Effect of transpiration inhibitors on June fruit drop of apple trees

M. Kelderer[1], E. Lardschneider[2], A. Topp[3]

Abstract

In organic apple growing, yield control is commonly achieved by removing buds and flowers with mechanical thinning machines and/or lime sulphur sprays. To allow for thinning also later in the season, trials with shading nets have been carried out over several years. By shading trees with close-meshed nets before June fruit drop, photosynthesis in the leaves can be drastically reduced. Regardless the good trial results, the method is not used in the field, because shading trees with nets is labour-intensive and expensive. We therefore tested different substances as alternatives to shading nets. First promising results were obtained with different oily substances. However, based on our current knowledge, negative side effects such as leaf burn and fruit russeting, can not be excluded.

Keywords: apple, June drop, thinning, transpiration inhibitors

Introduction

Yield control is an essential practice in apple growing to obtain consistent and high-quality yields. In integrated farming systems, growers rely primarily on synthetic plant growth regulators. Depending on their active substance and application rate, these products may be applied also very late in the season (Südtiroler Beratungsring für Obst- und Weinbau, 2009). As a consequence, fruit set can be estimated accurately and unnecessary manual thinning can be avoided. These products are not allowed in organic farming. Thinning is done at flowering using mechanical thinning machines (Strimmer et al. 1997, Kelderer et al. 2009, Weibel & Walther 2003) and/or applying lime sulphur sprays (Kelderer et al. 2006). Methods which allow for thinning later in the season, have been tested for several years. Promising results were obtained by drastically reducing the net photosynthesis of apple trees using close-meshed shading nets (75 - 90% sunlight reduction), and highest efficacy was achieved by shading trees at fruit size up to 10 - 15 mm (Byers et al. 1985, Kelderer et al. 2008, McArtney et al. 2004, Musacchi & Corelli Grappadelli 1994, Stadler et al. 2005, Widmer et al. 2008). However, the method is not used in the field, because shading nets are very expensive and opening and closing them for short periods of time is labour intensive.

Different substances have already been tested as alternatives to shading nets. A minor effect was achieved with applications of bentonite sprays, but at harvest visible deposits of the substance were still present around the calyx and stalk end of fruits, which thus became unmarketable (Prantl et al. 2004).

It is known from literature that oily substances can inhibit transpiration in leaves, close stomata, and thus affect photosynthesis. Our trials aimed at evaluating the thinning efficacy and possible negative side effects of pine oil-, mineral oil-, soybean oil- and canola oil-based products, tested at different dose rates and timings.

[1] M. Kelderer, VZ-Laimburg, 39040 Post Auer, South Tyrol, Italy; Markus.Kelderer@provinz.bz.it
[2] E. Lardschneider, VZ-Laimburg, 39040 Post Auer, South Tyrol, Italy; Ewald.Lardschneider@provinz.bz.it
[3] A. Topp, VZ-Laimburg, 39040 Post Auer, South Tyrol, Italy; Anne.Topp@provinz.bz.it

Material and Methods

Trial design:

The trials were conducted in 2008 and 2009 in two different apple cv Golden Delicious (Klon B) orchards at the Research Centre Laimburg (Pfatten, South Tyrol, Italy). Both study orchards are located in the valley floor at 220 m above sea level. A randomised block design was used, and assessments were made on 5 trees per plot, uniform in growth, size, and number of flowers. The number of repetitions used in each trial is reported in Table 1. All oil-based treatments were applied with a sprayer designed for field trials from WAIBL (transverse current blower) using a spray volume of 500 l water per hectare and m foliage height.. The shading nets (shading rate: 75%) were left on the trees for 3 days. A detailed description of the study orchards, the tested treatments, and the timing of the applications is provided in Table 1 - 3.

Table 1: study orchard description

Year	Cultivar/Clone	Rootstock	Planting year	Planting density	Experimental-design
2008	Golden Delicious/Reinders	M9	1993	3 x 1.2 m	randomised, 2-4 repetitions
2009	Golden Delicious/Klon B	M9	1997	3.15 x 1 m	randomised, 4 repetitions

Table 2: tested treatments

Year	Treatment	Trade name	Producer/ distributor	Applied rate	No. applic.s	Phenol. stage Fruit size (mm)
2008	Pine oil	Vapor Gard	Intrachem Bio Italia	4 l/100 l	1	15 mm
	Pine oil	Vapor Gard	Intrachem Bio Italia	2 l/100 l	1	15 mm
	Pine oil	Vapor Gard	Intrachem Bio Italia	3 l/100 l	1	15 mm
	Pine oil	Vapor Gard	Intrachem Bio Italia	2 l/ 100 l	3	≥ 15 mm
	Net	Bartex nero 75%	Artes	75% shading rate	3 days	≥ 15 mm
	Control	-	-	-	-	-
2009	Pine oil	Vapor Gard	Intrachem Bio Italia	1 l/ 100 l	3	≥ 15 mm
	Pine oil	Vapor Gard	Intrachem Bio Italia	2 l/100 l	3	≥ 15 mm
	Mineral oil	UFO	Intrachem Bio Italia	0,5 l/100 l	3	≥ 15 mm
	Mineral oil	UFO	Intrachem Bio Italia	1 l/100 l	3	≥ 15 mm
	Mineral oil	UFO	Intrachem Bio Italia	1 l/100 l	2	≥ 15 mm
	Rapeseed oil*	experimental product	-	2 l/100 l	3	≥ 15 mm
	Soybean oil	experimental product	Cedax	3 l/100 l	3	≥ 15 mm
	Net	Bartex nero 75%	Artes	75% shading rate	3 days	≥ 15 mm
	Control	-	-	-	-	-

* emulsified with lecithin

Table 3: Timing of applications

Year	Date	Remark	Days after full bloom
2008	14.05.2008	1st application & installation of nets	26
	16.05.2008	2nd application	28
	17.05.2008	Removal of nets	29
	19.05.2008	3rd application	31
2009	09.05.2009	1st application & installation of nets	27
	11.05.2009	2nd application	29
	12.05.2009	Removal of nets	30
	13.05.2009	3rd application	31

Assessments:

Thinning: to assess for the thinning efficacy of the different treatments in each plot after June fruit drop, the number of fruits was counted on 100 randomly selected flower clusters (henceforth FC) per tree. To take into consideration also the position of the flowers on the tree, 40 FC were selected in the upper third of the tree, and 60 in the lower part of the tree, uniformly distributed within the outer and inner part of the tree canopy. Counts were made using Fankhauser's method (Fankhauser et al. 1979): after June fruit drop, the number of fruits was counted on all FC present on entire branch sections. The number of fruits per 100 FC was then inferred by calculating the mean value of the assessed data. The efficacy of the different treatments in reducing the number of fruits/100 FC compared to the untreated control (% thinning efficacy) was then calculated according to Abbott.

Fruit russeting: to assess for fruit russeting, in each plot, at harvest, fruits were checked for symptoms of fruit russeting and classified according to a scale ranging from 0 to 10, with 0 = fruit with no russeting symptoms, 1 = fruit with russeting symptoms at stalk cavity, 2 = fruit with 10 - 20% fruit area affected by fruit russeting, and so on. The percentage of fruits with fruit russeting index above 3 was then calculated.

Flower formation: in 2008, to assess for possible side effects of the different treatments on flower formation the next season, the following year in spring, the percentage of flowers on the sprou buds was determined.

Leaf drop: in 2009, we also made visual assessments on leaf drop. To establish leaf drop incidence, a scale ranging from 0 to 5 such as the following was used: 0 = no leaf drop, 1 = light drop of rosette leaves, 2 = moderate drop of rosette leaves, 3 = moderate drop of rosette leaves and first symptoms of leaf drop on shoots, 4 = severe drop of rosette leaves and light to moderate-medium leaf drop on shoots, and 5 = severe drop of rosette leaves and light to moderate leaf drop on shoots.

Yield, fruit weight, and percentage of deformed fruits: at harvest, the 5 sample trees within each plot were harvested individually and fruit yield (kg/tree), fruit weight (g), and the percentage of deformed fruits were assessed. Fruit yield and fruit weight were determined using a sorting machine from AWETA, deformed fruits were determined by visual assessment.

The number of fruits/100 FC, fruit weight (g), yield (kg/tree), the percentage of deformed fruits and of fruits with fruit russeting idex above 3 were compared across treatments using 1-way ANOVAs followed by Student-Newman-Keuls' test for posthoc comparisons of means ($P<0.05$). To improve homoschedasticity, data expressed in percentages were arcsen(radq(x/100))-transformed. All analyses were performed with the statistics programme PASW 17.

Results

Table 4: trial results 2008. Assessments after June fruit drop (no. fruits/100 FC) and at harvest (fruit weight in g, yield in kg/tree, % deformed fruits and % fruits with fruit russeting index > 3).

Treatment	No. fruits/ 100 FC		Fruit weight (g)		Yield (kg/tree)		Deformed fruits (%)		Fruit russet (%)	
Control	117,8	c	142	a	35,6	b	15,4	a	5,8	a
×4 l/100 l Vapor Gar	116,1	c	159	a	37,1	b	18,9	a	2,3	a
×3 l/100 l Vapor Gar	106,7	b	-		-		-		-	
×2 l/100 l Vapor Gar	114,8	c	-		-		-		-	
×2 l/100 l Vapor Gar	92,7	a	202	b	26,8	a	17,5	a	12,6	a
Net 75%	89,7	a	213	b	27,8	a	20,1	a	3,9	a
Stderr.	1,70		5,51		1,17		1,26		2,20	

In the first trial year (2008), the transpiration inhibitor Vapor Gard (distributor: Intrachem Bio Itala S.p.A.) based on pine oil (concentration of active substance: 96% di-1-p-menthene) was tested at different application rates and timings. Best results were obtained when Vapor Gard was applied three times at a rate of 2 l/100 l (3x2 l/100 l): the thinning efficacy of this treatment amounted to 21.4% and was comparable to that of the shading net with a shading rate of 75% (Table 4). Harvest assessments were made only for some of the tested treatments. Fruit weight was significantly higher for the shading net and 3x2 l/100 l Vapor Gard than for the untreated control (respectively 202 g und 213 g versus 142 g), and also yield values of the two treatments were acceptable (respectively 26.8 and 27.8 kg/tree). In this first trial year, no negative side effects were observed for any of the treatments. Fruit russeting was highest for 3x2 l/100 l Vapor Gard, but differences were not significant. Also flower formation for the following year was comparable among the treatments, dividing them into three statistically different groups: in the first group there are the untreated control, 1x2 l/100 l Vapor Gard and 1x3 l/hl Vapor Gard with a percentage of flower formation of respectively 1.4%, 1.3% and 2.4%. In the second group there is 1x4 l/100 l Vapor Gard with 3.6% of flower formation. In the third group we find 3x2 l/100 l Vapor Gard and the reference shading net treatment with 12.7% and 13.5% of flower formation.

Table 5: trial results 2009. Assessments after June fruit drop (no. fruits/ 100 FC and leaf drop index) and at harvest (fruit weight in g, yield in kg/tree, % fruits with fruit russeting index > 3).

Treatment	No. fruit/100 FC		Fruit weight (g)		Yield (kg/tree)		Fruit russet (%)		Leaf drop (classes 0-5)
Control	101.5	e	163	a	30.9	c	0.7	a	0.0
3 x Vapor Gard 1l	82.9	d	155	a	27.3	c	4.2	a	1.0
3 x Vapor Gard 2l	82.3	d	176	b	29.0	c	1.2	a	2.0
3 x UFO 0,5l	84.9	d	191	cd	28.0	c	0.7	a	3.0
3 x UFO 1l	67.2	c	197	d	21.0	b	3.7	a	4.0
2 x UFO 1l	72.2	c	185	bc	24.2	b	3.4	a	3.0
3 x Rapeseed oil 2l*	45.3	a	184	bc	13.2	a	41.1	b	5.0
3 x Sojbean oil 3l	64.8	c	182	bc	20.7	b	6.4	a	5.0
Net 75%	57.2	b	212	e	22.8	b	1.1	a	0.5

*emulsified with lecithin

In 2009, the following products were tested: the transpiration inhibitor Vapor Gard, the mineral oil UFO (concentration active substance: 98.8% refined mineral oil), canola oil emulisified with lecithin, soybean oil, and shading net with a 75% shading rate. All treatments reduced the number of fruits/100 FC compared to the untreated control (Table 5). Lowest thinning efficacy values were recorded for 3x2 l/100 l Vapor Gard (19.0%), 3x1 l/100 l Vapor Gard (18.3%), and 3x0.5 l/100 l UFO (16.4%), intermediate values were registered for 3x1 l/100 l UFO (33.8%), 2x1 l/100 l UFO (28.8%) and 3x3 l/100 l soybean oil (36.2%), while highest thinning efficacy values were obtained with the shading net (43.7%) and with 3x2 l/100 l canola oil (55.4%). All treatments except 3x1 l/100 l Vapor Gard significantly increased fruit weight in comparison to the untreated control. Fruit yield was acceptable for all treatments except for 3x2 l/100 l canola oil. This treatment also caused significantly higher fruit russeting, while in all the other tested treatments fruit russeting was comparable to the untreated control. Some treatments furthermore led to considerable leaf drop: especially on the trees treated with canola and soybean oil leaf burn and thus leaf drop was extremely high on both rosette leaves and shoots (Table 5).

Discussion

In organic farming, yield control is achieved using mechanical thinning machines and/or lime sulphur sprays. These tools allow for flower thinning. At this crop stage it is already visible how many flowers each tree will bear, but actual fruit set depends also on several additional factors which can not be predicted at the time of flower thinning. Frequently, successive steps must be undertaken to assure high quality yields. In integrated fruit growing this is achieved by applying phytohormones. In organic farming, instead, at the moment the only available tool is manual thinning, which is labour-intensive and expensive. The use of nets at a fruit size of 10 - 15 mm for shading trees and reducing net photosynthesis showed interesting results in various small-plot trials.

However, efficient installation methods for a large scale use in commercial orchards, are not yet available. Therefore until now, especially bentonite and dyes were tested as alternatives to shading nets. Aiming at the reduction of transpiration of leaves and net photosynthesis, and thus increasing June fruit drop, oily substances were tested at the research centre Laimburg (South Tyrol, Italy) in 2008 and 2009. The trials were conducted in integrated apple cv Golden Delicious orchards (training system: spindle). In 2008, the pine oil-based product Vapor Gard was tested according to the following application schedules: 1 application at 4 l/100 l, 1 application at 3 l/hl, 1 application at 2 l/100 l, and 3 applications at 2 l/100 l.

Shading nets with a shading rate of 75%, which were left on the trees for 3 days, acted as reference treatment. The following mean thinning efficacy values were obtained: 1.5% for 1x4 l/100 l Vapor Gard, 2.6% for 1x3 l/100 l Vapor Gard, 9.5% for 1x2 l/100 l Vapor Gard, 21.4% for 3x2 l/100 l Vapor Gard, and 23.8% for the reference shading net treatment. No negative side effects on fruits and leaves were observed in 2008. In 2009, in addition to Vapor Gard applied three times at 1 and 2 l/100 l, respectively, also the mineral oil-based product UFO (tested respectively at 3x0.5 l/100 l, 3x1 l/100 l, and 2x1 l/100 l), an experimental product based on canola oil (application rate: 3x2 l/100 l) and one based on soybean oil (application rate: 3x3 l/100 l) were tested. Also in this trial, shading nets with a shading rate of 75%, left o the trees for 3 days, acted as reference treatment. The thinning efficacy of the different treatments amounted to: 18.3 % for 3x1 l/100 l Vapor Gard, 19.0% for 3x2 l/100 l Vapor Gard, 16.4 % for 3x0.5 l/100 l UFO, 33.8 % for 3x1 l/100 l UFO, 18.8% for 2x1 l/100 l UFO, 55.4% for 3x2 l/100 l canola oil, 36.2% for 3x2 l/100 l soybean oil and 43.7% for the shading net. In 2009, all oil-based treatments caused leaf damage, especially canola and soybean oil. Generalizing the results it can be concluded that the oily substances tested show a promising thinning potential, but at the moment the risk of injuries on fruits and leaves can not be excluded. Further studies with different formulations of these active substances, less likely to cause phytotoxic effects, are required.

References

Byers R.E., Lyons, C.G., Yoder, K.S., Barden, J.A., Young, R.W (1985). Peach and apple thinning by shading and photosynthetic inhibition. *Journal of Horticultural Science* **60** (4), 465-472.

Fankhauser F., Schumacher R, Stadler W. (1979). Ausdünnung mit unterschiedlichen Brühmengen und Konzentrationen. *Schweizerische Zeitschrift für Obst- Weinbau* **115** (6), 205-213.

Kelderer M., Lardschneider E., Casera C. (2009). Das Ausdünnungsgerät, eine Alternative für die Ertragsregulierung. *Obstbau Weinbau, Ausdünnung spezial*, **46** (2), 74-76

Kelderer M. Lardschneider E., Casera C. (2008). Tree shading: an efficient method to control alternate bearing? Ecofruit - 13th International Conference on Cultivation Technique and

Phytopathological Problems in Organic Fruit-Growing, Förderungsgemeinschaft Ökologischer Obstbau e. V. Weinsberg 13, 310-313

Kelderer M., Lardschneider E., Casera C. (2006). Thinning effect of lime sulphur applied during blossom with the overhead irrigation system in comparison to the sprayer. 12th International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit-Growing, Förderungsgemeinschaft Ökologischer Obstbau e. V. Weinsberg 12, 234-238

McArtney S., White M., Latter I., Campbell J. (2004). Individual and combined effects of shading and thinning chemicals on abscission and dry-matter accumulation of 'Royal Gala' apple fruit. *Journal of Horticultural Science & Biotechnology* **79 (3)**, 441-448

Musacchi S., Corelli Grappadelli L. (1994). Ombreggiamento artificiale quale metodo per il diradamento dei frutti del melo. Atti II Giornate Scientifiche S.O.I. – S. Benedetto del Tronto – 22-24 Giugno 1994, 247-248

Prantl M., Lardschneider E., Corelli Grapadelli L., Kelderer M. (2004) Reduction of net photosynthesis after plossom a possibility to control alternate bearing in organic orchards? Ecofruit - 11th International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit-Growing, Förderungsgemeinschaft Ökologischer Obstbau e. V. Weinsberg, 11, 217-221

Stadler W., Widmer A., Dolega E., Schaffner M., Bertschinger L. (2005). Fruchtausdünnung durch Beschattung der Apfelbäume – eine Methode mit Zukunft? *Schweizerische Zeitschrift für Obst- und Weinbau* (SZOW) Wädenswil **10**, 10-13

Strimmer M., Kelderer M., Pieber K. (1997). Ertragsregulierung im Ökologischen Obstbau. Einsatz der mechanischen Ausdünnungsmaschine. 8. Internationaler Erfahrungsaustausch über Forschungsergebnisse zum Ökologischen Obstbau. FÖKO (Fördergemeinschaft Ökologischer Obstbau), 196-109

Südtiroler Beratungsring für Obst- und Weinbau (2009). Leitfaden 2009, Chemische Fruchtausdünnung, 64-67

Weibel F., Walther A., (2003). Ausdünnung beim Apfel: Beim Fadengerät lässt sich noch einiges herausholen! In: Häseli, Andreas (Hrsg.) Tagungsband. FiBL Obstbautagung. Beiträge zur FiBL Obstbautagung 29.01.2003 in Frick, Forschungsinstitut für biologischen Landbau, Frick, 37-41.

Widmer A., Kockerols, K., Schwan S., Stadler W., Bertschinger L. (2008). Towards Grower-friendly Apple Crop Thinnimng by Tree Shading. Ecofruit - 13th International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit-Growing, Förderungsgemeinschaft Ökologischer Obstbau e. V. Weinsberg 13, 314-318