

## ***FINAL REPORT***

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### **Quadris Not Effective in Controlling Rhabdocline Needlecast on Douglas-fir Christmas Trees**

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#### **Introduction**

Douglas-fir (*Pseudotsuga menziesii*) is one of the most popular conifers grown for cut Christmas trees in Pennsylvania due to its fast growth rate, attractive foliage, good form and excellent postharvest characteristics (8, 10, 18). Use of Douglas-fir in commercial and residential landscape plantings is also increasing because of its wide availability and adaptability to a variety of sites (5).

Intermountain forms of Douglas-fir (*P. menziesii* subsp. *glauca*) comprise the majority of trees grown in the northeastern and mid-Atlantic United States. Trees derived from these Rocky Mountain seed sources tend to have better cold hardiness and postharvest needle retention traits than coastal forms (*P. menziesii* subsp. *menziesii*) grown in the Pacific Northwest (10). However, research has shown that intermountain provenances are also very susceptible to Rhabdocline needlecast disease (*Rhabdocline pseudotsugae*) (3, 14, 16). *Rhabdocline* is the major pathogen limiting production of Douglas-fir in Pennsylvania (14, 16).

In late winter or early spring, the previous year's *Rhabdocline*-infected needles develop spots that are at first yellow and then characteristic brown to brick red (Fig. 1). A common diagnostic feature is a distinct border between healthy and infected areas of a needle. As the current year shoots are elongating, fruiting bodies erupt through the epidermis of infected year-old needles, exposing the orange-bronze apothecia (Fig. 2). Spores are expelled from the fruiting bodies and wind disseminated to infect the current year's developing needles. Infected older needles are cast during summer, leaving severely infected trees with only one year's complement of needles (Fig. 3). Repeated severe *Rhabdocline* infection may weaken and kill young trees and even a single infection may render larger trees unmarketable (2, 15).

Strategies recommended to reduce infection include the use of resistant seed sources and disease-free planting stock, removal of reservoirs of inoculum, and cultural practices to promote rapid drying of foliage (13, 16). These practices alone however will not control *Rhabdocline* on susceptible trees grown from intermountain seed sources under favorable infection conditions, requiring growers to resort to multiple fungicide applications.

There are relatively few fungicides labeled for needlecast control on conifers and they are all solely preventative (19). This is a serious limitation, as *Rhabdocline* needlecast infects during the period of tissue elongation in the spring. At this time, protectant fungicides must be applied on a weekly or biweekly basis to maintain coverage

on the rapidly expanding tissue, even under the best weather conditions. If long periods of rainfall occur during this critical time of tissue elongation, it becomes extremely difficult to prevent infection. Management of *Rhabdocline* with three or four applications of Bravo (chlorothalonil) has traditionally been effective albeit expensive. Other fungicides have been tested but were found to be ineffective in preventing infection (19, 22). Pressure is also mounting to use lower-risk, environmentally compatible fungicides to control common diseases in commercial production settings as well as in landscapes.

Azoxystrobin, which is marketed under the trade name Quadris (Syngenta, Greensboro, NC), is the first of a new class of reduced-risk fungicides with a very favorable toxicological and environmental profile to be registered for needlecast control on conifers. Azoxystrobins control plant pathogens from all four major fungal groups and exhibit systemic properties on some crops. Effective disease control has been reported for tree fruit (11), herbaceous perennials and bulbs (6), vegetables (1), turfgrass (12) small grain (9), and small fruit (21). There are, however, no reports on the use of Quadris to control *Rhabdocline* needlecast on Douglas-fir.

The objective of this study was to assess the impact of Quadris fungicide application rate and treatment interval on the effectiveness of *Rhabdocline* needlecast control on Douglas-fir.

## Experimental Methods

During springs of 2002 and 2003, two replicated field trials were conducted in commercial Douglas-fir Christmas tree farms in Schuylkill and Clinton Counties, PA. At the Schuylkill site, all work was conducted in a planting of approximately 12 acres of sheared trees, near Schuylkill Haven, PA. Trees were 4-6 ft. tall and planted on 6 ft. centers. At the Clinton site, the planting consisted of approximately 15 acres of sheared 7-9 ft. trees planted on 7 ft. centers, near Beech Creek, PA. All trees at both sites were derived from the Lincoln National Forest seed source. During spring 2001, needlecast caused by *Rhabdocline pseudotsugae* subsp. *pseudotsugae* was found generally distributed throughout both farms. Interviews with the farm managers indicated that the sites suffered severe infection levels during the previous two seasons. In order to minimize variation, treatment trees were selected based on presence of uniform, heavy natural infection and well-formed buds.

Treatments were applied to single trees in each block. Experiments consisted of 7 treatments, 6 fungicide and a non-sprayed control in 2002 and 5 treatments, 4 fungicide and a non-sprayed control in 2003 (Table 1). All fungicides were applied to the point of runoff as a directed spray with a 4.7 h.p. Solo Port (Model 450) backpack mistblower at approximately 1100m<sup>3</sup>h. In all experiments, Bravo Weather Stik (chlorothalonil; Syngenta, Greensboro, NC) was applied four times at 1.7 kg ai/ha between April 30 and June 7, and represented the standard control program used by most commercial Douglas-fir Christmas tree growers in Pennsylvania. The initial fungicide applications in all experiments coincided with the initiation of budbreak. In 2002, treatments 1-5 were designed to evaluate the effectiveness of Quadris as a part of a Bravo-based control program. Treatments 1, 2 and 3 replaced the first Bravo application of the standard program with 0.15 or 0.3 kg ai/ha Quadris and incorporated a 2 or 3 week interval prior to the second Bravo application (Table 1). Treatments 4 and 5 were identical to the standard Bravo treatment, except the second Bravo application on 8 May, 2002 was

replaced with 0.15 and 0.3 kg ai/ha azoxystrobin. In 2003, azoxystrobin was used alone and applied at 0.3 (maximum labeled rate), 0.6 and 1.2 kg ai/ha on 30 April, 7 May, 19 May and 3 June to evaluate the impact of high azoxystrobin rates on *Rhabdocline* control. A non-ionic surfactant was used with all azoxystrobin spray applications at a rate of 0.5 ml/liter. At least three rows of buffer trees separated all treatment trees to avoid overlapping treatments or “blow-through” of the fungicides. Trees selected for fungicide treatment and control trees in 2002, were not used in the 2003 experiments. Temperature, relative humidity and rainfall were recorded at each site throughout each growing season. Relative humidity and temperature varied during the study at the time of fungicide treatment, but applications were made only on rainless days and under conditions of low wind. After every application, the fungicide sprays were observed to dry on the tree foliage.

Evaluation of infection levels were performed in early March each year of the study. The effect of fungicide treatments on disease development was assessed using a five-class disease severity rating system (17), where 1=no obvious infection of the foliage, 2=light-moderate infection of foliage in the bottom ¼ of crown and no infection in the higher portions of the crown, 3=moderate-severe infection of the bottom ¼ and light-moderate infection of the second ¼ of the crown; no infection in higher portions of the crown, 4=severe infection bottom half and light-moderate infection of the third ¼ of the crown, and 5=severe infection of the bottom ¾ of the crown. A disease incidence rating was determined by randomly collecting a 3-4 inch stem section from the N, S, E, and W quadrant of each tree, approximately 3 ft above ground level, and randomly selecting 10 needles from each stem section. Needles with 1 or more lesions were counted, and ratings from the four quadrants averaged. The disease severity rating was multiplied by the mean disease incidence rating to derive an overall disease index. Thus the disease indices could range from 0 to 50. Trees scoring a disease index rating above 10 were deemed commercially unacceptable. Needle color on treated trees was evaluated 2 weeks after the final fungicide application and rated on a 1 to 5 scale where 1 = healthy dark green needles, 2 = healthy green or light green needles, 3 = dull green needles with light to moderate chlorosis, 4 = moderate to extensive yellowing or browning, and 5 = yellow needles displaying necrotic tips or spots. Significance of treatment effects was tested by analysis of variance, and treatment means were compared with Fishers protected least significant difference (LSD; P=0.05).

## Results

Abundant moisture and cool temperatures between 50-59° F are optimum conditions for *Rhabdocline pseudotsugae* infection (20). In May 2002 and 2003, unseasonably cool and moist weather conditions produced numerous likely infection periods at each test site. Based on collected weather data, conditions conducive for infection occurred on 10 May, 13-14 May, and 19 May, in 2002, and 5 May, 8 May, 17 May and 22-23 May, in 2003. Untreated control trees at the Clinton site had disease index ratings of 44.9 in 2002 and 36.3 in 2003, while the Schuylkill site control tree disease index rating was 38.6 and 26.1 in 2002 and 2003, respectively. Based on disease index ratings, infection conditions were favorable during the test periods, however disease pressure appeared higher in 2002 compared to 2003 (Fig. 4 and 5).

In both years four applications of Bravo at 1.7 kg ai/ha between 30 April and 7 June was highly effective against *Rhabdocline* at both sites and resulted in disease indices of less than 4 (Fig. 4 and 5). While light infection on the lower quarter of the crown of some trees was observed, all trees receiving the standard Bravo treatment remained marketable.

In 2002, application interval had a significant impact on the effectiveness of Quadris sprays against *Rhabdocline*. For treatments 1, 2 and 3, the first spray was applied 1 May and contained 0.15 or 0.3 kg ai/ha Quadris and the second Bravo spray was not applied until 15 May or 21 May. Treatments 1, 2 and 3 were only slightly more effective than the untreated controls and disease indices at the Schuylkill site were between 25 and 31 and the Clinton site ratings were between 30 and 34 (Fig. 4). For treatments 4 and 5, the first Bravo spray was applied on 1 May and the second spray containing Quadris was applied on 8 May. Temperature and moisture conditions optimum for infection were recorded throughout the day of 10 May and a portion of 11 May. Treatments 4 and 5 provided significantly better control than treatments 1, 2 or 3 (Fig. 4). If the first infection event occurred on 10 May, treatments 1, 2 and 3 were sprayed 9 days prior to infection, whereas treatments 4 and 5 were sprayed only 2 days before infection. These results indicate that 0.15 and 0.3 kg ai/ha Quadris offers poor protection against *Rhabdocline* infection when the interval between sprays is extended beyond the standard 7 days, particularly when disease pressure is high. Furthermore, recommended rates of Quadris do not offer acceptable control even when applied within 2 days of an infection event compared to the standard Bravo program. Treatments 4 and 5, which replaced the second Bravo spray with 0.15 kg ai/ha and 0.3 kg ai/ha of Quadris, had significantly higher disease indices than the standard Bravo treatment at both sites. There was no significant difference between the 0.3 and 0.15 kg ai/ha rates of Quadris at either site in 2002.

In 2003, application rate did not significantly influence the efficacy of Quadris against *Rhabdocline*. Treatment 1 replaced the standard Bravo treatment with four sequential applications of Quadris at the maximum labeled rate of 0.3 kg ai/ha and only moderately reduced infection at both sites compared to untreated controls (Fig. 5). Treatments 2 and 3 increased the Quadris rate to 0.6 or 1.2 kg ai/ha respectively, and did not significantly improve control at either the Clinton or Schuylkill site. Applications of Quadris applied alone resulted in disease indices between 11 and 14 and 18 and 23 at the Clinton and Schuylkill sites, respectively. Quadris performed better under the lighter disease pressure of the Schuylkill site in 2003, compared to 2002, or the Clinton site in either year. No treatments in any of the experiments had an adverse effect on needle color and no phytotoxicity was noted.

### **Significance for Pennsylvania Growers**

*Rhabdocline* needlecast continue to present a major constraint to Douglas-fir production in Pennsylvania and other areas of the northeastern United States. A recent survey of Christmas tree farms in New York found *Rhabdocline pseudotsugae* at nearly 90% of the collection sites and discovered Swiss needlecast (*Phaeocryptopus gauemanii*) to be more prevalent than previously suggested (7). In this study, Bravo was effective in controlling the *Rhabdocline*, however in recent years evidence from growers suggest that Bravo is not as effective as it has been in the past (7). The reduced effectiveness of Bravo should be verified and alternatives to Bravo-based control programs identified, if

possible. Interviews with Pennsylvania growers over the past two years also revealed that the first application of Bravo is sometimes applied well beyond breakbreak. In this scenario, new emerging foliage is unprotected and may allow the disease a window of opportunity to gain a foothold in the field. Recently Syngenta modified the Bravo label, recommending that the first application coincide with budbreak.

Results of this study indicate that Quadris at the label rate and up to four times the label rate, does not adequately control *Rhabdocline* either when used alone or in combination with Bravo. In addition, Quadris is much more expensive than Bravo, per treated acre. These results are in agreement with Dr. Gary Chastagner (4) who found azoxystrobin (Heritage) to be ineffective in controlling Swiss needle cast on stands of Douglas-fir timber at sites with high disease pressure. Results from this study also suggest that the level of natural inoculum plays a role in Quadris effectiveness.

Additional studies are needed to understand the behavior of Quadris on conifer leaf surfaces and to develop alternatives to Bravo that are effective in controlling needlecast diseases. Use of seed sources more resistant to *Rhabdocline* than the Lincoln N.F. and selection of resistant trees may be a less expensive alternative for the future.

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Table 1. Azoxystrobin (Quadris) and chlorothalonil (Bravo Weather Stik) treatment rates, combinations and intervals for 2002 and 2003 spray trials in Clinton and Schuylkill Counties, Pennsylvania.

Treatment	Date - 2002					
	5/1	5/8	5/15	5/21		6/7
Control <sup>Z</sup>	---	---	---	---	---	---
Standard	C <sup>Y</sup>	C	---	C	---	C
1	A(1X) <sup>X</sup>	---	C	---	---	C
2	A(1X)	---	---	C	---	C
3	A(.5X)	---	C	---	---	C
4	C	A(1X)	---	C	---	C
5	C	A(.5X)	---	C	---	C
Treatment	Date - 2003					
	4/30	5/7		5/19		6/3
Control	---	---	---	---	---	---
Standard	C	C	---	C	---	C
1	A(1X)	A(1X)	---	A(1X)	---	A(1X)
2	A(2X)	A(2X)	---	A(2X)	---	A(2X)
3	A(4X)	A(4X)	---	A(4X)	---	A(4X)

<sup>Z</sup>Control trees were untreated.

<sup>Y</sup>C = Chlorothalonil (Bravo Weather Stik), 1.7 kg ai/ha (standard commercial regime).

<sup>X</sup>A (.5X, 1X, 2X, 4X) = Azoxystrobin (Quadris), 0.15 kg ai/ha, 0.3 kg ai/ha, 0.6 kg ai/ha, 1.2 kg ai/ha, respectively.



Figure 1. Rhabdocline-infected Douglas-fir needles in early spring exhibiting characteristic lesions.



Figure 2. Rhabdocline pseudotsugae apothecia on the underside of Douglas-fir needle.



Figure 3. Douglas-fir Christmas trees derived from the Lincoln National Forest. Infected tree (left) has only current season needles; resistant tree (right) has 2-3 age classes of needles.

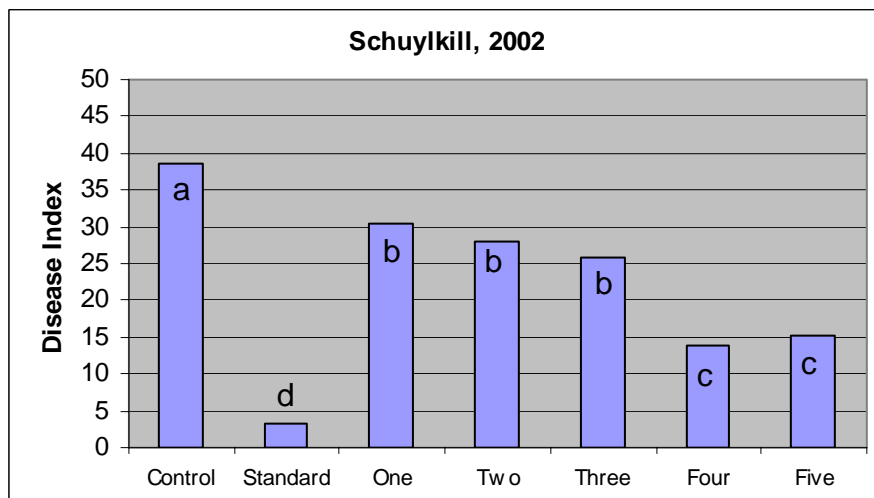
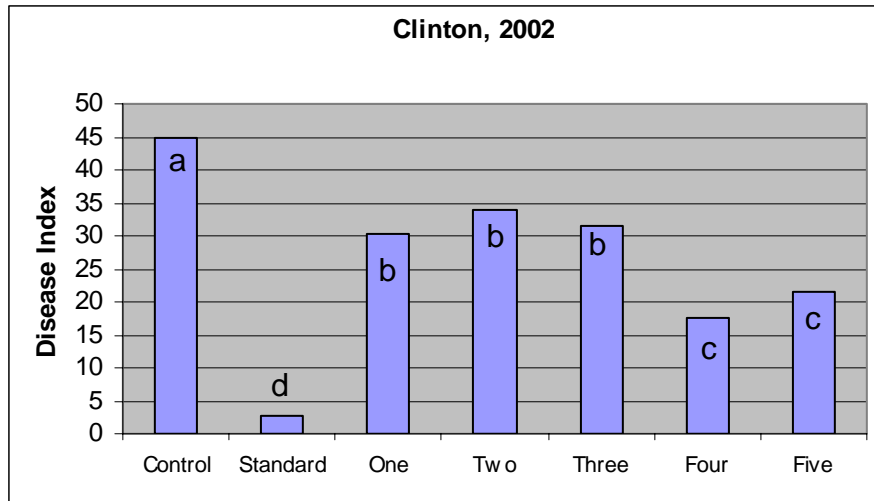


Figure 4. Efficacy of azoxystrobin (Quadris) and chlorothalonil (Bravo Weather Stik) spray treatments on Rhabdocline needlecast infection of Douglas-fir at two Pennsylvania sites during 2002. Disease Index = disease severity (1-5 scale; 1 = no infection) x disease incidence (needles with one or more lesions). Control = untreated trees; Standard = Chlorothalonil 1.7 kg ai/ha, four applications; 1, 2, 3, 4, 5 = Azoxystrobin, 0.15 kg ai/ha, 0.3 kg ai/ha, one application as first or second spray. Letters indicate significant differences between treatments. Mean separation was tested according to Fisher's Protected Least Significance test (LSD; P = 0.05).

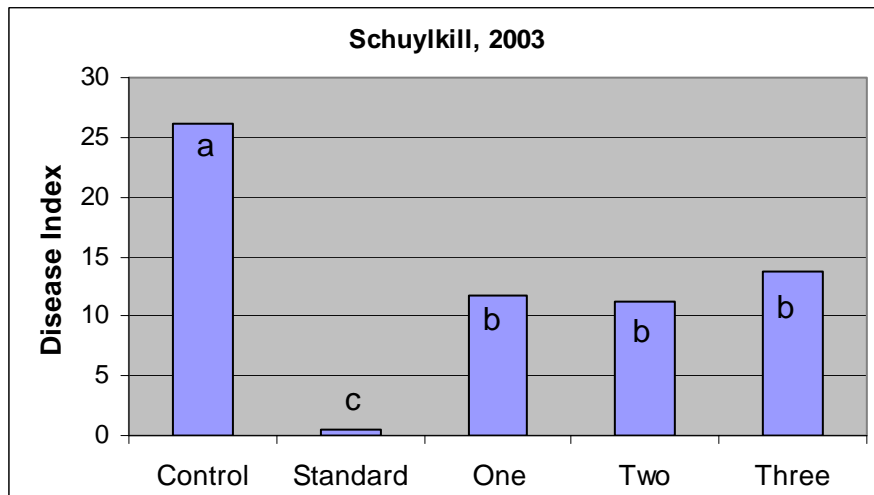
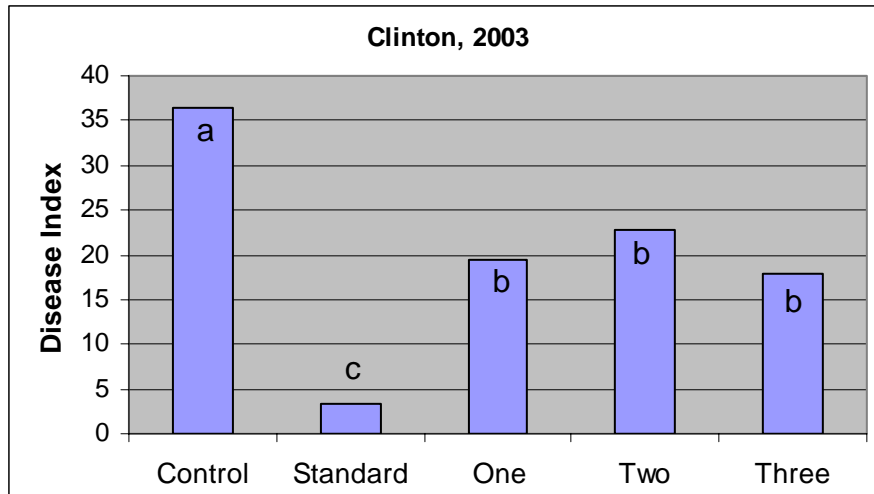


Figure 5. efficacy of azoxystrobin (Quadris) and chlorothalonil (Bravo Weather Stik) spray treatments on Rhabdocline needlecast infection of Douglas-fir at two Pennsylvania sites during 2003. Disease Index = disease severity (1-5 scale; 1 = no infection) x disease incidence (needles with one or more lesions). Control = untreated trees; Standard = Chlorothalonil 1.7 kg ai/ha, four applications; 1, 2, 3 = Azoxystrobin , 0.3 kg ai/ha, 0.6 kg ai/ha, 1.2 kg ai/ha, four applications. Letters indicate significant differences between treatments. Mean separation was tested according to Fisher's Protected Least Significance test (LSD; P = 0.05).