PROHEXADIONE CALCIUM - A TOOL FOR REDUCING SECONDARY FIRE BLIGHT INFECTION

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Abstract

Apple trees are highly susceptible to fire blight when actively growing, but this period of susceptibility can be reduced to 1 to 2 weeks with a single high-rate application of the growth retardant prohexadione calcium (BAS 125W, Apogee). Prohexadione calcium inhibits the biosynthesis of gibberellin. Inhibition of gibberellin biosynthesis results in an early cessation of growth and reduced risk of infection by *Erwinia amylovora*. Trees treated with 250 mg·L^{-1} prohexadione calcium late in the bloom period were found to have a significantly lower incidence of secondary shoot blight than unsprayed trees. Also, infections were suppressed on shoots inoculated 7 days after treatment with 250 mg·L^{-1} prohexadione calcium. Two applications of 125 mg·L^{-1} prohexadione calcium were not as effective as one 250 mg·L^{-1} application in suppressing infection or secondary spread. Prohexadione calcium appears to offer a new and novel approach to fire blight control that does not involve the use of antibiotics.

1. Introduction

Spread of *Erwinia amylovora* from infected fruit spurs to vegetative shoots can result in a significant buildup of fire blight during mid-summer. Trees that exhibit vigorous shoot growth are especially vulnerable to infection (Crosse *et al.*, 1972). The succulent leaves and shoot tips are easily damaged during storms. Such hail- or wind-damaged tissues are very susceptible to infection by waterborne inoculum (McManus and Jones, 1994). Leaves and shoots that have ceased growth are more resistant to wounding and therefore less vulnerable to infection.

Prohexadione calcium is a plant growth regulator that is used to control the vegetative growth of apple and pear trees (Evans *et al.*, 1999). It acts by inhibiting synthesis of gibberellin, a natural plant hormone that regulates cell elongation. Inhibition of gibberellin synthesis in turn inhibits further shoot growth.

The objective of this study was to determine whether foliar applied applications of prohexadione calcium were effective for reducing the incidence and severity of fire blight during the summer. Reducing fire blight risk with prohexadione calcium would provide an alternative to streptomycin thereby reducing the selection pressure for streptomycin resistance in orchard bacteria.

2. Materials and methods

The experiment was carried out in a 26-year-old orchard of Jonathan and Golden Delicious apple trees on M106 rootstock. The treatments were replicated six times on two-tree plots (one tree of each variety) arranged in a completely randomized design.

Prohexadione calcium (BAS 125W 10DF) was applied with a handgun at 2,800-3,000 kPa to runoff. The treatments were prohexadione calcium at 250 mg·L^{-1} applied once and prohexadione calcium at 125 mg·L^{-1} applied twice. The first applications were applied on June 9, 1997, at 8.5-12 cm of shoot growth; the second application at 125 mg·L^{-1} was on June 24, 1997.

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All treatments except an non-inoculated control were inoculated with rifampicin-resistant *E. amylovora* strain Ea110 7 days after the 9 June application. Inoculations were done by injecting a drop from a bacterial suspension containing 10^8 colony-forming units (cfu)/ml into shoots at their tip. Four shoots in the top of each tree, one shoot per quadrant, were inoculated. First visual symptoms of fire blight were observed on June 22, 1997.

Sixty leaves from each tree were collected 21 days after inoculation from the canopy immediately below the inoculated shoots. The leaves were washed in water and populations of *E. amylovora* on the leaves determined by auto-plating the wash solution on LB agar amended with rifampicin.

The length of infected tissue and the shoot's total length were recorded for each inoculated shoot. The length of ten healthy shoots per tree was measured on August 26, 1997. Severity of the infection on inoculated shoots was expressed as the percentage of the current season's shoot growth with necrotic (diseased) tissue. Secondary spread was determined by counting the number of non-inoculated shoots showing typical symptoms of fire blight.

2. Results and discussion

2.1. Infection and lesion extension on inoculated shoots

Prohexadione calcium had no effect on the percentage of Jonathan shoots that developed fire blight following inoculation (Table 1). On Golden Delicious trees treated *with 250 mg·L^{-1} prohexadione calcium, fewer inoculated shoots developed fire blight than* on non-treated trees and on trees treated twice with 125 mg·L^{-1} prohexadione calcium (Table 1).

Shoots on Jonathan trees treated with prohexadione calcium at 250 mg·L^{-1} one week before inoculation had less of their current season's growth infected with fire blight than did shoots on non-treated trees. The two-spray treatment at 125 mg·L^{-1} did not reduce the severity of fire blight on inoculated shoots of Jonathan. Inoculated shoots of Golden Delicious treated once with 250 mg·L^{-1} and those treated twice with 125 mg·L^{-1} prohexadione calcium had significantly less shoot growth infected than did the shoots on non-treated trees.

2.2. Secondary spread to shoots

On Jonathan, a 250 mg·L^{-1} and two 125 mg·L^{-1} applications of prohexadione calcium reduced the number of new shoot infections significantly compared with the inoculated control (Table 1). No infection developed on shoots in non-inoculated trees indicating a lack of fire blight spread from inoculated trees.

2.3. Bacterial populations on leaves

Leaves collected from the canopy under inoculated shoots on non-treated Jonathan trees 21 days after inoculation were harboring approximately 10^7 cfu of *E. amylovora* per gram of leaf tissue (Table 1). Bacterial populations on leaves collected from prohexadione calcium-treated Jonathan trees were significantly lower. Bacterial populations on leaves collected 21 days after inoculation from Golden Delicious trees treated with prohexadione calcium at 250 mg·L^{-1} had significantly fewer bacteria than leaves from non-treated trees or from trees sprayed twice with 125 mg·L^{-1}. No rifampicin-resistant *E. amylovora* were detected on leaves from non-inoculated trees.

2.4. Shoot growth

Shoots on prohexadione calcium treated Jonathan trees were significantly shorter than shoots on non-treated trees, while shoots on treated Golden Delicious trees were not shorter then those on non-treated trees (Tables 1). There might have been greater differences in shoot growth between the treatments had shoot measurements been made in the tops of the trees where the shoots were more vigorous. Shoots in the tops of treated trees were rossetted.

Further work is needed to define the time period required for trees to become resistant to fire blight infection following treatment with prohexadione calcium. Understanding how quickly the onset of resistance occurs would help growers assess the potential value of particular treatments for reducing the incidence and severity of secondary fire blight.

References

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Table 1. Effects of prohexadione calcium (BAS 125W) treatments on the growth of apple shoots, fire blight development on inoculated shoots, secondary spread of fire blight and populations of *Erwinia amylovora* strain Ea110 on healthy leaves collected from areas below inoculated shoots.

Treatments	Inoculated shoots: Infected (%)[a]	Inoculated shoots: Current growth infected (%)[b]	Secondary shoots infected (#/tree)	*Erwinia amylovora* Ea110 population (cfu/g leaf)	Shoot growth (cm)
Jonathan					
BAS 125W 250 mg·L^{-1} and strain Ea110	92.0 a	59.0 b	1.3 b	1 x 10^{2} c	20.0 b
BAS 125W125 mg·L^{-1} and strain Ea110	100.0 a	77.1 ab	2.1 b	5.4 x 10^{5} b	23.4 b
Ea110 only	100.0 a	83.3 a	17.6 a	9.8 x 10^{7} a	27.7 a
Non-treated and non-inoculated	----	----	0.0 b	0.0	----
Golden Delicious					
BAS 125W 250 mg·L^{-1} and strain Ea110	54.0 b	7.3 b	0.0 b	2.2 x 10^{1} b	18.7
BAS 125W mg·L^{-1} and strain Ea110	96.0 a	11.2 b	0.2 b	1.8 x 10^{5} a	20.8
Ea110 only	96.0 a	55.4 a	2.1 a	1.0 x 10^{6} a	16.0
Non-treated and non-inoculated	----	---	0.0 b	0.0	--

[a] Percent of four inoculated shoots per tree infected. Shoots were inoculated with rifampicin-resistant *Erwinia amylovora* strain Ea110.

Means within a column followed by the same letter are not significantly different according to LSD (P<0.05).

[b] Percent lesion extension on current season's shoot growth.