

Evaluation of Fungicides for Control of *Phytophthora ramorum*¹

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Abstract

As part of the project European *Phytophthora ramorum* Pest Risk Analysis (RAPRA) a wide range of fungicides was tested for *in vitro* activity against mycelial growth and zoospore germination of *P. ramorum*. A preliminary set of experiments was performed to study the effect of nine common fungicides specific for *Phytophthora* spp. Dimethomorph, copper-octanoate, and the combination of mancozeb and fenamidone inhibited mycelium growth and zoospore germination of *P. ramorum* isolates *in vitro*. Mancozeb alone did not inhibit mycelial growth effectively. Propineb, azoxystrobin, propamacarb, and cyazofamid did not effect mycelial growth and zoospore germination. Five resistant isolates towards metalaxyl-M in the European population were detected. Further testing *in planta* is required before the actual efficacy of each treatment can be evaluated.

Key words: *Phytophthora ramorum*, fungicides, mycelial growth, zoospore germination, *in vitro* tests.

Materials and Methods

Fifteen isolates of *P. ramorum* from different host plants were examined, 12 originated from Europe (11 isolates mating type A1 and one isolate A2) and three isolates were obtained from the USA (all mating type A2). The strains were isolated from nursery plants and from plants of natural habitats, e.g. public gardens or forests. Nine fungicides with different mode of action and active ingredients were tested (see table 1). Each fungicide was tested with seven different concentrations of the active ingredient (a.i.), ranging from 0.001 to 1.000 µg a.i./mL by the agar plate method (15 mL / Petrie dish) for mycelium growth and by the use of a spectrophotometric test (200 µL / microtiter plate) for zoospore germination. The classification of effective and not effective fungicide follows after calculation of the hypothetical concentration of the registered minimal effective dose according to the manufacturer.

Results and Discussion

Dimethomorph, copper-octanoate, and the combination of mancozeb and fenamidone were the most effective chemical compounds against *P. ramorum* with a complete

¹A version of this paper was presented at the Sudden Oak Death Third Science Symposium, March 5–9, 2007, Santa Rosa, California.

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inhibition mycelium growth and zoospore germination at fungicide levels of 0.1 to 10 µg a.i. /ml (Table 1). In contrast azoxystrobin, cyazofamid and propamocarb showed very less effectiveness on mycelium growth and on the germination of the zoospores. Even concentrations of 100 µg a.i./ml or 1000 µg a.i./ml active ingredient, which is 100 times higher than recommended by the manufactures guides, couldn't reduce completely inhibit the mycelium growth or the zoospore germination (Table 1). For mancozeb less inhibition of mycelium growth was measured at the highest applied concentration. As expected for a contact fungicide there was a strong reduction of the zoospore germination. Similar was the situation for propineb with less inhibition of mycelium growth, whereas only six isolates showed a reduction in zoospore germination.

The investigations with metalaxyl-M showed that for mycelium growth five isolates were sensitive, four isolates were less sensitive and five isolates were resistant to this compound during mycelium growth (all of them were of European origin). For zoospore germination the same five isolates were tolerant and 10 isolates reacted sensitive. All *P. ramorum* isolates which were tolerant towards metalaxyl-M came from European nurseries.

Results from the *in vitro* tests lead to the assumption that several potentially valid options for chemical control of *P. ramorum* could be available. Dimethomorph, copper-octanoate, and the combination of mancozeb and fenamidone appear to be useful active ingredients against *P. ramorum*. The study also showed that in the European population first resistant isolates for metalaxyl-M can be found. Further testing *in planta* is required before the actual efficacy of each treatment can be evaluated.

Table 1—Effect of fungicides on mycelial growth and zoospore germination of *P. ramorum* isolates (µg active ingredient / mL)

Trade name	Active ingredient	Mode of action	Inhibition of mycelium growth (µg / ml)	Inhibition of zoospores germination (µg / ml)
Acrobat®	Dimethomorph	systemic	1.0	0.1 – 1.0
Antracol® WG	Propineb	contact	100 - 1000	1.0 - 100
Cueva®	Copper-octanoate	contact	10.0	10.0
Dithane Ultra® WP	Mancozeb	contact	> 1000	1.0
Fonganil Gold®	Metalaxyl-M	systemic	1.0 - > 1000	0.01 - 1000
Gemini®	Mancozeb + Fenamidone	contact / systemic	1.0	1.0
Ortiva®	Azoxystrobin	systemic	100 - >1000	100 - 1000
Previcur N®	Propamocarb	systemic	> 1000	> 1000
Ranman®	Cyazofamid	contact	1000	100 - 1000