Efficacy of Microinjected Apogee and ArborFos against Fire Blight Disease Incidence and Shoot Growth of Apple

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Project summary:

In this investigation, the efficacy of the J. J. Mauget Company's microinjectable Apogee (prohexadione calcium), formulated at 125 ppm and 250 ppm in 6 ml capsules, and ArborFos (45.8% phosphoric acid) in 7.5 ml capsules were evaluated against the shoot blight phase of the fire blight pathogen *Erwinia amylovora.* Inoculated field trials were performed on Paulared apple in Shelburne, Massachusetts. Actively growing apple shoots were inoculated in early June, 2008 with cultures of fire blight bacteria. Shoot growth evaluation, efficacy and phytotoxicity data were taken. ArborFos was the most effective fire blight treatment, reducing fire blight incidence and severity by 67% compared to the untreated control. Apogee treatments had only a slight inhibitory effect on disease occurrence, showing a numerical reduction in disease incidence when compared to the untreated control but not a statistical reduction. None of the treatments appeared to have any effect on shoot growth. No phytotoxicity was observed in any of the treatments.

Objectives:

The objectives of this study were:

1. To evaluate 2 formulations of microinjected Apogee at two different application rates and one rate of ArborFos against the shoot blight phase of fire blight of pome fruits caused by *Erwinia amylovora* and to document any phytotoxicity resulting from the injections.
2. To evaluate the effects of microinjected Apogee as a growth regulator on shoot growth and expansion in apple.

Materials and Methods:

MIcroinjectable formulations of J. J. Mauget Co.'s Apogee and ArborFos were applied to Paulared (a highly fire blight- susceptible cultivar) apple trees on m7 rootstock in a randomized-plot design on May 30, 2008. (Table 1) There were four single-tree plots per treatment. Weather conditions were excellent for uptake with air temperatures in the high 70s, soil temperature of 65 ^{o}F, and soil moisture at field capacity. Capsules were applied at the rate of 1 capsule/ 6 inches of tree circumference (or dbh/2) or in dosage as described in Table 1. All capsules were empty within one hour and removed 24 hours later. Foliar expansion in the tree canopy was complete at this time; the only rapidly expanding foliar tissue at injection time was at the tip of growing shoots.

Table 1. Dosages and treatments used in JJ Mauget Apogee/ArborFos fire blight microinjection trial, Shelburne, MA, May 2008.

Treatment	Dosage	Timing
1 Apogee 125 ppm -6 ml	1 capsule per inch dbh[1]	spring 2008
2 Apogee 125 ppm -6ml	1 capsule per inch dbh/2	"
3 Apogee 250 ppm -6ml	1 capsule per inch dbh	"
4 Apogee 250 ppm -6 ml	1 capsule per inch dbh/2	"
5 ArborFos -7.5 ml	1 capsule per inch dbh	"
6 untreated control	-	-

[1]diameter of tree at breast height

Disease incidence/efficacy

On June 5, 2008, 6 days post injection, 10 rapidly-growing terminal shoots per tree, four trees per treatment, were inoculated with *E. amylovora*. Inoculations were made by cutting the top three terminal leaves of each shoot three times with sterile scissors dipped in liquid cultures of *E. amylovora* containing 1 X 10^8 colony forming units per ml. Observations of inoculated shoots were made at weekly intervals until all signs of new disease development/advancement ceased. Disease incidence and development were recorded as per key described in Appendix 1.

Shoot growth effects

On June 5, 2008, an additional five separate shoots per tree were chosen for shoot growth measurement and were measured at approximately two-week intervals. These shoots were not inoculated and were allowed to grow normally.

Phytoxicity

Phytotoxicity evaluations were made 10 days post-injection.

Results and discussion:

Disease incidence/efficacy

Shoot inoculations with *E. amylovora* were successful. Spotting, browning and wilting of inoculated leaf tissues could be observed 15 days post-inoculation, on June 20 (Figure 2) and were monitored for the next 30 days (Figures 3 and 4). Observations made on June 20, presented in Table 2 and Graph 1 indicate some initial suppression of fire blight advancement into leaf tissues adjacent to the inoculation site in all treatments except the untreated control but statistically, only the ArborFos treatments were significantly different. Final observations on July 24 showed disease development had completely ceased, and there was no disease advancement beyond levels measured on July 10. Initially observed separation between treatments continued to be observed but only ArborFos remained significantly effective. ArborFos appears to have had the greatest effect in preventing colonization of shoot tissues, reducing disease incidence by 67%. The other four rates of Apogee, which all appeared to have small degree of numerical disease suppression (Table 2 and Graph 1), all performed very similarly, despite a large difference in the dosage between treatments, and did not separate from the untreated controls.

Phytotoxicity

There was no phytotoxicity observed in any of the treatments, including the tree trunk or canopy, including no phytotoxic effects on the newly-expanding leaves on the shoot tips.

Table 2. Effects of Apogee and ArborFos microinjection treatments on fire blight disease incidence and severity, Paulared apple, Shelburne, MA, 2008.

Treatment	Inoc on 6/05/08	6/20/08	7/10/08	7/24/08
			disease index[1]	
125 ppm Apogee dbh		1.56 ab[2]	2.78 ab	2.78 ab
125 ppm Apogee dbh/2		1.85 ab	3.05 ab	3.05 ab
250 ppm Apogee dbh		2.11 ab	3.56 ab	3.56 ab
250 ppm Apogee dbh/2		2.03 ab	3.73 ab	3.73 ab
ArborFos dbh		1.30 a	2.10 a	2.10 a
untreated control		2.97b	4.94 b	4.94 b

[1] *see appendix I. disease rating key*
[2] *means within columns followed by the same letter are not significantly different (Fisher's Protected LSD, p<0.05)*

Shoot growth effects

Shoot growth observations were recorded pre-injection on 5/23, and then post-injection on 6/6, 6/16 and 7/18. As Table 3 indicates, there were no differences in growth rates of the shoots between any of the treatments and the untreated controls. From our experience with topically applied Apogee at similar rates (125 and 250 ppm) we have seen direct and dramatic inhibitory effects on shoot growth. It is surprising that microinjected 250 ppm Apogee, applied at 1 capsule/inch dbh would have no effects on growth. This seems to indicate that the Apogee is being somehow tied up in the tree post-injection, and was not able to distribute.

Table 3. Effects of Apogee and ArborFos microinjection treatments on shoot growth, in inches, Paulared apple, Shelburne, MA 2008.

Treatment	5/23/08	6/6/08	6/18/08	7/18/08
	(pre-injection)			
125 ppm Apogee dbh	3.76 a	9.43 a	13.50 a	15.90 a
125 ppm Apogee dbh/2	4.21a	9.55 a	12.35 a	11.70 a
250 ppm Apogee dbh	3.91a	9.46 a	12.37 a	12.50 a
250 ppm Apogee dbh/2	3.56 a	8.59 a	11.14 a	13.00 a
Arborfos dbh	3.70 a	8.60 a	12.42 a	14.20 a
untreated control	3.80 a	9.50 a	12.34 a	12.50 a

Graph 1. JJ Mauget Apogee/Arborfos Field Trial - Fire Blight Disease Severity Rating

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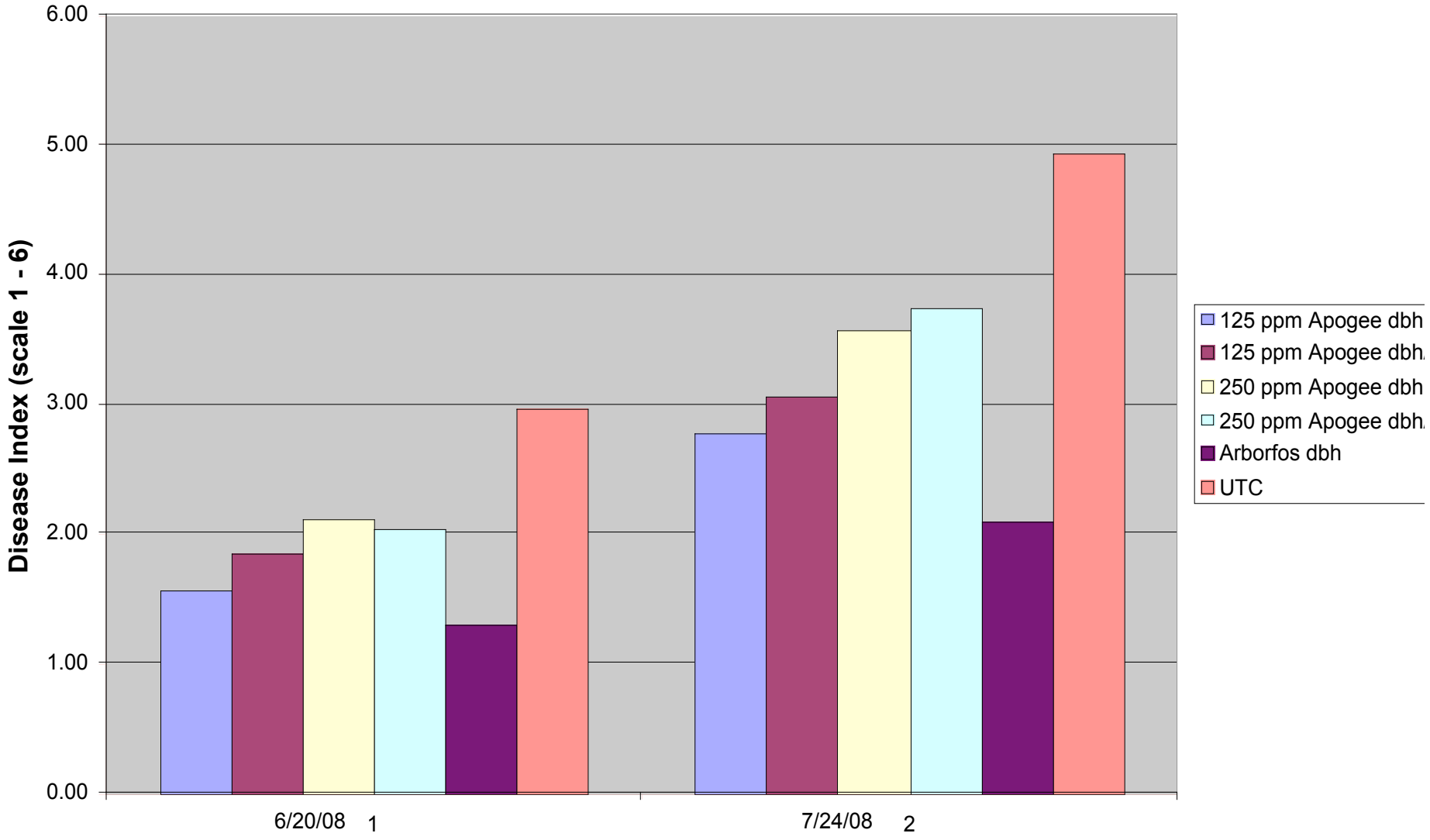

Figure 1. Healthy shoot with not bacterial colonization of leaves, Apogee 125 ppm, dbh/2.

Figure 2. Bacterial colonization and movement from inoculation site into leaf tissue, Apogee 125 ppm, dbh/2. Note browning of cuts and cholorotic mottling.

Figure 3. Early wilting and flagging of shoot terminal indicating movement of bacteria from injection site into tree vascular system (Apogee 250 ppm dbh/2).

Figure 4. Advanced fire blight infection, untreated control.

Conclusions:

- ArborFos significantly reduced fire blight shoot infections 67% in apple when injected into apple trees approximately one week before inoculation of shoots with 10^8 colony forming units of *E. amylovora*.

- Four different concentrations of Apogee appeared to numerically reduce fire-blight incidence when compared to the untreated control, but did not provide statistically significant disease inhibition.

- ArborFos and four different concentrations of Apogee (Table 1) had no measurable effect on apple terminal shoot growth. These data would lead to questions whether the microinjected Apogee was moving successfully through tree tissues, as topically applied Apogee is highly effective in suppressing apple tree growth. The highest Apogee treatment level in this trial should have had some measurable growth-suppressive effect.

Appendix 1.

Disease incidence key for rating degree of fire blight infection

Hickey's[1] Disease Rating System

1. small necrotic lesions around inoculation site
2. movement of infection into shoot
3. lightly infected (2-3 dead leaves)
4. moderately infected (3-5 dead leaves)
5. severely infected (more than 5 dead leaves)
6. second year wood infected

[1] K.D. Hickey et al, 1998. Evaluation of fire blight management tactic in apple orchards. Penn State Univ. Fruit Extension Bulletin, Biglerville, PA