especially the rope thinner 1 BBCH 57 had a high amount of fruits with an excellent colour, while unthinned control had lots of green and small fruits. All treatments with the rope thinner (1) had a higher accumulated yield than the treatment thinning by hand (1). Looking at the time needed for thinning by hand after treatments, using the rope thinner (1) saved between 60-110 h/ha compared to the treatment thinning by hand (1).

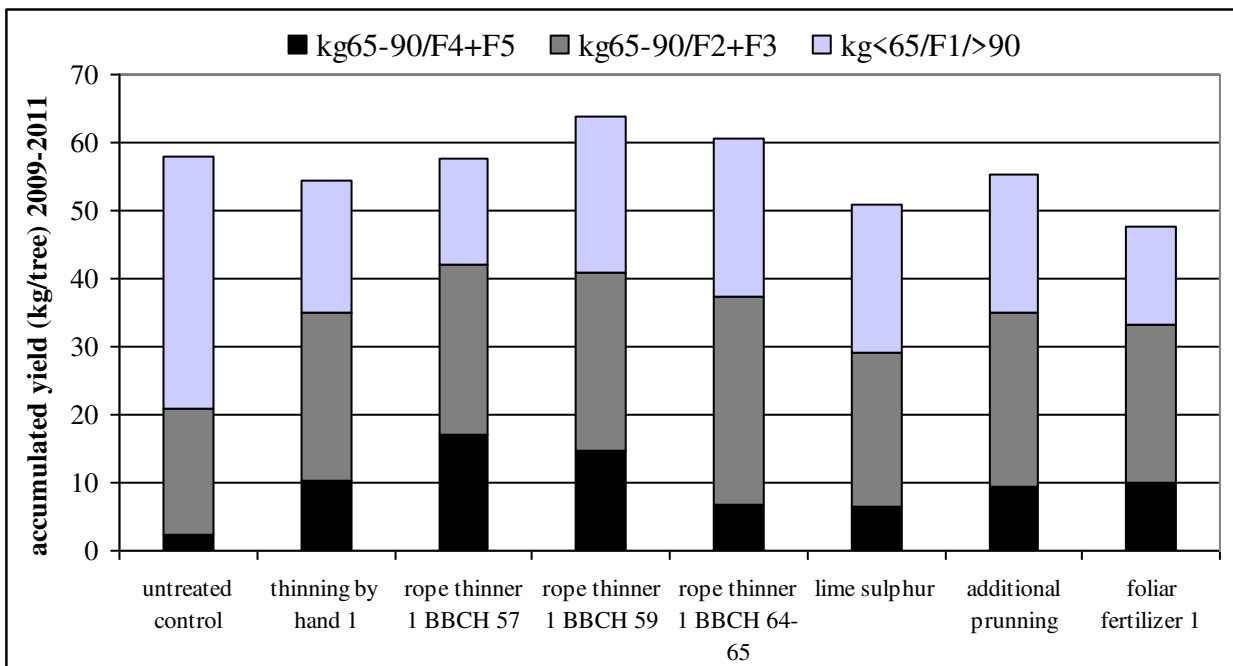


Figure 1: Accumulated yield (kg/tree) 2009-2011 for three quality levels (size and colour): 65-90mm/F4+F5 (good size + excellent coloured), 65-90/F2+F3 (good size + well coloured), <65/F1/>90 small (or to large) and green fruits).

Using 3 x lime sulphur also reduced the time for thinning by hand. An overthinning in 2009 with lime sulphur because of an application mistake lead to a lower accumulated yield (sum 2009-11) than thinning by hand (1).

The treatment additional pruning lead to a good yield with good quality, but about 43 % more time than the treatment thinning by hand (1) was needed to remove the apples by hand. Treatments with the rope thinner (2) had a yield of 32-34 kg/tree (175-184 g/fruit) combined with a good fruit quality. Yield of the treatment thinning by hand (2) was higher, but more green and small fruits (155 g/fruit) were harvested. The combination of rope thinner plus a late lime sulphur application on open flowers of one-year-old branches had the lowest effort for thinning by hand in this part of the trial and the highest setting of blossoms in 2011, as well as a favourable effect on the fruit quality. Comparing the two sunflower oil treatments in 2011, the formulation with TS-forte lead to a higher yield and better fruit quality; time reduction for thinning by hand was about 13-17 h/ha (comparable to lime sulphur).

In general, the pollination is very well in this organic orchard because there are 15 bee colonies nearby. In 2009 good weather conditions lead to a good pollination, but thinning by hand after treatment was not strong enough. Spring 2010 started late, around pink bud stage minimum temperature of -0,6 °C was observed. Because of alternation, in 2010 lower yield was observed. In 2011 a high number of flower buds on annual shoots occurred. Late frost on Mai 4<sup>th</sup> 2011, 2 ½ weeks after full blossom, lead to a severe June drop. Most varieties were strongly affected, but 'Pinova' with the tremendous high number of blossom clusters not as much.

Table 4: Blossom clusters/tree, accumulated yield (kg/ha) and accumulated amount of apples removed by hand (2009-2011), as well as time saving for thinning by hand for different treatments at Weinsberg, 'Pinova' (2400 trees/ha), (Tukey-test  $\alpha=0.05$ ).

Treatment	Blossom clusters/tree			Accumulated yield (kg/tree) 2009-2011	Accumulated amount of apples removed by hand 2009-2011	Time saving (h/ha) in comparison to thinning by hand*** (%)
	2009	2010	2011			
untreated control	274	51 a	552 cde	58.53 ab		
thinning by hand (1)	236	117 abcd	520 cde	54.42 ab	349 ab	100 %
rope thinner (1) BBCH 57	233	86 ab	595 de	57.67 ab	236 a	32
rope thinner (1) BBCH 59	267	110 abc	644 de	63.85 b	264 ab	24
rope thinner (1) BBCH 64-65	223	172 cd	381 ab	60.61 ab	290 ab	17
lime sulphur	249	178 d	506 bcd	50.84 a	336 ab	4
additional pruning	220	80 ab	359 a	55.38 ab	499 c	-43
foliar fertilizer (1)	227	72 a	486 bcd	47.70 a	379 bc	-9
thinning by hand (2)*		191	405 a	40.00 b	366 b	100 %
rope thinner (2) BBCH 64-65*		200	417 a	31.57 a	196 a	47
rope thinner (2) + lime sulphur*		189	468 a	33.92 ab	133 a	64
thinning by hand (2)**			405	21.52 ab	199 a	100 %
sunfloweroil + TS-forte**			405	22.68 b	182 a	9
sunfloweroil + Rimulgan**			417	19.37 a	186 a	7

\*2010-2011, \*\*2011, \*\*\* Presumption: thinning one apple per tree needs one hour per ha (2500 trees/ha)

## Trial 2

In 2010 and 2011 the control, which was only thinned by hand, showed the lowest number of blossom clusters per tree. In spring 2010 in most of the treatments including the control the highest number of blossom clusters was counted. The treatment with Darwin rope thinner at the BBCH stage 59 led to a homogeneous number of blossom clusters over all three years (table 5).

From 2009 to 2011 all treatments reduced the remaining time for thinning by hand compared to the control (thinning by hand). Using Darwin rope thinner at BBCH 59 and BBCH 63-64 the number of apples removed by hand was reduced by half, which means a time saving of about 300 h/ha. In the lime sulphur treated plots 502 apples still had to be removed. This corresponds to a time saving of only 90 h/ha in comparison with the control. The accumulated yield of the years 2009-2011 with about 59.0 kg per tree was nearly the same in the control and the mechanically treated plots. The lime sulphur treatment had with 55.8 kg the lowest yield.

Table 5: Blossom clusters/tree, accumulated yield (kg/tree), accumulated amount of apples removed by hand and time saving for thinning by hand for the different treatments at Klein-Altendorf, 'Pinova' 2009 - 2011, (Tukey-test  $\alpha=0.05$ ).

Treatment	Blossom clusters/tree			Accumulated yield [kg/tree] 2009-2011	Accumulated amount of apples removed by hand 2009-2011*	Time saving (h/ha) in comparison to thinning by hand*** (%)
	2009	2010	2011			
Thinning by hand	227	242	225	58.5 a	596 b	100 %
Rope thinner BBCH 59	265	268	246	58.7 a	287 a	52
Rope thinner BBCH 63-64	265	278	229	59.0 a	309 a	48
Lime sulphur	263	261	229	55.8 a	502 b	16

\* Presumption: thinning one apple per tree needs one hour per ha (2500 trees/ha)

## Trial 3

At Jork the influence of every thinning method was assessed at 'Elstar' from 2009 to 2011 by means of flowering intensity in the following year, yield and fruit quality. The mechanical thinning caused an average yield reduction of about 30 % over the years compared to the untreated control (table 6). In 2009 it was given with 50 % towards untreated control, except for treatment at BBCH 63-64 (B) and 210 U/min with 30 %. In 2010 and 2011, using the rope thinner at BBCH 58-59, yields about 18 kg/tree could be reached – only 15 % reduction towards untreated control. The lowest yield (12 kg/tree) showed the mechanical thinning at BBCH 64-65 (C) with a high rotation of 270 U/min. From 2009 to 2011 a yield reduction of 15-20 % (except for 2010) was observed when thinning with lime sulphur. This treatment achieved yields about 16-22 kg/tree. The lower yield resulted in better fruit qualities. An increase of size, weight and better colour of the fruits could be observed. Most fruits of untreated control were graded at size 70-75 mm with a weight of 140 g, but trees thinned with rope thinner showed the highest peak at size 75-80 with 170 g/fruit.

Over the years a reduction of biennial bearing was shown after mechanical thinning (BBCH 64-65, A, C) and treatment with lime sulphur (table 6). In 2010 and 2011 the intensity of flowering was given with constant notes of five at both variants. Especially the upcoming biennial bearing in 2010 has been stopped. The trees of untreated control and thinning by hand showed a low and alternating intensity of flowering (2010).

Mechanical thinning may stimulate vegetative tree growth. This effect was assessed by counting and measuring new shoots in summer (pruning) and January/February the following year. The variants “untreated control”, “thinning by hand” and “lime sulphur” had the lowest vegetative growth (19 m/tree) in 2009 and 2010. But the trees of mechanical thinning showed an increasing growth (trend). Using the rope thinner on BBCH 64-65 with 240-250 U/min achieved the highest value (27 m/tree) in both years.

Table 6: Intensity of flowering (1-9) and total yield at Jork, ‘Elstar’ 2009 - 2011, (Tukey-test =0.05).

Treatment	2009			2010			2011	
	Bloom 2009	Yield (kg/tree)	Bloom 2010	Bloom 2010	Yield (kg/tree)	Bloom 2011	Bloom 2011	Yield (kg/tree)
untreated control	5.6	23.0 a	3.8	4.5	20.7 a	4.2	4.7	21.2 a
thinning by hand	6.0	19.2 a	3.7	4.1	17.7 ab	4.3	4.4	19.8 a
rope thinner BBCH 58-59	5.8	9.4 b	4.6	4.6*	18.6* ab	4.2*	4.8	18.0 a
rope thinner BBCH 64-65 (A)	6.5	11.0 b	4.7	4.8	14.3 ab	4.5	4.8	15.3 a
rope thinner BBCH 64-65 (B)	6.1	15.3 ab	3.7	4.7	15.0 ab	4.5	4.7	12.6 a
rope thinner BBCH 64-65 (C)	6.1	9.7 b	4.6	4.9	11.7 b	4.6	5.1	15.1 a
rope thinner BBCH 67	6.3	8.9 b	3.7	5.0	18.3 ab	3.8	4.9	15.5 a
lime sulphur	6.4	20.2 a	4.8	5.0	22.1 a	4.6	5.4	16.1 a

\*BBCH 61

## Discussion

At **Weinsberg** using the Darwin rope thinner at the cultivar ‘Pinova’ saved between 60-110 working hours per hectare for thinning by hand over a period of three years. ‘Pinova’ trees at Weinsberg are much more affected by alternation than in Klein-Altendorf. Therefore at Weinsberg about 200 hours less were needed for thinning by hand compared to Klein-Altendorf (where about 300 hours were saved). In general, growth of ‘Pinova’ reacted not as strongly as ‘Elstar’ to the use of rope thinner. The best results for breaking alternation showed the rope thinner at BBCH 64-65. Also the combination of rope thinner and lime sulphur worked well. The most important difference between the treatments (except for saving time at thinning by hand) was the better fruit quality at the treatments with the rope thinner (less green and small fruits). Using three times lime sulphur was not as efficient as the rope thinner. Lime sulphur supported a high flower setting in the following year. Both sunflower oil treatments saved some time at thinning by hand, similar to the results described by EIS ET AL. (2008), but there the breaking of alternate bearing was not successful. At **Klein-Altendorf** in all three trial years the treatments with the Darwin rope thinner in the variety ‘Pinova’ showed the best results. Besides that the amount of larger fruits (75+) was generally higher. Applications with lime sulphur also reduced the time for thinning, but they were not efficient enough. These and others here not described results of field trials in the variety ‘Elstar’ and ‘Braeburn’ proved a positive effect of the treatments on biannual bearing (SINATSCH ET AL. 2011). At **Jork** mechanical thinning (BBCH 59-63, 250 U/min) and lime sulphur showed the best results over the years, regarding the yield, fruit size, weight and colour. Also a first reduction of biennial bearing was shown after both treatments. The stimulation of vegetative tree growth by mechanical thinning has to be examined in the following years.

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