

First strategies for controlling *Glomerella* leaf spot and apple bitter rot in organic apple orchards in South Tyrol

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Abstract

Glomerella Leaf Spot (GLS) and pre-harvest apple bitter rot (ABR), both caused by fungi within the *Colletotrichum gloeosporioides* species complex, pose a significant threat to organic apple production in certain areas of South Tyrol. GLS symptoms were first identified in the region in 2020, while ABR was first detected on apples in 2023. This one-year trial on Cripps Pink–Rosy Glow® tested eight organic-approved products (copper, acidic clay (± sulphur), potassium bicarbonate, orange oil, lime sulphur, and Epsom salt) against an untreated control. Thirteen applications were made between June and September. Results indicate copper and acidic clay as key components for GLS and ABR management strategies in organic production. Multi-year trials are needed.

Keywords: *Glomerella* Leaf Spot (GLS), pre-harvest apple bitter rot (ABR), *Colletotrichum chrysophilum*, organic orchard, Cripps Pink

Introduction

Glomerella leaf spot (GLS) and Apple Bitter Rot (ABR) have become increasingly important threats to apple production in South Tyrol. Originally known mainly from other regions of the world (Brazil, North America, China, Japan, and South Korea), both diseases now occur locally and affect leaves and fruits. Rising temperatures and changing precipitation patterns appear to facilitate disease establishment and spread. Severe infestations have been recorded between Terlan and Meran, with detections across valley locations from Salurn to Meran.

GLS was first detected on leaves and fruits in South Tyrol in 2020, while ABR appeared in summer 2023, affecting fruits of various varieties. According to investigations by the Phytopathology working group at the Laimburg Research Centre, both diseases are caused by the fungal species *Colletotrichum chrysophilum*. Despite the very different symptoms, genetic analyses in South Tyrol have so far found no distinguishing features between isolates of GLS and those of ABR (Deltedesco & Öttl, 2024).

Material and Methods

The trial was conducted in an organically managed Cripps Pink - Rosy Glow® orchard in Terlan. Randomised blocks were established with four replications per treatment, leaving two buffer rows between trial rows. During the study, buffer and border rows were treated by the owner only in the direction away from the trial rows to minimise drift effects.

Applications were performed using a Waibl (Sinich, BZ) plot sprayer from the Laimburg Research Centre at triple concentration (500 L ha⁻¹). Drift-reducing injector nozzles (Albuz CVI 80°), as mandated in South Tyrolean fruit production, were employed. Treatments were made approximately every 10 days on dry foliage. In total, 13 treatment dates were executed from 2 June to 30 September. Eight different plant protection products, plant strengtheners, and foliar fertilizers approved for organic farming were applied (see Table 1), along with an untreated control. On 29 October, two trees per plot (eight trees per treatment) were completely harvested, and the apples were taken to Laimburg. Using the sorting machine

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(Aweta Sorting and Packaging) at the Laimburg Research Centre, external quality and weight were recorded, with an average of 23.7 kg per tree. The assessed data were compared across treatments using one-way ANOVA, followed by Tukey's B test ($P < 0.05$) for post-hoc mean comparisons. All analyses were performed using IBM SPSS Statistics 29.

Table 1: Applied products, production or distribution company, active substance and dose per hectare.

Product	Company	Active substance	dose/ha
Untreated	-	-	-
Polisolfuro di calcio	Polisenio	Lime Sulphur	12 L
Ulmasud+Microthiol D.	CBC+UPL	Acid clay+Sulphur	15 kg + 1,5 kg
Armicarb 85	Scam	Potassium bicarbonate	5 Kg
Poltiglia Disperss+Caolino BPLN	UPL+O.Bitossi	Copper+Kaolin	1,5 kg (300g copper) + 3 kg
Microthiol D.	UPL	Sulphur	1,5 kg
Ulmasud	CBC	Acid clay	15 kg
EPSO Combitop	K+S	Epsom salt+Mn+Zn	9 kg
PREV-AM PLUS	Nufarm	Citrus oil	2 L

Results and Discussion

On 17 September, 180 fruits per plot (640 per treatment) were assessed on the tree (90 on the east side and 90 on the west side). In the control and in the less effective treatments, a severe GLS infestation had developed on the fruits (Figure 1). On the fruits of the untreated control, an average of 4.8 spots was counted, whereas in the best treatment with copper, only 0.25 spots were recorded on average. The treatments with acidic clay (with and without sulphur) also showed relatively low infestation, with an average of around 0.4 spots. Formulated potassium bicarbonate (Armicarb 85) demonstrated good, though clearly weaker, efficacy, with an average of about one spot per fruit. The remaining treatments were generally intermediate between the mentioned active substances and the control.

This result is also reflected in the proportion of healthy fruits (Table 2). For copper, this was 84%, and for acidic clay 72% (with sulphur) and 76% (without sulphur), with no significant difference between these two. In the potassium bicarbonate (Armicarb) treatment, 55% of fruits were healthy, while in the control only about 10% of apples were spot-free. It is also noteworthy that in the control, almost 30% of fruits had more than nine spots per fruit.

Leaf infestation was assessed using an index that accounted for leaves already heavily affected or partially fallen. A score of 0 corresponded to healthy leaves, while a score of 4 indicated severe damage with significant leaf drop. GLS infestation on leaves was detectable, and the efficacy of the individual products was very similar to that observed on fruits. Some products can trigger phytotoxic reactions, such as repeated applications of acidic clay or potassium bicarbonate, which may cause leaf damage and leaf drop. However, in this trial, only very few phytotoxic reactions were observed. A positive effect on leaf health was achieved by adding sulphur to acidic clay. By counting fallen leaves on 10 October, approximately 100 leaves per tree were recorded in the control, while the copper treatment had around 40 leaves per tree. All other treatments ranged between 50 and 60 leaves per tree.

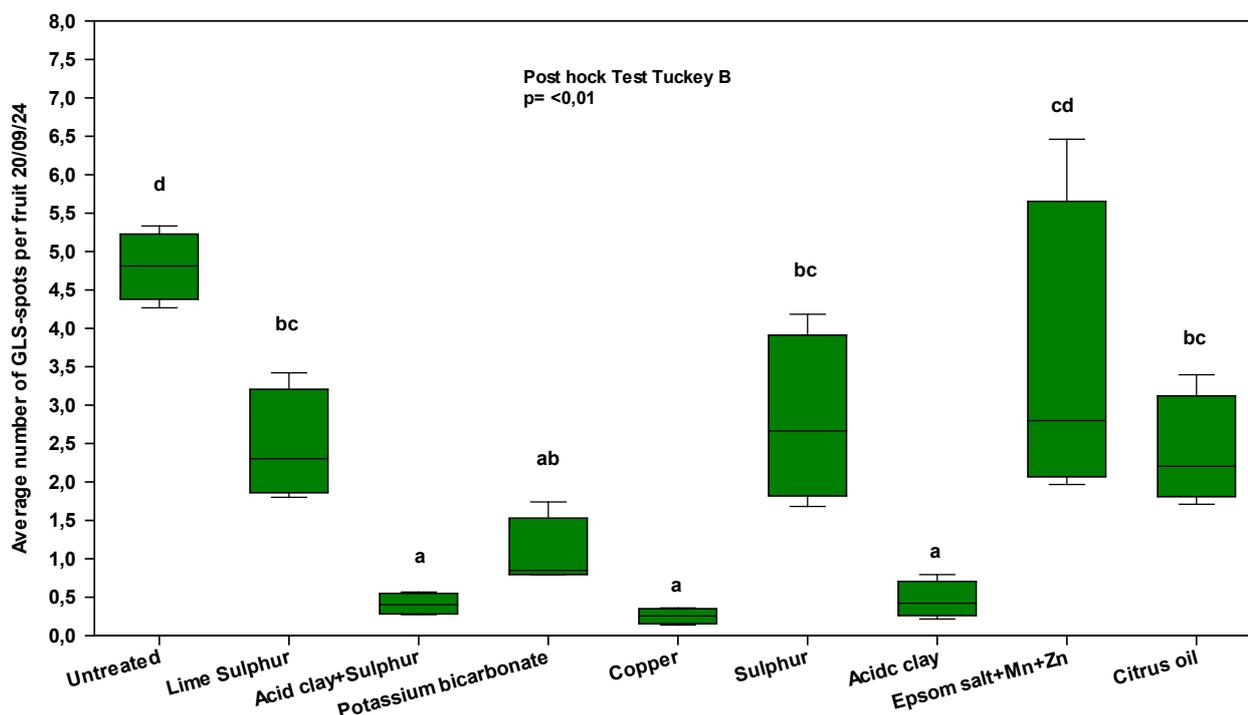


Figure 1: Average number of GLS-spots per fruit on 20 September 2024.

Fruit rot caused by ABR also occurred in this Cripps Pink orchard to a moderate extent. ABR infestation often appears in clusters and on individual trees, but in this heavily GLS infested GLS orchard it was found in all plots. In the control, slightly more than 2% of fruits were affected on 17 September. Interestingly, GLS and ABR infestations seem to go hand in hand: effective control of GLS using products permitted in organic farming also appears to be effective against ABR. Citrus oil (PREV-AM PLUS) showed significantly better efficacy against ABR than against GLS, achieving a similar level of control as copper and acidic clay treatments.

Table 2: Effect of organic treatments on GLS, ABR incidence (fruit with ABR), fruit health, leaf health index, fruit colour, and pre-harvest drop in a Cripps Pink orchard.

	GLS spots per fruit		ABR incidence (%)		Healthy fruits (%)	
	Mean	Group	Mean	Group	Mean	Group
Untreated	4,8	d	2,3	b	9,7	a
Lime Sulphur	2,2	bc	1,1	ab	27,4	ab
Acetic clay+Sulphur	0,4	a	0,3	a	74,5	d
Potassium bicarbonate	1,1	bc	0,6	ab	53,9	c
Copper (300g/ha)	0,3	ab	0,1	ab	83,2	d
Sulphur	2,8	a	1,3	a	26,5	ab
Acetic clay	0,5	a	0,3	a	73,1	d
Epsom salt+Mn+Zn	3,5	cd	1,6	ab	23	ab
Citrus oil	2,4	bc	0,4	a	31,3	b

	Leaf health Index		Red fruit colour (%)		Fruit drop (per tree)	
Untreated	2,7	c	91,3	b	2,5	a
Lime Sulphur	1,5	abc	84,5	ab	1,7	a
Acetic clay+Sulphur	0,2	a	78,1	a	1,1	a
Potassium bicarbonate	1,3	abc	89,5	ab	0,9	a
Copper (300g/ha)	0,3	a	88,6	ab	7,5	b
Sulphur	2,1	c	87,4	ab	1,5	a
Acetic clay	0,5	abc	79,3	ab	1	a
Epsom salt+Mn+Zn	2	c	83,5	ab	1,4	a
Citrus oil	1,8	ab	89,6	b	1,3	a

A noticeable and atypical pre-harvest fruit drop was observed in the copper treatment. On average, 7.5 fruits per tree were found on the ground in this treatment, compared to about 2.5 fruits in the control. All other treatments had a fruit drop of 1 to 1.5 fruits per tree.

Fruit colouring was high despite the single complete harvest (which is not typical in practice). Acidic clay showed about 12–13% less fruit colouring compared to the control, while lime sulphur solution was 7% lower and Epsom salt (EPSO Combitop) about 8% lower.

Summary

These are only one-year trials, which must be continued in the coming years.

- Copper and acidic clay were the most effective treatments against GLS and ABR in this trial and should be considered key components of future control strategies. Unfortunately, these products are difficult to alternate, as they can cause severe leaf damage.
- Formulated potassium bicarbonate showed good but significantly weaker efficacy.
- Orange oil also demonstrated interesting effects, particularly against ABR.
- Sulphur lime solution showed only slightly better efficacy than the sulphur treatment. Its weak effect against GLS and ABR may be due to calendar-based rather than targeted application.
- Adding wettable sulphur to acidic clay slightly improved leaf health, while no difference was observed on fruits. The positive effect of low sulphur doses on leaf health in Cripps Pink has already been demonstrated in other trials (Prechsl U. et al., 2022).
- Acidic clay, as well as Epsom salt and lime sulphur solution, reduced fruit colouring.
- Repeated copper applications triggered pre-harvest fruit drop. This effect has not been observed before and will require further detailed monitoring in future trials.

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