Efficacy of organic and biological fungicides for control of hop downy mildew

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Introduction

Hop downy mildew, caused by *Pseudoperonospora humuli*, is one of the most devastating diseases of hops and can cause 100% crop loss if cones become severely infected or if the plant dies from infected crowns. The pathogen can overwinter in dormant hop buds or crowns causing a persistent systemic infection. Organic growers have difficulty achieving season long control due to the small number of effective registered products. The objective of this study was to evaluate the efficacy of organic and biological fungicides for control of hop downy mildew and identify products with potential for registration.

Figure 1. a) Downy mildew basal spike and foliar lesions on upper leaf surface, b) lesions on underside of leaf showing sporulation, c) downy mildew symptoms on harvested cones.

Materials and Methods

The study took place in 2019 at the Simcoe Research Station in a one year old planting of hops cv. 'Chinook'. Treatments (Table 1) were arranged in a randomized complete block design with four replications and were applied using a SOLO 451 backpack mist blower. SERENADE OPTI and TORRENT 400SC were included as organic and conventional standards for comparison. Plots were assessed throughout the growing season by recording incidence and severity of downy mildew (DM) on shoots, leaves and cones (Fig. 1). Severity of DM on the leaves and cones was rated based on the area with DM symptoms. Disease severity ratings were used to calculate the Disease Severity Index and Area Under the Disease Progress Curve. Total cone weight was recorded at harvest.

Table 1. Fungicide treatments, active ingredients and application dates.

Treatment	Active Ingredient	Rate	Application dates
Untreated check	-	-	-
ACTINOVATE[1]	*Streptomyces lydicus*	840 g/ha	24, 31 May, 7, 19, 28 June, 10, 24 July, 2, 12, 23 Aug
ORGANOCIDE	sesame oil, fish oil	24 ml/L	24 May, 19 June, 3, 12, 23 Aug
TIMOREX GOLD	tea tree oil	15 L/ha	24, 31 May, 7, 19, 28 June, 10, 24 July, 2, 12, 23 Aug
BURAN	garlic powder	18 L/ha	24, 31 May, 7, 19, 28 June, 10, 24 July, 2, 12, 23 Aug
TIVANO[1]	Citric acid, lactic acid	12 L/ha	24, 31 May, 7, 19, 28 June, 10, 24 July, 2, 12, 23 Aug
CUEVA	Copper octanoate	8 L/ha	24, 31 May, 7, 19, 28 June, 10, 24 July, 2, 12, 23 Aug
TIVANO/CUEVA rotation	Citric acid, lactic acid Copper octanoate	12 L/ha 8 L/ha	24 May, 7, 28 June, 24 July, 12 Aug 31 May, 19 June, 10 July, 2, 23 Aug
OXIDATE 2.0	Hydrogen peroxide, peroxyacetic acid	1% v/v	24, 31 May, 7, 19, 28 June, 10, 24 July, 2, 12, 23 Aug
SERENADE OPTI	Bacillus subtilis	3.3 kg/ha	24, 31 May, 7, 19, 28 June, 10, 24 July, 2, 12, 23 Aug
TORRENT 400SC[1]	Cyazofamid	0.2 L/ha	24 May, 7, 28 June, 24 Jul, 12, 23 Aug

[1] The non-ionic surfactant, AGRAL 90, was added to the spray solution at a rate of 0.1% v/v.

Results and Discussion

- Incidence of basal and aerial spikes, indicative of systemic downy mildew (DM) infection, was variable among plots, ranging from 0-40% and 0-30%, respectively.
- Differences in the intensity/progress of DM symptoms on leaves over time (AUDPC), were observed although none of the fungicides were significantly different from the untreated check (Fig. 2). Among the organic fungicides, the TIVANO/CUEVA rotation, and TIVANO or CUEVA applied alone resulted in the numerically lowest AUDPC and were similar to the conventional fungicide TORRENT 400SC.
- Among the organic fungicides, CUEVA and the TIVANO/CUEVA rotation had the numerically lowest percent of leaves with DM symptoms at harvest and were similar to TORRENT 400SC but were not significantly different from the untreated check (Fig. 3)

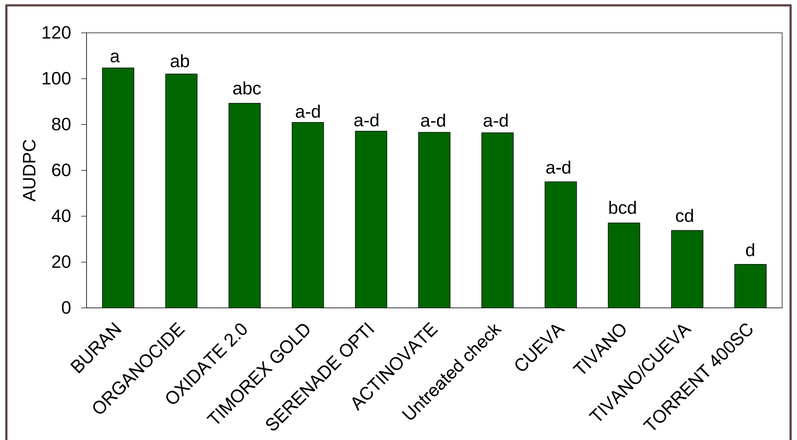

Figure 2. Intensity/progress of DM lesions on leaves over time (AUDPC), of 'Chinook' hops sprayed with various fungicides. Treatments with the same letter above the column are not significantly different at *P*=0.05 using Tukey's HSD test.

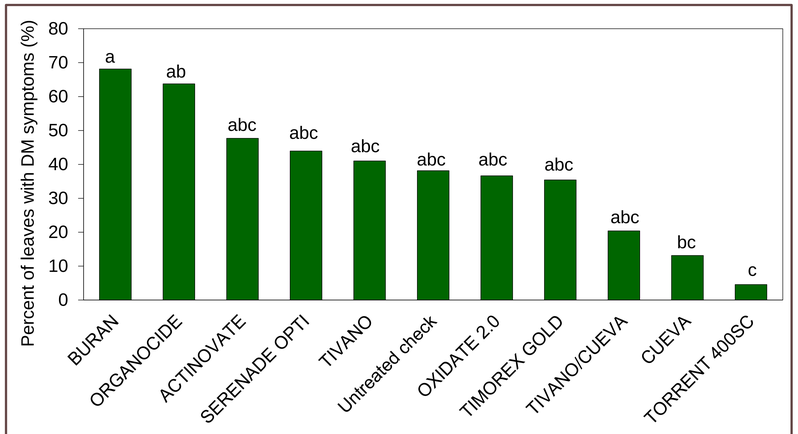

Figure 3. Percent of leaves with DM symptoms at harvest of 'Chinook' hops sprayed with various fungicides. Treatments with the same letter above the column are not significantly different at *P*=0.05 using Tukey's HSD test.

- Total cone yield ranged from 5.6-8.6 kg/plant but was unaffected by the fungicide treatments.
- Cone disease/browning was widespread at harvest, affecting 87-100% of the cones.
- Severity of cone disease (DSI) was significantly lower in plots sprayed with TORRENT 400SC compared to the untreated check (Fig. 4). None of the organic fungicides reduced cone disease compared to the untreated check.
- *Pseudoperonospora humuli* was isolated from 100% of the cone samples and *Alternaria* sp. was found in 45% of samples.

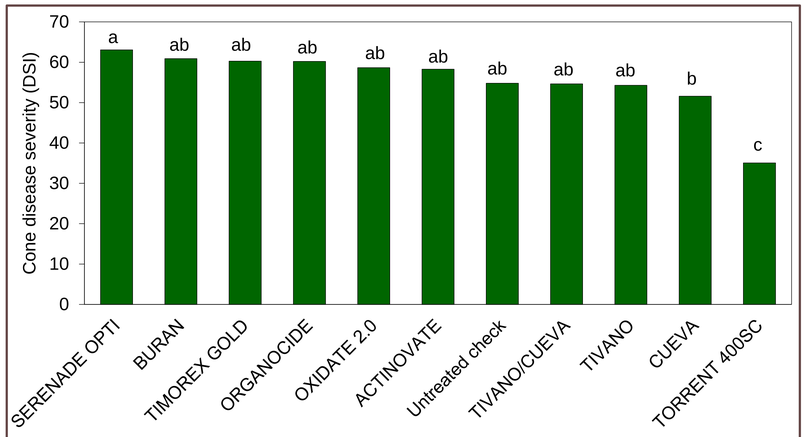

Figure 4. Severity of cone disease/browning (DSI) at harvest of 'Chinook' hops sprayed with various fungicides. Treatments with the same letter above the column are not significantly different at *P*=0.05 using Tukey's HSD test.

Conclusions

- **Disease pressure was high but variable among the plots making it difficult to discern differences in disease levels among treatments.**
- **None of the organic fungicides significantly reduced downy mildew compared to the untreated check, however there was a trend of lower levels of disease with CUEVA or TIVANO.**
- **A rotation of TIVANO and CUEVA resulted in similar levels of disease compared to CUEVA or TIVANO applied alone.**

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