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Reviewed Paper

Can the addition of paraffin oil improve the thinning effect of lime sulphur?

E. Lardschneider, M. Kelderer and J. Telfser[1]

Abstract

In several experiments carried out in 2022 and 2023, lime sulphur was mixed with paraffin oil to improve its thinning effect. The intention was to achieve the same or a better thinning effect with lower doses of lime sulphur. The trials were carried out at Laimburg (South Tyrol, Northern Italy) on the Golden Delicious and Gala varieties. In addition to the thinning effect, the yield and phytotoxicity effects on apples and leaves were determined. In the trials conducted, the thinning effect of lime sulphur was increased by the addition of paraffin oil, resulting in a significant reduction in the application rate. No significant phytotoxic damage was evident on either the fruit or the leaves. In the treatments carried out in 2022, there was severe clogging of the sprayer's filter system during the treatments. There were no more cloggings in further tests. The cause of the cloggings is unclear.

Keywords: apple, blossom thinning, lime sulfur, paraffin oil

Introduction

Blossom thinning with lime sulphur has been common practice in organic apple cultivation for many years (Kiem, 2023). However, experience in trials and practice has shown that the use of lime sulphur is not always entirely unproblematic. Depending on the variety, weather conditions, concentration and frequency of treatment, the thinning effect varies considerably, and sometimes phytotoxic damage can also occur (Kelderer *et al.*, 2002). Furthermore, only insufficient thinning effects can be achieved with the currently authorised application rates of lime sulphur (Kelderer *et al.*, 2002). In order to counteract these problems, an improvement in the thinning effect of lime sulphur with a simultaneous reduction of the dosage used should therefore be aimed for.

Thinning trials (Strimmer *et al.*, 1997, Mössler, 1998) and pollen germination tests (Yoder *et al*., 2009, McArtney *et al*., 2006) have shown that oils can impair the fertilisation of flowers and and lead to good thinning of the flowers. Other experiments show that the addition of oily substances can improve the thinning effect of lime sulphur (Bound, 2010).

Based on these results, thinning tests were carried out at the Research Centre Laimburg in 2022 and 2023, in which lime sulphur was mixed with different doses of paraffin oils and its thinning effect was evaluated.

Material and methods

The trials were carried out in 2022 and 2023 in various apple orchards under integrated management conditions at the Research Centre Laimburg (Pfatten, South Tyrol, Italy) at 220 metres above sea level. The rows of trees were orientated south-north. The climatic conditions can be described as Mediterranean.

A detailed description of the trial sites is given in Table 1.

[1] Research Centre Laimburg, IT-39040 Auer, ewald.lardschneider@laimburg.it

Table 1: Description of the trial sites: year, variety/clone, rootstock, planting year, planting distance.

Year	Cultivar/Clone	Rootstock	Planting Year	Planting distance (m)
2022	Golden Delicious / Klon B	M9	2003	3,2 x 1
2023	Gala / Obrogala	M9	2017	3,2 x 0,9
	Golden Delicious / Klon B	M9	2009	3,2 x 0,8

A randomised block design with 4 replicates per treatment was used. Each replicate consisted of 5 evaluation trees, so that a total of 20 evaluation trees were available for each variant. The evaluation trees were selected and marked before flowering. Trees with strong and homogeneous flowering and balanced growth were selected.
All treatments were carried out using a plot sprayer with a transverse current blower (prototype) from WAIBL (Merano, Italy). The amount of water required per hectare was 500 litres per metre of canopy height, i.e. 1500 litres per hectare. The nozzles used were ALBUZ (Evreux, France) injector nozzles of the type CVI 80°-015.
3 treatments were carried out within the flowering period, the first at stage 63 (according to BBCH code), the second at stage 65 and the third at stage 67. The exact treatment dates are listed in Table 2.

Table 2: Treatment dates: date, vegetation stage according to BBCH scale.

Year	Cultivar/Clone	1. treatement		2. treatement		3. treatement	
		date	BBCH	date	BBCH	date	BBCH
2022	Golden Delicious / Klon B	14.04.22	63	16.04.22	65	18.04.22	67
2023	Gala / Obrogala	08.04.23	63	11.04.23	65	14.04.23	67
	Golden Delicious / Klon B	05.04.23	63	08.04.23	65	11.04.23	67

In all trials, an untreated control and a standard thinning with a lime sulphur dosage of 2 l/100l (30 l/ha) were included. Detailed information on the variants and dosages can be seen in Table 3.

Table 3: Description of the variants: Year, cultivar, treatment, product name, distributor, dosage in litres/100l spray mixture, dosage in litres/ha, treatment frequency.

Yaer	Cultivar	Treatment	productname	distributor	dosage l/100l	dosage l/ha	appli-cations
2022	Golden Delicious	Untreated Control	*	*	*	*	*
		Lime sulphur	Polisolfuro di Calcio	Polisenio	2	30	3
		Lime sulphur	Polisolfuro di Calcio	Polisenio	1	15	3
		Lime Sulphur	Polisolfuro di Calcio	Polisenio	1	15	3
		Paraffin oil	Ovipron Top	UPL	1	15	3
		Lime Sulphur	Polisolfuro di Calcio	Polisenio	1	15	3
		Paraffin oil	Ovipron Top	UPL	0,5	7,5	3
		Lime Sulphur	Polisolfuro di Calcio	Polisenio	1	15	3
		Paraffin oil	Ovipron Top	UPL	0,25	3,75	3
2023	Golden Delicious	Untreated Control	*	*	*	*	*
		Lime sulphur	Polisolfuro di Calcio	Polisenio	2	30	3
		Lime Sulphur	Polisolfuro di Calcio	Polisenio	1	15	3
		Paraffin oil	Ovipron Top	UPL	0,25	3,75	3
		Lime	Polisolfuro di Calcio	Polisenio	1	15	3
		Paraffin oil	Ovipron Top	UPL	0,1	1,5	3
		Lime Sulphur	Polisolfuro di Calcio	Polisenio	1	15	3
		Paraffin oil	Ovipron Top	UPL	0,05	0,75	3
	Gala	Untreated Control	*	*	*	*	*
		Lime sulphur	Polisolfuro di Calcio	Polisenio	2	30	3
		Lime Sulphur	Polisolfuro di Calcio	Polisenio	1	15	3
		Paraffin oil	Ovipron Top	UPL	0,25	3,75	3

Assessments

Thinning: to assess the thinning efficacy of the different treatments, after June fruit drop, in each plot the number of fruits was counted on 70 randomly selected flower clusters (henceforth FC) per tree. To take into consideration also the position of the flowers on the tree, 30 FC were selected in the upper third of the tree, and 40 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 in spring.
Phytotoxicity on leaves: Visual assessments were carried out on leaf rosettes and long shoots
Yield and fruit weight: At harvest, all evaluation trees were harvested and the fruit yield (kg/tree), fruit weight (g) and diameter were determined using a sorting machine from AWETA (Nootdrop, Netherlands)
Statistical 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 ANOVA followed by Student-Newman-Keuls' test for posthoc comparisons of means ($P<0.05$). All analyses were performed with the statistics programme IBM SPSS (Version 29.0.1.0).

Results
Thinning trial 2022:
In 2022 all lime-sulphur-oil mixtures showed a significantly lower number of fruits/100 flower clusters (FR/100FC) than the untreated control. The difference to the untreated control and thus the thinning effect was 20.9% for the variant 1 litre lime sulphur (LS) + 1 litre paraffin oil/100l, 20.1% for the variant 1 litre LS + 0.5 litre oil/100l and 21.8% for the variant 1 litre LS + 0.25 litre oil/100l. There were no statistical differences between the variants with the different oil admixtures. In the lime sulphur variants without oil admixture, only the variant with a high dosage (2 l/100l) showed a statistically significant difference compared to the control. The thinning effect here was 14.3 %. The low lime sulphur variant did not differ statistically from the untreated control.
In terms of tree yield at harvest, only the variants LS 1l + 1l oil/100l (20.5 kg/tree) and LS 1l + 0.5l oil/100l (19.8 kg/tree) differed statistically significant from the control (23.6 kg/tree). The fruit weight was also slightly higher in relation to the control. No statistically significant difference was found between the variants with regard to russeting. Re-flowering was very low in all variants. There was only a significant difference to the control in the LS 2l/100l variant, which had 6.6% flower buds, whereas the control had a flower bud percentage of 1.6%.
Phytotoxic damage to leaves was only observed in the 1l LS +1l oil/100l variant. This manifested itself as slight leaf lightening on basal long shoot leaves.

Table 4: Fruits/100 flower clusters (FR/100 FC) before and after the June fruit drop in the trial years 2022/23.

Year	Cultivar	treatment	No.Fruits/100 FC after June drop	
2022	Golden Delicious	Untreated control	116,4	a
		Lime sulphur 2l/hl	100,2	bc
		Lime sulphur 1l/hl	109,6	ab
		Lime sulphur 1l/hl + Oil 1l/hl	92,0	c
		Lime sulphur 1l/hl + Oil 0,5l/hl	93,0	c
		Lime sulphur 1l/hl + Oil 0,25l/hl	91,0	c
2023	Golden Delicious	Untreated control	176,0	a
		Lime sulphur 2l/hl	150,7	a
		Lime sulphur 1 l/hl + Oil 0,25 l/hl	160,2	a
		Lime sulphur 1 l/hl + Oil 0,1 l/hl	170,9	a
		Lime sulphur 1 l/hl + Oil 0,05 l/hl	166,1	a
	Gala	Untreated control	158,0	a
		Lime sulphur 2l/hl	139,0	b
		Lime sulphur 1 l/hl + Oil 0,25 l/hl	142,0	b

Thinning trials 2023:

Golden Delicious variety:

The LS 2l/100l and LS 1l + 0.25l oil/100l variants showed a slight reduction in FR/100 FC compared to the control, but this was not statistically significant. With regard to yield/tree, fruit weight and russeting, the different varieties did not show any significant differences.

Gala variety:

When analysing the FR/100 FC, both treatment variants differed statistically significantly from the untreated control. The LS 2l/100l variant showed a 12% thinning effect, the 1l LS + 0.25l oil/100l variant 10.1%. As expected, the yield was also lower in these variants and differed statistically significant from the control. The fruit weight was slightly higher in the treated variants but did not differ statistically significant.

Table 5: Yield in kg/tree, fruit weight in g/apple, % russeted fruit area and % flower buds in the trial years 2022-23.

Yare	Cultivar	treatment	Yield (kg/tree)		Fruit weight (g)		% Fruit russeting		% Flower	
2022	Golden Delicious	Untreated control	23,6	ab	154,1	a	10,5	a	1,5	ab
		Lime sulphur 2l/hl	21,2	ab	167,6	a	10,8	a	6,6	c
		Lime sulphur 1l/hl	24,2	a	158,9	a	10,2	a	0,0	a
		Lime sulphur 1l/hl + Oil 1l/hl	20,5	c	165,4	a	12,3	a	3,0	abc
		Lime sulphur 1l/hl + Oil 0,5l/hl	19,8	c	164,1	a	10,9	a	5,5	bc
		Lime sulphur 1l/hl + Oil 0,25l/hl	22,0	abc	158,8	a	10,9	a	1,5	ab
2023	Golden Delicious	Untreated control	29,8	a	158,0	a	11,8	a	-	
		Lime sulphur 2l/hl	32,0	a	157,2	a	12,4	a	-	
		Lime sulphur 1 l/hl + Oil 0,25 l/hl	26,7	a	159,6	a	12,8	a	-	
		Lime sulphur 1 l/hl + Oil 0,1 l/hl	28,4	a	158,0	a	11,3	a	-	
		Lime sulphur 1 l/hl + Oil 0,05 l/hl	27,5	a	156,3	a	12,2	a	-	
	Gala	Untreated control	16,9	a	147,2	a	-		-	
		Lime sulphur 2l/hl	15,0	b	155,3	a	-		-	
		Lime sulphur 1 l/hl + Oil 0,25 l/hl	14,4	b	158,2	a	-		-	

Summary and conclusion

Blossom thinning with lime sulphur can have phytotoxic effects with the currently recommended dosage, and this high dosage is no longer authorised according to the product registration. It is therefore important to find ways to reduce the dosage of this product while at the same time at least maintaining its effectiveness.

In the trials conducted in 2022 and 2023, it was possible to improve the thinning effect of the lime sulphur mixture by adding paraffin oil. This made it possible to halve the dosage of the lime sulphur while maintaining the same thinning effect. The thinning effect was around 20% in 2023. In 2022, unfavourable weather conditions reduced the thinning effect considerably.

In the tests carried out, a slight phytotoxic effect on leaves was only observed in one case and only in the variant with the highest oil addition of 1 litre/100l. However, even with lower oil additions and half the amount of lime sulphur, comparable thinning results could be achieved as with the full LS dosage without oil addition. None of the treatments carried out had any effect on the russeting of the apples.

In the coming years, it will be necessary to confirm the results and check whether the experience gained can also be transferred to other varieties and confirmed under different weather conditions. It is also important to check if these treatments have any undesirable effects on the beneficial insects. Furthermore, it is important to find out why the filter system became clogged during one application with the lime-sulphur-oil mixture.

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