



Trunk applications of phosphite for the control of foliar and fruit scab on pecan



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ABSTRACT

Pecan scab (*Fusicladium effusum*) is the major disease of pecan in the southeastern United States. Apart from issues of fungicide resistance and the need to test efficacy of novel fungicides such as phosphites, management of the disease in tall trees is challenging due to the technical difficulties of getting sufficient spray coverage to the upper parts of the canopy. The use of trunk application of phosphite, which is systemically transported within the tree, was investigated in six separate experiments in 2010 and 2011. Spray application of phosphite to the trunks of young 3 to 4 year-old trees provided excellent control of scab on foliage of cultivar Desirable, but slightly less control on the susceptible cultivar Wichita, but neither incidence nor severity of scab was reduced on 11 to 12 year-old trees of cultivar Desirable by trunk-spray application in 2010, although slightly less severe disease was observed in 2011. In two factorial cultivar × fungicide treatment experiments in 2010 and 2011 using 13 to 14 year-old trees there was little effect of trunk applications on scab incidence or severity on foliage or fruit. However foliar application of phosphite and a conventional fungicide both significantly reduced the incidence and severity of scab on most cultivars on both foliage and fruit, confirming previous observations of the efficacy of these foliar sprays. Different methods of trunk application, for example injections of phosphite, might prove more efficacious than surface application in older trees.

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1. Introduction

The most widespread and serious disease of pecan (*Carya illinoensis* Wanzh.) in the southeastern United States is pecan scab, caused by the plant pathogenic fungus *Fusicladium effusum* (Seyran et al., 2010; Goff et al., 1996). The pathogen infects susceptible cultivars of pecan, with resulting disease causing serious yield and economic loss in epidemic years (Gottwald and Bertrand, 1983, 1988; Sanderlin, 1995; Stevenson and Bertrand, 2001). The disease is particularly severe in years with above average rainfall (Sparks et al., 2009). The disease is polycyclic and the pathogen produces conidia from early in the spring through to harvest, during which time the spores are dispersed in wind and rain splash, requiring a period of leaf wetness to subsequently infect leaves and fruit (Gottwald, 1985; Turechek and Stevenson, 1998).

Much of the acreage in the southeastern U.S. is planted to scab-susceptible cultivars (e.g., Desirable), and growers must apply a fungicide several times during the growing season to maximize

quality. During the last eighty years several different fungicides have been applied to manage pecan scab (Demaree, 1925; Cole and Large, 1939; Brenneman et al., 1999; Seyran et al., 2010). However, resistance to certain fungicides has now occurred in populations of *F. effusum* (Isakeit, 2010: <http://ipm.tamu.edu/pecans/diseases.html>; Littrell and Bertrand, 1981; Stevenson, 1998; Brenneman et al., 1999; Stevenson et al., 2004; Seyran et al., 2010). Furthermore increasingly stringent regulation on use of fungicides will likely continue to limit their availability and use, and more intense use of a limited number of fungicides will increase the chances of resistance becoming more widespread. By using combinations of fungicides during the season, the risk of resistance developing should be reduced, and testing new fungicides that might combine efficacy with reduced environmental impact will further diversify the available fungicides and minimize the risk of fungicide resistance becoming a major issue in management of pecan scab.

Phosphite is one such fungicide that has been found efficacious as a foliar spray on pecan and other tree crops to control not only oomycete pathogens, but also fungal pathogens of various genera (Agostini et al., 2003; Rebollar-Alviter et al., 2005; Percival and Haynes, 2008; Percival et al., 2009; Rosenberger and Cox, 2009; Percival and Noviss, 2010; Bock et al., 2012). Phosphite (or

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phosphorous acid [$\text{HPO}(\text{OH}_2)$], on which the salts are based) is a simple compound and has low environmental toxicity. The mode of action of phosphite is not fully understood, although it may operate at two different levels. First, it appears there may be a direct mode of action (Fenn and Coffey, 1984; Wilkinson et al., 2001; Bock et al., 2012). Second, it appears to have an indirect effect by stimulating plant host defense responses, which can include the accumulation of various antimicrobials such as phytoalexins, cell wall changes including lignification, and the formation of various pathogenesis-related products that contribute to minimizing or preventing infection (Guest and Grant, 1991; Kessmann et al., 1994; Sticher et al., 1997; Becot et al., 2000; Jackson et al., 2000; Percival, 2001; Gozzo, 2003; Percival et al., 2009; Miller et al., 2006; Olivieri et al., 2012).

Foliar applications of phosphite reduced foliar scab on pecan and young fruit early in the season, although there was some evidence of phytotoxicity (Bock et al., 2012), and on mature fruit phosphite was less efficacious compared to conventional fungicides. Furthermore, foliar applications of phosphite require large expensive spraying rigs, which is less affordable for small-scale growers or homeowners who have perhaps only a few trees in a backyard. Applications of phosphite to trunks of several tree crops including apple, avocado, oak and eucalyptus have been shown to reduce disease comparable to a conventional fungicide (Dunstan et al., 2006; Darvas and Bezuidenhout, 1987; Schutte et al., 1988; Garbelotto et al., 2007; Cox et al., 2008; Gentile et al., 2009). The possibility that trunk applications of phosphite on pecan trees might be an alternative management approach for control of scab has not been explored.

The objective of this study was to assess whether trunk (bark) applications of phosphite reduce the incidence and severity of pecan scab on foliage and fruit of pecan, and to establish the risk of any phytotoxic effects on the tree.

2. Materials and methods

2.1. Ty Ty, Georgia

2.1.1. Location and experiment design

Two experiments were situated at the University of Georgia's Ponder Research Farm in Ty Ty, Georgia in 2010 and 2011. The site has soils with a pH of approximately 6, has a Tifton loamy sand type soil, and was located at $31^{\circ}30'38.78''\text{N}$, $83^{\circ}38'28.73''\text{W}$, at an elevation of 112 m, with an average annual rainfall of 100 cm. The first experiment (done only in 2010) was on 3 to 4-year-old trees of cultivars Desirable and Wichita, and the second experiment (done in 2010 and 2011) was on 11–12-year-old Desirable trees. Cultivar Wichita is extremely susceptible to scab, while cultivar Desirable is moderately susceptible. Trees were planted in a 12.2×12.2 m spacing. The younger trees were sprinkler irrigated and the older trees were drip-irrigated, with water applied as needed each season. No fungicide cover sprays were applied to the trees, but they were managed for insects and weeds according to standard production practices (Brock and Brenneman, 2011).

In all three experiments, treatments were arranged in a randomized complete block design with six replicates. The treatments consisted of i) a non-treated control, and ii) a trunk spray of Agri-fos (50% v/v in water, potassium phosphite, 45.8% a.i., Agrichem, Queensland, Australia) + Pentrabark (Quest, Linwood, KS, at 0.02 L per 1.0 L water) as a surfactant. The trunk spray was applied using a Hudson type pump sprayer (Sears, USA) by directly spraying the tree trunk to run-off from the ground to the lower branches (approximately 1.2 m). The trunks received a calendar-based spray program of three sprays, all applied as described above, on 13 April, 27 April, and 11 May in both years.

2.2. Disease and phytotoxicity assessment

Disease was assessed on leaves in the two experiments in 2010 on 26 July (younger trees) and 22 July (older trees), respectively. In the experiment on 3–4 year-old trees, six terminals were arbitrarily selected from each of three canopy levels (bottom, middle and top third) of each tree, and the middle leaf of the terminal assessed for disease. Leaf scab incidence was recorded as the number of leaflets per leaf with one or more scab lesions divided by the total number of leaflets per leaf, multiplied by 100%. Leaf scab severity was determined by visually estimating the percentage of leaf area covered by scab lesions. In the trial on 11–12-year-old trees, six terminals were sampled per tree without regard to canopy level, and the middle leaf assessed for disease incidence and severity. If fruit were present, scab incidence and severity were both evaluated on 30 August 2010 and 16 August 2011 on all fruit from six fruiting terminals per tree. If leaf injury was observed, it was evaluated at each of three canopy levels (bottom, middle, and top third of each tree) by a visual assessment of the percent of foliage exhibiting brown, necrotic lesions (as described above for the foliar scab severity).

2.3. Byron, Georgia

2.3.1. Location and experiment design

A single experiment was located at the ARS-USDA research farm in Byron, Georgia in 2010, and repeated in 2011. The site was located at $32^{\circ}39'54''\text{N}$, $83^{\circ}44'31''\text{W}$, with an elevation of ≈ 156 m and ≈ 240 d freeze-free growing period and an annual precipitation of ≈ 118 cm. The site has Faceville sandy loam soils [FoA; fine, Kaolintic, thermic Typic Kandiodult soil]. In both years the orchard consisted of a mixed planting of four cultivars (Wichita, Desirable, Apache and Cheyenne) planted as bare-root transplants in 1998 at 4.05×9.1 m spacing, and thinned in 2006 to 9.1×9.1 m spacing, with rows running north-south. Cultivar Wichita is extremely susceptible to scab, cvs. Apache and Cheyenne are slightly less susceptible, and cv. Desirable is moderately susceptible. After thinning, the orchard configuration consisted of single consecutive series of two to three trees of each of the four cultivars assigned randomly in each of eight blocks also assigned randomly in the orchard. Trees had a girth of approximately 55–60 cm and were approximately 6–10 m tall, and were reproductively mature. The orchard received standard farm practice fertilizer and weed control (Hudson et al., 2011), and sub-surface drip irrigation as required, but received no insecticide applications. Fungicide application was based on calendar date as is common practice for managing scab-susceptible pecan (Gottwald and Bertrand, 1988; Brenneman et al., 1999). Treatment applications commenced in mid-April and were applied on eight occasions in 2010 and on seven occasions in 2011 at approximately two week intervals until mid-August (Brock and Brenneman, 2011). Weather conditions affected exact timing and frequency of applications in both seasons. In 2010 the following treatments were applied: i) non-treated control, ii) Agri-fos applied to foliage using a handgun sprayer (potassium phosphite, 45.8% a.i., 5.00 L Agri-fos 1000 L^{-1} ha^{-1} , Agrichem, Queensland, Australia), iii) Super Tin 4 L (Triphenyltin hydroxide [TPTH], 40.0% active ingredient, at the standard rate of 0.90 L 1000 L^{-1} ha^{-1} , United Phosphorous, Inc., King of Prussia, PA) applied to the foliage using a handgun sprayer, iv) Agri-fos (1.90 L Agri-fos, 2.36 L water, and 0.06 L Pentrabark) applied to a 30-cm section of the trunk using a brush, and v) Agri-fos applied to the bark as described for the previous treatment, but the 30-cm section of bark was scarified using a wood plane to provide more ready access for the phosphite (this treatment was included

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