Interaction between varierties, lime sulphur and hainet on the thinning effect and on side effects using paraffin oil as a June drop thinner

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Abstract

In organic apple growing in South Tyrol, (Italy) 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 leaves is drastically reduced. Notwithstanding the good trial results, the method is not used in the field, because shading trees with nets is labour-intensive and expensive. During the last years 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 russetting, cannot be excluded. In this experiment, the paraffin oil-based products UFO (Ultra Fine Oil) and EKO (EKO Oil spray) were applied on different apple cultivars and their thinning efficacy and interaction with lime sulphur sprays and hail nets were recorded. There have been promising results in thinning, but differences in the observed effects among apple cultivars were high. Therefore, the choice of product and thinning strategy strongly depends on the cultivar.

Keywords: apple, June drop, thinning, transpiration inhibitors

Introduction

For successful apple growing efficient fruit thinning is a crucial requirement. 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, 2011). 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 in organic orchards in South Tyrol is done at flowering by using mechanical thinning machines (Strimmer et al., 1997; Kelderer *et al*., 2009; Weibel & Walther, 2003) and/or by applying lime sulphur sprays (Kelderer *et al*., 2006).

Several studies showed that close-meshed shading nets, commonly applied to reduce the net photosynthesis of apple trees, can also be used for fruit thinning in a later phenological stage (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, this method is not used by growers, because it is too labour-intensive and expensive. Different studies were thus carried out to find a more suitable alternative. Good results were achieved with applications of bentonite sprays, but residue of bentonite on the fruits make them unmarketable (Prantl *et al*., 2004). It is known that oily substances can inhibit transpiration in leaves, close stomata, and thus affect photosynthesis. In 2008 and 2009 different oily substances such as pine oil-, paraffin oil-, soybean oil- and canola oil-based products have been tested (Kelderer *et al*. 2010). Due to the promising results obtained in 2010 and 2011 with paraffin oil-based products (Kelderer *et al*. 2012), additional studies with these products have been conducted in 2012 and 2013 on various apple cultivars in order to collect additional information on the thinning effect and on possible negative side effects as e.g. russetting at different application rates on different apple cultivars. A further

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important aim was to evaluate the interactions of paraffin oil with lime sulphur, commonly used in organic apple growing to control apple scab, and with hail nets, commonly installed in the apple orchards of the region.

Material and Methods

Trial design:

The trials were conducted in 2012 and 2013 in different apple orchards under integrated management conditions at the Research Centre Laimburg (Pfatten, South Tyrol, Italy). All study orchards were lowland orchards, located at 220 m above sea level. A detailed description of the study orchards is provided in Table 1. The climatic conditions can be described as Mediterranean.

A randomised block design with 4 replications per treatment and cultivar was used, except for Red Delicious in 2013, for which only 2 replications were used. Assessments were conducted on 5 trees (approx. 3 m canopy height) per plot, uniform in growth vigor, size-, and number of flowers (at least 80 %). All paraffin oil-based treatments were applied with a motorized sprayer (transverse current blower) for experimental trials, (prototype) from WAIBL (Meran, Italy). The treatments of paraffin oil were applied twice from the 30th April to the 7th May in 2012 and from the 15th May to the 11th May in 2013 on each tested cultivar. The time lap between the applications of paraffin oil was three days. Lime sulphur was applied separately before, between and after the applications of paraffin oil. In 2012, the paraffin oil-based product UFO Ultra Fine Oil (98.8 % paraffin oil) from CBC (Europe) S.r.l. (Nova Milanese, Italy) was tested, and the entire tree canopy of the study plots was treated with the product. In 2013, the product EKO oil spray (98.8 % paraffin oil) from Makhteshim Agan Italia (Grassobbio, Italy) was tested, and only the top of the canopy was treated to avoid overthinnig of the lower part of the trees. In both study years a spray volume of 500 l/ha per m canopy height was used.

In both study years, the paraffin oil-based product was tested by at different rates on trees not covered with a hail net and without additional applications of lime sulphur, on trees covered with hail net, and applied in alternation with lime sulphur sprays (Table 2). In the plots, in which the paraffin oil was tested in combination with hail net, a conventional hail net (mesh size 8 x 3 mm) was directly installed when fruit size had reached 15 mm (BBCH 72), and retained up to harvest. In the plots, in which the paraffin oil was tested also in alternation with lime sulphur, lime sulphur was applied 3 times to all plots at the recommended label rate of 1.5l/100 l in alternation with the paraffin oil-based products.

Table 1: Characteristics (cultivars, rootstock, year of planting, planting distance) of the study orchards, in which the thinning trials were conducted in 2012 and 2013.

Year	Cultivar/Clone	Rootstock	Planting Year	Planting distance (m)
2012	Fuji / Kiku 8	M9	2005	3,0 x 0,9
	Gala / Obrogala	M9	2005	3,3 x 0,8
	Golden Delicious / Klon B	M9	1997	3,1 x 0,9
	Granny Smith	M9	2009	3,3 x 1,0
	Nicoter	M9	2008	3,0 x 0,8
	Crips Pink	M9	2004	3,0 x 0,8
2013	Braeburn / Maririred	M9	1997	3,4 x 0,9
	Fuji / Kiku 8	M9	2003	3,2 x 1,0
	Gala / Obrogala	M9	1997	3,5 x 0,8
	Golden Delicious / Klon B	M9	2009	3,2 x 0,8
	Nicoter	M9	2007	3,0 x 0,8
	Crips Pink	M9	2001	3,1 x 1,0
	Red Delicious	M9	1991	3,4 x 0,9

Table 2: Tested treatments: products, applied rates and timing of applications.

Year	Treatment			Trade name	Producer/ distributor	Applied-rate l/100l	No. appli-cations	Phenological-stage/ Fruit size
2012	entire canopy	1	Paraffin oil	UFO	CBC (Europa)	1.5	2	15mm
			Lime sulphur	Polisolfuro	Polisenio	2	3	
		2	Paraffin oil	UFO	CBC (Europa)	1.5	2	15mm
			Net					
		3	Paraffin oil	UFO	CBC (Europa)	1.5	2	15mm
		4	Untreated Control	*	*	*	*	*
2013	only top of canopy	1	Paraffin oil	Eko Oil Spray	Makhteshim	1.5	2	15mm
		2	Paraffin oil	Eko Oil Spray	Makhteshim	1	2	15mm
		3	Paraffin oil	Eko Oil Spray	Makhteshim	1	2	15mm
			Lime sulphur	Polisolfuro di Zolfo	Polisenio	1	2	
		4	Paraffin oil	Eko Oil Spray	Makhteshim	1	2	15mm
			Lime sulphur+Net	Polisolfuro di Zolfo	Polisenio	1	2	
		5	Untreated Control	*	*	*	*	*

<u>Assessments:</u>

Thinning: to assess the thinning efficacy of the different treatments, after June fruit drop, in each plot 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). 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.

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

Return to bloom: to assess effects of the different treatments on flower bud formation in the next season, the percentage of flowers on the sprouted buds was determined by visual estimation the following year (2013) in spring.

Leaf drop (phytotoxicity): visual assessments were made on leaf drop. To establish the incidence of leaf drop, a scale ranging from 0 to 5 was used with 0 = no leaf drop, 1 = light drop of rosette leaves, 2 = medium drop of rosette leaves, 3 = medium drop of rosette leaves and first symptoms of leaf drop on shoots, 4 = high drop of rosette leaves and light-medium leaf drop on shoots, and 5 = high drop of rosette leaves and leaves on shoots.

Yield and fruit weight: at harvest, all fruits present on the 5 sample trees within each plot were harvested, and fruit yield (kg/tree) and fruit weight (g) were assessed, using a sorting machine from AWETA (Nootdrop, Netherlands). Yield and fruit weight were not assessed in 2012 due strong frost on the 9th of April 2012.

Statististical analysis:

The number of fruits/100 FC, fruit weight (g), yield (kg/tree), percentage of russeted fruit surface and percentage of flower buds the following season were compared across treatments using 1-way ANOVAs followed by Student-Newman-Keuls' test for posthoc comparisons of means (P<0.05). To achieve normal distribution of data expressed in percentages were transformed by arcsin (sqrt(x/100)). All analyses were performed with the statistics programme IBM SPSS 20.

Results

Table 3: Mean number of fruits/100 FC in the lower (bottom) and upper (top) part of the tree canopy, and mean total number of fruits/100 FC on the different apple cultivars in 2012 (assessments after June fruit drop). *

Cultivar	Treatment		No.Fruits/100 FC bottom		No.Fruits/100 FC top		No.Fruits/100 FC total	
Fuji	1	2x1.5l UFO + 3x2l LS	5.2	a	7.0	a	5.8	a
	2	2x1.5l UFO + Net	7.2	a	13.2	b	9.2	a
	3	2x1.5l UFO	16.2	b	21.7	c	18.0	b
	4	Untreated	28.3	c	36.5	d	31.0	c
Gala	1	2x1.5l UFO + 3x2l LS	22.6	a	25.4	a	23.5	a
	2	2x1.5l UFO + Net	26.9	a	38.9	b	30.9	b
	3	2x1.5l UFO	29.8	a	44.1	b	34.6	b
	4	Untreated	55.4	b	68.9	c	59.9	c
Golden D.	1	2x1.5l UFO + 3x2l LS	7.6	a	18.0	a	11.1	a
	2	2x1.5l UFO + Net	12.9	ab	30.9	b	18.9	ab
	3	2x1.5l UFO	16.6	abc	34.7	b	22.6	b
	4	Untreated	45.1	c	73.2	c	54.4	c
Granny S.	1	2x1.5l UFO + 3x2l LS	6.5	a	12.6	a	8.6	a
	2	2x1.5l UFO + Net	11.8	b	20.9	a	15.5	b
	3	2x1.5l UFO	16.6	b	23.1	a	18.0	b
	4	Untreated	28.1	c	40.6	b	32.3	c
Nicoter	1	2x1.5l UFO + 3x2l LS	n.a.	*	n.a.	*	3.5	a
	2	2x1.5l UFO + Net	n.a.	*	n.a.	*	12.1	b
	3	2x1.5l UFO	n.a.	*	n.a.	*	25.6	c
	4	Untreated	n.a.	*	n.a.	*	46.7	d
Crips P.	1	2x1.5l UFO + 3x2l LS	28.3	a	58.2	a	38.3	a
	2	2x1.5l UFO + Net	44.8	b	79.6	b	56.4	b
	3	2x1.5l UFO	59.3	c	95.8	c	71.4	c
	4	Untreated	100.8	d	160.4	d	120.7	d

* Different letters within the same column indicate statistically significant differences (SNK test: P<0.05). LS = Lime sulphur. Net = Hail net.

Table 4: Mean leaf drop (scale 0-5), fruit russetting (% of affected fruit surface) and % of flower buds the fallowing year on the different cultivars in 2012. *

Cultivar	Treatment		Leaf drop	% Fruit russeting		%Flower buds	
Fuji	1	2x1.5l UFO + 3x2l LS	2.0	8.9	a	24.0	b
	2	2x1.5l UFO + Net	1.0	8.8	a	16.5	a
	3	2x1.5l UFO	1.0	9.4	a	28.5	b
	4	Untreated	0.0	9.3	a	23.0	b
Gala	1	2x1.5l UFO + 3x2l LS	3.0	9.9	a	25.5	c
	2	2x1.5l UFO + Net	1.0	10.2	a	25.5	ab
	3	2x1.5l UFO	1.0	11.0	a	30.0	b
	4	Untreated	0.0	12.6	a	17.0	a
Golden D.	1	2x1.5l UFO + 3x2l LS	5.0	29.2	a	55.5	c
	2	2x1.5l UFO + Net	2.0	38.3	a	40.5	b
	3	2x1.5l UFO	3.0	38.9	a	51.5	c
	4	Untreated	0.0	42.1	a	30.0	a
Granny S.	1	2x1.5l UFO + 3x2l LS	2.0	3.3	a	82.1	a
	2	2x1.5l UFO + Net	1.0	7.2	b	79.5	a
	3	2x1.5l UFO	1.0	6.3	b	84.1	a
	4	Untreated	0.0	2.0	a	82.5	a
Nicoter	1	2x1.5l UFO + 3x2l LS	3.0	2.0	b	88.0	b
	2	2x1.5l UFO + Net	2.0	2.4	b	79.5	b
	3	2x1.5l UFO	2.0	1.9	b	79.5	b
	4	Untreated	0.0	0.1	a	54.5	a
Crips P.	1	2x1.5l UFO + 3x2l LS	2.0	n.a.	*	71.0	c
	2	2x1.5l UFO + Net	2.0	n.a.	*	45.5	a
	3	2x1.5l UFO	1.0	n.a.	*	60.5	b
	4	Untreated	0.0	n.a.	*	42.0	a

* Different letters within the same column indicate statistically significant differences (SNK test: P<0.05). LS = Lime sulphur. Net = Hail net.

In 2012, a statistically significant thinning effect in comparison to the untreated control was achieved with all tested treatments on all cultivars (Table 3). On all cultivars, Treatment 1 showed the strongest thinning effect (e.g. Fuji No.Fruits/100FC total 5.8), followed by Treatment 2 (e.g. Fuji No.Fruits/100FC total 9.2), indicating the interference of lime sulphur and the hail net with paraffin oil.

The assessment on leaf drop (phytotoxic symptoms) showed that the treatment, in which paraffin oil was used in alternation with lime sulphur, caused highest leaf drop (Table 4). Among the cultivars, Golden Delicious (class 5) was the cultivar most susceptible to leaf drop, while Fuji (class 2), Granny Smith (class 2) and Crips Pink (class 2) showed less severe symptoms.

No significant increase in fruit russetting in comparison to the untreated control was observed on the cultivars Fuji, Gala and Golden Delicious (Table 4). On Granny Smith, instead, significantly higher fruit russetting than in the untreated control was recorded in Treatment 2 and 3 (2.0 % versus respectively 6.3 and 7.2 %). On the cultivar Nicoter all treatments with UFO resulted in increased fruit russetting. However, the level of fruit russetting on both Granny Smith and Nicoter was generally low in all treatments.

Return to bloom was assessed in spring 2013. On Fuji, significantly lower flower formation than in the untreated control was observed in Treatment 2 (UFO in combination with hail net) while the other tested treatments did not differ from the untreated control (Table 4). With Gala, the untreated control showed the lowest return to bloom (17 %), and Treatment 3 the highest (30 %). On Golden Delicious, flower formation was again lowest in the untreated control (30 %), intermediate in Treatment 2 (40.5 %), and highest in Treatment 1

(55.5 %) and 3 (51.5 %), which showed statistically comparable flower formation values. On Granny Smith, differences among treatments in flower formation failed significance, while on Nicoter flower formation was significantly higher in treated than in untreated control plots (Table 4). On Crips Pink, flower formation was significantly lower in the untreated control (42 %) and in Treatment 2 (45.5 %), than in Treatment 3 (60.5 %) and Treatment 1 (71 %), with the latter showing highest flower formation values.

In 2012, no assessment on yield at harvest was conducted because of strong frost in spring, which impaired production.

Table 5: Mean number of fruits/100 FC in the lower (bottom) and upper (top) part of the tree canopy, and mean total number of fruits/100 FC on the different apple cultivars in 2013 (assessments after June fruit drop). *

Cultivar	Treatment		No.Fruits/100 FC bottom		No.Fruits/100 FC top		No.Fruits/100 FC total	
Braeburn	1	2x1.5l EKO.	90.7	a	95.1	b	92.2	a
	2	2x1l EKO.	92.1	a	88.3	b	90.8	a
	3	2x1l EKO.+3x1l LS	92.3	a	70.6	a	85.1	a
	4	2x1l EKO.+3x1l LS+Net	91.1	a	71.9	a	84.7	a
	5	Untreated	97.3	a	112.7	c	102.4	b
Fuji	1	2x1.5l EKO.	110.8	ab	127.2	ab	116.2	abc
	2	2x1l EKO.	108.2	ab	142.7	b	119.7	bc
	3	2x1l EKO.+3x1l LS	97.1	a	119.0	a	104.4	a
	4	2x1l EKO.+3x1l LS+Net	98.2	a	130.9	ab	109.1	ab
	5	Untreated	115.3	c	145.3	b	125.3	c
Gala	1	2x1.5l EKO.	38.4	c	39.3	c	38.7	c
	2	2x1l EKO.	33.0	bc	46.7	d	37.6	c
	3	2x1l EKO.+3x1l LS	26.6	ab	29.5	b	27.5	b
	4	2x1l EKO.+3x1l LS+Net	22.4	a	19.9	a	21.5	a
	5	Untreated	33.2	bc	56.8	f	41.0	c
Golden D.	1	2x1.5l EKO.	52.2	ab	64.0	b	56.2	b
	2	2x1l EKO.	51.4	ab	65.3	b	56.0	b
	3	2x1l EKO.+3x1l LS	41.7	a	60.6	b	48.0	ab
	4	2x1l EKO.+3x1l LS+Net	43.5	a	49.1	a	45.4	a
	5	Untreated	55.9	c	97.0	c	69.6	c
Nicoter	1	2x1.5l EKO.	41.2	b	34.0	b	38.8	b
	2	2x1l EKO.	43.0	b	30.3	ab	38.8	b
	3	2x1l EKO.+3x1l LS	26.3	a	25.3	ab	26.0	a
	4	2x1l EKO.+3x1l LS+Net	21.7	a	21.0	a	21.4	a
	5	Untreated	47.4	b	61.6	c	52.1	c
Crips P.	1	2x1.5l EKO.	86.8	c	72.0	a	81.8	b
	2	2x1l EKO.	77.0	bc	89.4	b	81.2	b
	3	2x1l EKO.+3x1l LS	71.9	ab	68.6	a	70.8	a
	4	2x1l EKO.+3x1l LS+Net	63.3	a	66.2	a	64.2	a
	5	Untreated	84.6	c	99.6	b	89.6	b
Red. D.	1	2x1.5l EKO.	70.2	c	55.2	b	65.2	c
	2	2x1l EKO.	73.7	c	75.1	c	74.2	d
	3	2x1l EKO.+3x1l LS	32.1	b	10.0	a	24.7	b
	4	2x1l EKO.+3x1l LS+Net	17.3	a	10.4	a	15.0	a
	5	Untreated	83.9	c	102.5	d	90.1	e

* Different letters within the same column indicate statistically significant differences (SNK test: $P<0.05$). LS = Lime sulphur. Net = Hail net.

Table 6: Mean leaf drop (scale 0-5), fruit russetting (% of affected fruit surface) and % of flower buds the fallowing year on the different cultivars in 2013). *

Cultivar	Treatment		Leaf drop	% Fruit russeting		Yield (kg/tree)		Fruit weight (g)	
Braeburn	1	2x1.5l EKO.	2.0	n.a.	*	19.7	b	187.2	a
	2	2x1l EKO.	1.0	n.a.	*	18.4	b	180.3	a
	3	2x1l EKO.+3x1l LS	2.0	n.a.	*	13.0	a	217.9	b
	4	2x1l EKO.+3x1l LS+Net	2.0	n.a.	*	10.1	a	215.1	b
	5	Untreated	1.0	n.a.	*	22.5	b	169.6	a
Fuji	1	2x1.5l EKO.	0.5	5.0	a	37.3	a	140.3	a
	2	2x1l EKO.	0.5	6.2	a	35.2	a	137.8	a
	3	2x1l EKO.+3x1l LS	0.5	5.3	a	31.9	a	149.9	a
	4	2x1l EKO.+3x1l LS+Net	0.5	5.6	a	32.1	a	142.6	a
	5	Untreated	0.0	7.9	a	36.5	a	136.8	a
Gala	1	2x1.5l EKO.	1.0	12.1	a	24.7	a	120.4	b
	2	2x1l EKO.	1.0	12.2	a	24.6	a	121.0	b
	3	2x1l EKO.+3x1l LS	1.0	12.3	a	22.3	a	119.9	b
	4	2x1l EKO.+3x1l LS+Net	1.0	13.4	a	23.8	a	124.1	b
	5	Untreated	0.5	13.2	a	25.4	a	108.0	a
Golden D.	1	2x1.5l EKO.	3.0	28.0	a	18.5	b	179.0	b
	2	2x1l EKO.	2.0	30.3	a	17.9	b	172.5	b
	3	2x1l EKO.+3x1l LS	2.0	30.4	a	16.9	ab	201.8	c
	4	2x1l EKO.+3x1l LS+Net	2.0	27.1	a	14.3	a	197.2	c
	5	Untreated	1.0	26.3	a	25.2	c	157.9	a
Nicoter	1	2x1.5l EKO.	1.0	0.0	a	17.5	b	186.1	bc
	2	2x1l EKO.	0.5	0.4	a	18.0	b	178.1	ab
	3	2x1l EKO.+3x1l LS	1.0	1.7	a	11.6	a	203.6	c
	4	2x1l EKO.+3x1l LS+Net	0.5	1.0	a	11.5	a	205.7	c
	5	Untreated	0.0	0.2	a	23.7	c	163.1	a
Crips P.	1	2x1.5l EKO.	1.0	n.a.	*	n.a.	*	n.a.	*
	2	2x1l EKO.	1.0	n.a.	*	n.a.	*	n.a.	*
	3	2x1l EKO.+3x1l LS	1.0	n.a.	*	n.a.	*	n.a.	*
	4	2x1l EKO.+3x1l LS+Net	0.5	n.a.	*	n.a.	*	n.a.	*
	5	Untreated	0.0	n.a.	*	n.a.	*	n.a.	*
Red. D.	1	2x1.5l EKO.	0.5	1.5	a	22.4	b	169.6	a
	2	2x1l EKO.	0.5	3.4	a	27.0	b	166.9	a
	3	2x1l EKO.+3x1l LS	2.0	1.7	a	11.4	a	246.6	b
	4	2x1l EKO.+3x1l LS+Net	1.0	4.5	a	5.5	a	246.8	b
	5	Untreated	0.0	3.5	a	28.2	b	152.1	a

* Different letters within the same column indicate statistically significant differences (SNK test: P<0.05). LS = Lime sulphur. Net = Hail net.

In 2013, all tested treatments showed a significant thinning effect in comparison to the untreated control on the cultivars Braeburn, Golden Delicious, Nicoter, and Red Delicious, while on Fuji, Gala and Crips Pink only the Treatments 3 and 4 resulted in a significant reduction in the number of fruis/100 FC (Table 5). Among the tested treatments, Treatment 4 (paraffin oil used in alternation with lime sulphur on hail net-covered trees) showed the highest thinning efficacy producing a over thinning on the cultivars Braeburn, Golden Delicious and Red Delicious (Table 5).

The most evident phytotoxic effects in terms of leaf drop were observed in Treatment 1 on the cultivars Golden Delicious and Braeburn (Table 6), while almost no differences among treated plots were recorded on the cultivars Fuji, Gala, Nicoter and Crips Pink. Red Delicious seemed to be slightly more susceptible to leaf drop, when paraffin oil was applied in alternation with lime sulphur (Treatment 3). On none of the cultivars, instead, any statistically significant differences in fruit russetting among the tested treatments emerged (Table 6).

On the cultivars Fuji and Gala, yield (kg/tree) was statistically comparable among all tested treatments, untreated control included (Table 6). On Golden and Nicoter, yield was significantly lower in treated than in untreated plots, while on Braeburn and Red Delicious a significant reduction in yield was recorded only in the treatments, in which paraffin oil was applied in alternation with lime sulphur (Treatments 3 and 4). Due to technical problems yield was not assessed on Crips Pink in 2013.

Fruit weight (g) was statistically comparable among treatments on Fuji, while on Gala fruit weight was significantly lower in untreated than in treated plots (Table 6). On Braeburn, Nicoter, Golden Delicious and Red Delicious fruit weight was significantly higher in Treatment 3 and 4 than in the other tested treatments. Furthermore, on these cultivars, the fruit weight in Treatment 1 and 2 was comparable indicating no significant dose-response effect. In 2013, on all cultivars, lowest fruit weight values were recorded for the untreated control.

Summary and Discussion

In organic apple growing in South Tyrol, yield control is achieved by using mechanical thinning machines and/or lime sulphur sprays during flowering (Südtiroler Beratungsring für Obst- und Weinbau, 2011b). At this crop stage it is already visible how many flowers each tree will bear, but fruit set depends also on several additional factors, which can not be predicted at the moment of flower thinning. Frequently, successive steps must be undertaken to assure yield of good quality. In integrated farming systems this is achieved by applying phytohormones. In organic farming, at the moment, the only available tool is manual thinning, which is labour-intensive and expensive.

With the aim of reducing net photosynthesis of leaves on apple trees, and thus promoting fruit drop in June, the paraffin oil-based products UFO (Ultra Fine Oil) and EKO (EKO Oil spray) were tested at the research centre Laimburg (South Tyrol, Italy) on different apple cultivars in 2012 and 2013.

Basically, it must be mentioned that the year 2012 was characterized by a severe frost during the flowering period (9th April 2012), which has greatly reduced the fruit set after flowering. This is particularly evident in the untreated control where the fruitload must be considert as very weak. Because the entire orchard was affected uniformly, the planned experiment was carried out. These circumstances have to be taken into account when interpreting the data of the the thinning efficacy. UFO was tested on the cultivars Fuji, Gala, Golden Delicious, Granny Smith, Nicoter, and Crips Pink. Treatment 1 consisted of 2 applications of UFO at 1.5 l/100 l, Treatment 2 of 2 applications of UFO at 1.5 l/100 l in alternation with 3 applications of lime sulphur at the recommended label rate, and Treatment 3 consisted of 2 applications of UFO at 1.5 l/100 l to trees covered with a standard hail net. In this trail, all tested treatments showed a significant thinning effect on all cultivars, and flower formation the following year was significantly higher than on untreated trees on Gala, Golden Delicious, and Nicoter. However, the levels of leaf drop (phytotoxicity) were very high especially in the treatments, in which paraffin oil was applied in alternation with lime sulphur. Also the percentage of fruit russetting reached high levels on some cultivars, especially on Golden Delicious.

Even when interpreting the data for 2013 is to be noted that the fruit set was rather weak at the pilot orchards. In this year EKO was tested on cultivars Braeburn, Fuji, Gala, Golden Delicious, Nicoter, Crips Pink and Red Delicious. Only the top of the tree canopy was treated. Treatment 1 consisted of 2 applications of EKO at 1.5 l/100 l, Treatment 2 of 2 applications of EKO at 1.0 l /100 l, Treatment 3 of applications of EKO at 1.0 l/100 l in alternation with 3 applications of lime sulphur at the recommended level rate and Treatment 4 consisted of 2 applications of EKO at 1.0 l/100 l in alternation with 3 applications of lime sulphur at the recommended label rate, to trees covered with a standard hail net. The thinning effects were of not as strong as the year before, and also leaf drop (phytotoxicity) and fruit russetting were less pronounced. Furthermore, the effects varied considerably among cultivars. On Fuji the thinning effect was less evident than on the other cultivars. Based on the results obtained in 2012, where the entire tree canopy had been treated, it can be assumed that applying the paraffin oil-based treatment only to the upper part of the tree canopy can be useful to avoid over-thinning of the lower part of the tree.

In general, it can be concluded that paraffin oil-based products can be considered as promising tools for fruit thinning on apple. However, in order to find an optimal thinning strategy for commercial growers, further studies on different cultivars and under different climatic conditions are deemed necessary.

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