USDA

United States
Department of
Agriculture

Agricultural
Research
Service

1998–04

February 1999

Pecan Industry: Current Situation and Future Challenges, Third National Pecan Workshop Proceedings

SPRAY ADVISORIES FOR PECAN SCAB: RECENT DEVELOPMENTS IN GEORGIA

Tim Brenneman[1], Paul Bertrand[1] and Ben Mullinix[2]

ABSTRACT

Various attempts have been made to develop environmentally-based spray advisories for pecan scab. Currently most growers still use a calender schedule with some intuitive adjustments for extremely dry or wet weather. Two new models have been developed recently in Georgia and are being evaluated in both small plots and by growers. One model utilizes primarily leaf wetness periods and calls for sprays to be applied after a favorable infection period. This model relies on the post-infection activity of systemmic triazole fungicides. The second model, AU-Pecan, is an adaptation of the AU-Pnut advisory for peanut leafspot. This model uses the number of rain events in conjunction with the five day percent chance of rain. It requires only a rain gauge and a weather forecast to operate. AU-Pecan is the first model to incorporate a true forecasting component and thus enable growers to respond prior to scab-favorable conditions. Simulations with weather data from 15 years in Tifton indicate that an average of 3.9 sprays would have been applied annually compared to seven on a standard grower schedule. Further field testing is required to verify the effectiveness of these models and better define limitations due to delayed spray response, cultivar variability, different fungicide chemistries, etc.

INTRODUCTION

Pecan scab, caused by *Cladosporium caryigenum* (Ellis & Langl.) Gottwald, continues to be the most damaging disease of pecan in the southeastern United States. In Georgia the estimated losses to scab have averaged $1.6 million from 1993 to 1997. This varies widely from wet years like 1994 with heavier losses ($4.1million) to dry years like 1993 with negligible losses. However, even in dry years fungicides represent a major cost of production. Growers spend an average of $11.5 million annually for fungicides to control scab, and this cost is increasing due to higher prices for fungicides.

Genetic resistance to pecan scab has been a priority for breeding programs, but the track record of success has not been great. In fact, experience has shown that cultivars with apparent resistance tend to become susceptible over time (Latham and Goff, 1991). Actually the cultivars do not change, but various strains of the pathogen exist (Converse, 1960), and they are able to change and adapt to new genotypes (Littrell & Bertrand, 1981). Other control measures include cultural practices such as pruning trees and cutting surrounding vegetation to improve air movement. While these may help reduce scab incidence, growers still rely heavily on fungicides for disease control.

The primary fungicide for scab is fentin hydroxide (Super Tin or TPTH) which has been used for over 30 years. Two triazoles, propiconazole (Orbit) and fenbuconazole (Enable), have been labeled for use on pecans and offer growers a systemmic alternative. Dodine is an older fungicide that is being used more recently due to availability of a competitively priced formulation. Other options include Ziram and Benlate but these are not widely used. The most recent addition is azoxystrobin (Abound) which is slowly systemmic and offers a totally different mode of action. These fungicides are generally applied on a calender schedule of three prepollination (2-week interval) and four postpollination sprays (3-week interval) with some adjustments made intuitively for weather extremes.

PECAN SCAB ADVISORIES

Several ways have been explored to reduce fungicide inputs. Reduced rates of TPTH have sometimes lead to higher disease and lower yields (T. B. Brenneman, unpublished data). Wells et al. (1976) tried using reduced numbers of sprays at double the normal use rates with mixed success. Terminating spray programs at shell hardening has been shown to have no impact on nut quality or yield (Gottwald and Bertrand, 1988).

Another way to maximize the benefit received from fungicides is to use them only during those periods of high humidity and warm temperatures favorable for infection by *C. caryigenum*. This idea has lead to the development of several models designed to identify those favorable infection periods, thus allowing growers to only spray when it is truly needed. Early forecasts used cumulative leaf-wetness hours as defined by 90% or greater relative humidity (Gazaway and McVay, 1980; Hunter et al. 1978) and

[1] Professors of Plant Pathology and [2] Agricultural Research Statistician, Univeristy of Georgia, CPES, Tifton, GA. 31794

some tree growth parameters were later incorporated as well (Hunter and Payne, 1980). Variations of this resulted in spray savings during some years and up to 17 sprays during wet years (Gazaway and McVay, 1980; McVay and Gazaway, 1980; Miller et al. 1979). Although these models have not subsequently been used by growers, they did demonstrate the potential for optimizing benefits from fungicide inputs.

Recently there have been renewed efforts towards development of weather-based advisories in Georgia. In the late 1980's several grower trials were conducted to evaluate a model using 16 hours of continuous leaf wetness as a threshold for spraying (Hargrove et al. 1991). This model utilized propiconazole (Orbit) applied post-infection and allowed a 10 day protection interval after application. Six of the eight experimental plots had equal or better scab control with the same or fewer applications than calender programs. Dr. Darrell Sparks (Sparks, HortTechnology 1995) then published a model that was also based on continuous leaf wetness periods (8 hours) and the curative control available with systemmic fungicides applied after a rain event. Some growers have tried this model and it needs to be evaluated under a wider range of conditions.

Another model under development in Georgia has been derived from the Au-Pnuts advisory for late leafspot (*Cercosporidium personatum*) in peanuts (Davis et al., 1994; Jacobi et al. 1995). In terms of epidemiology and control measures there are many similarities between the two diseases. Brenneman and Bertrand have modified Au-Pnut to accomodate differences due to pecan phenology and called it AU-Pecan. For example, a default spray at parachute stage is called for to ensure protection of the very susceptible young foliage and all sprays are terminated at shell hardening since scab occurring later in the year has been shown to not affect yield or quality (Gottwald & Bertrand, 1988). Also, the protection intervals utilized after each application are shorter for the prepollination than for the postpollination sprays.

FIELD TRIALS

Both the AU-Pecan model and the Sparks advisory were tested in 1997 at the Coastal Plain Experiment Station Ponder Farm and at Luke Orchards in Berrien County. The Sparks advisory was actually modified to utilize a threshold of 12 consecutive hours of leaf wetness, a compromise between the original model and the Hargrove model (1991) using 16 hours. Leaf wetness was monitored continuously every 15 minutes by on-site weather stations (Agricultural and Meterological Systems, Inc., Middlesex, NC) using 98% RH as a measure of leaf wetness. Weather stations also monitored rainfall which, in addition to the 5-day percent chance of rain, was used to drive the AU-Pecan model. The 5-day percent chance of rain was supplied by the Agricultural Weather Information Service, Auburn, AL. The Tifton site had both Desirable and Wichita trees whereas the Luke Orchard had only Desirable trees. The fungicide program in both trials was the Orbit 45W (0.25 lb/A)/Super Tin 80W (5.0 oz/A) co-pack. Treatments were replicated four times at both sites and all sprays were applied with commercial air-blast sprayers.

At the Tifton site eight sprays were applied according to the calender schedule versus six and five with the AU-Pecan and Sparks advisories, respectively (Table 4). At the Luke Orchard, 10 sprays were applied according to the calender schedule versus 8 and 6 with the AU-Pecan and Sparks advisories, respectively (Table 4). Pecan scab was not severe in 1997 due to relatively dry conditions. At Tifton, nontreated Desirables had only 10% scab severity on nuts as of Oct. 1 (Table 1). All treatments reduced foliar and nut scab disease severity compared to the nontreated trees, but there were no differences between treatments. Wichita had much higher disease levels with a nut scab severity of 95% as of Oct. 1 (Table 2). All treatments were significantly better than the nontreated control for both foliar and nut scab. The Sparks advisory did have significantly higher nut scab than the other treatments, but this was not reflected in yields (Table 2). At the Luke Orchard, there were no differences among fungicide programs in regard to foliar or nut scab or nut quality parameters (Table 3).

ADVISORY SIMULATION DATA

To better understand and predict the performance of spray advisories in Georgia, 15 years of weather data from Tifton were analyzed (1983-1997). Actual rainfall was used and assumed to be a 100% accurate forecast for the next five days. We also assumed that budbreak was on April 1 of each year and that pollination occurred on May 15 for the purpose of separating prepollination (PRE) and postpollination (POST) spray intervals. Shell hardening was assumed to occur on August 15 and no sprays were applied after that date. Additionally, any spray called for on a day with $\geq$ 1 inch of rain would be postponed to the next dry day. The standard AU-Pecan model was evaluated along with several modifications and scenarios where sprays were delayed beyond the advised spray dates. These variations are listed in Table 5 along with several calender spray schedules. An average of 7.0 and 9.7 sprays would have been applied using a calender schedule with a 14/21day or a 14/14 day PRE/POST interval, respectively. The basic AU-Pecan model uses a 10/14 day PRE/POST protection interval and a default spray at the parachute stage if a spray has not already been applied. This model (trt. #1, Table 5) called for an average of only 3.9 sprays per year from 1983-1997. Spray numbers ranged from a low of only one during the very dry year of 1986 to a high of seven during 1991. If the default spray at the parachute stage were eliminated from the model, the number of sprays dropped to only 3.0 annually (trt. #10, Table 5). Changing the protection intervals to either 10/11 days PRE/POST or even 12/17 days PRE/POST had very little impact on the average number of sprays applied annually. Similarly, a consistent two day delay in spraying had little impact on spray numbers, but a four day delay reduced average spray numbers by about 0.5 sparays per year. Of course the impact of such delays on disease control is not known.

DISCUSSION

The most pressing need at this time is for replicated field data to verify the performance of these models under "real world" conditions. Simulations such as those reported here are useful, but are no substitute for actual field trials. Also, the assumptions made with some of the models in use are based on greenhouse studies where plants were sprayed to runoff with a hand sprayer. Tests we have conducted in Tifton indicate that this method greatly overestimates fungicide deposition when compared to field applications with an airblast sprayer. This may result in misleading conclusions regarding basic efficacy as well as curative or post-infection activity. Recent studies by Dr. Chuck Reilly comparing hand-sprayed versus airblast sprayer applied treatments give reason to doubt the reality of extended curative activity under field conditions. Since most growers are not able to immediately spray their entire orchard on every advised spray, this question is critical in helping them know how to use this system. In fact, some growers should not even attempt to use an advisory because they do not have adequate equipment to spray in a timely fashion.

With the limited data available, the Sparks advisory and the AU-Pecan advisory seem to give similar end results. The Sparks model may tend to call for fewer sprays, but it should be noted that we were using a 12 hour rather than an eight hour wetness period as a threshold. Using an eight hour threshold would undoubtedly have been more conservative and called for additional sprays. One advantage of the AU-Pecan model is that it is more of a true forecast since it utilizes the five day weather forecast and does not rely strictly on events that have already occurred. This allows a grower to spray ahead of advancing weather fronts. It should also be noted that the manufacturers of DMI fungicides such as Orbit and Enable specifically request that there products <u>not</u> be used as post-infection treatments due to the increased risk of fungicide resistance.

We also need to know more about other aspects of these advisories. How do other fungicides such as the new methoxy acrylates (Abound) perform with predictive models versus calender sprays? What effect does cultivar susceptibility have on the models? It may be beneficial to incorporate several layers of risk into the model. This would allow growers to select the level of risk they are comfortable with and tailor programs to individual orchards. Research is underway to try and answer these and other questions.

Many pecan growers are experiencing economic hardships related to rising production costs, uncertain prices, and erratic production. There is an urgent need for technology to reduce the cost of production, and pecan scab advisories certainly have that potential. For example, in our 1997 test on Desirables in Tifton, unsprayed trees sustained nut scab severity of only 10%. Applying seven or eight fungicides to these trees would have been a waste of money. With focused research efforts and cooperation of growers we should be able to make great progress in this area.

LITERATURE CITED

Converse, R. H. 1960. Physiological specialization of *Fusicladium effusum* and its evaluation in vitro. Phytopathology 50:527-531.

Davis, D. P., Jacobi. J. C., and Backman, P. A. 1994. Twenty-four hour rainfall, a simple environmental variable for predicting peanut leafspot epidemics. Plant Dis. 77:722-725.

Gazaway, W. S. and McVay, J. R. 1980. Measurement of leaf wetness as a means to determine fungicide application timing for pecan scab control. Proc. SE Pecan Growers Meeting, 73:106-109.

Gottwald, T. R. and Bertrand, P. F. 1988. Effects of an abbreviated pecan disease control program on pecan scab disease increase and crop yield. Plant Dis. 72:27-32.

Hunter, R. E., Newton, J. E. and Kolb, M. C. 1978. Preiminary research on a fungicide spray schedule for pecan scab based on weather data. Proc. SE Pecan Growers Meeting, 71:171-177.

Hunter, R. E. and Payne, J. A. 1980. Modified spray schedules for control of scab in Georgia and Texas. Proc. SE Pecan Growers Meeting, 73:61-66.

Jacobi, J. C., Backman, P. A., Davis, D. P., and Brannen, P. M. 1995. AU-Pnuts advisory I: Development of a rule-based system for scheduling peanut leaf spot fungicide applications. Plant Dis. 79:666-671.

Latham, A. J. and Goff, W. D. 1991. Pecan scab: A review and control strategies. Proc. Natl. Pecan Workshop 1 (ARS 96):89-93.

Littrell, R. H. and Bertrand, P. F. 1981. Management of pecan fruit and foliar diseases with fungicides. Plant Dis. 65:769-774.

McVay, J. R. and Gazaway, W. S. 1980. Measurement of leaf wetness as a means to determine fungicide application timing for pecan scab control II. Proc. SE Pecan Growers Meeting 73:121-125.

Miller, R. W., Goff, W. D., Teeter, K. M. and Drye, C. E. 1979. Effectiveness of certain fungicides and fungicide application systems for management of pecan diseases. Proc. SE Pecan Growers Meeting, 72:77-83.

Sparks, D. 1995. Pecan scab control - A climatic approach, hypothesis and epidemiological validation. Northern Nut Growers Association Annual Report, 86:85-97.

Wells, J. M., Payne, J. A. and McGlohon, N. E. 1976. Abbreviated spray programs for control of pecan scab in Georgia. Plant Dis. Reptr. 60:953-956.

Table 1. Evaluation of two spray advisories and a calender schedule for control of pecan scab on Desirable trees, Ponder Farm, CPES, 1997 [1]

Fungicide Schedule	# of Sprays	Nut Scab Incidence 8/19	Nut Scab Severity 10/1	Leaf Scab Incidence 6/2	Nuts per Pound
1. AU-Pecan	6	9.7	0.0	0.7	49.8
2. Sparks Model	5	13.5	0.3	0.3	49.1
3. Calender	8	7.6	0.1	0.0	47.8
4. Nontreated	0	77.4	10.0	5.1	49.7
LSD ($P \leq 0.05$)		15.5	1.1	2.9	N. S.

[1] The fungicide program used for all treatments was Orbit 45WP (0.25 lb/A) + Super Tin 80WP (5.0 oz/A).

Table 2. Evaluation of two spray advisories and a calender schedule for control of pecan scab on Wichita trees, Ponder Farm, CPES, 1997[1]

Fungicide Schedule	# of Sprays	Nut Scab Incidence 8/19	Nut Scab Severity 10/1	Leaf Scab Incidence 6/2	Nuts per Pound
1. AU-Pecan	6	100.0	31.4	21.4	74.1
2. Sparks Model	5	100.0	50.0	21.9	78.3
3. Calender	8	100.0	27.1	29.2	83.9
4. Nontreated	0	100.0	95.3	70.4	105.5
LSD ($P \leq 0.05$)		N. S.	12.6	10.3	17.0

[1] The fungicide program used for all treatments was Orbit 45WP (0.25 lb/A) + Super Tin 80WP (5.0 oz/A).

Table 3. Evaluation of two spray advisories and a calender schedule for control of pecan scab on Desirable trees, Luke Orchard, 1997[1]

Fungicide Schedule	# of Sprays	Nut Scab Severity 7/25	Nut Scab Severity 8/20	Leaf Scab Incidence	Nuts per Pound
1. AU-Pecan	7	0.6	3.8	7.4	52.8
2. Sparks Model	6	1.5	7.1	11.0	55.4
3. Calender	9	0.8	5.7	7.2	52.3
4. Nontreated	0	10.8	43.0	35.2	82.0
LSD ($P \leq 0.05$)		2.1	4.2	7.9	7.0

[1] The fungicide program used for all treatments was Orbit 45WP (0.25 lb/A) + Super Tin 80WP (5.0 oz/A).

Table 4. Actual spray dates for advisory and calender treatments in 1997 and 1998 field tests.

Test and Treatment	Spray Number 1	2	3	4	5	6	7	8	9	10
Ponder Farm, 1997										
AU-Pecan	4/2	4/24	5/20	6/12	7/2	7/30				
Sparks Model 4/2	4/24	5/24	6/12	7/30						
Calender	4/2	4/15	4/30	5/21	6/11	7/1	7/23	8/12		
Luke Orchard, 1997										
AU-Pecan	4/1	4/15	4/30	5/29	6/20	7/9	7/28	8/17		
Sparks Model 4/1	4/30	5/29	6/20	7/9	7/28					
Calender	4/1	4/15	4/30	5/15	5/29	6/11	6/24	7/9	7/23	8/7
Ponder Farm, 1998										
AU-Pecan	4/10	4/30	5/1		To be determined!					
Sparks Model 4/10	4/30	4/29		To be determined!						
Calender	4/6	4/21	5/4	5/25	To be determined!					

Table 5. Simulated spray applications determined from historical environmental data, Tifton, GA (1983-1997).

	Calender			AU-Pecan Variations*									
Year	14/21	14/14	10/14	1	2	3	4	5	6	7	8	9	10
1983	7	10	10	5	5	4	5	5	4	5	4	4	5
1984	7	10	10	5	5	4	5	5	5	5	4	4	4
1985	7	10	10	2	2	2	2	2	2	2	2	2	1
1986	7	10	10	1	1	1	1	1	1	1	1	1	0
1987	7	9	10	5	5	4	5	5	5	5	5	4	4
1988	7	9	10	3	3	2	3	3	2	3	3	2	2
1989	7	9	10	5	5	5	5	5	5	5	5	4	4
1990	7	10	10	2	2	2	2	2	2	2	2	2	1
1991	7	10	10	7	7	6	7	7	7	7	6	5	6
1992	7	9	10	4	4	3	5	4	3	4	4	3	3
1993	7	10	10	3	3	3	3	3	3	3	3	3	3
1994	7	10	10	6	6	4	6	6	5	5	5	4	6
1995	7	10	10	3	3	3	3	3	3	3	3	3	2
1996	7	10	10	3	3	3	3	3	3	3	3	3	2
1997	7	10	10	4	4	4	5	5	4	4	4	4	3
Avg.	7.0	9.7	10.0	3.9	3.9	3.3	4.0	3.9	3.6	3.8	3.6	3.2	3.0

* Variations of the AU-Pecan model were validated assuming for each year that bud break was April 1, pollination was May 15, and sprays were terminated on August 15 at shell hardening. Specifics regarding prepollination (PRE) and postpollination (POST) protection intervals and other varibles are as follows:

Model	PRE/POST Protection Interval	Default Spray at Parachute Stage?	Days of Delay After a Favorable Advisory
1.	10/14	Yes	0
2.	10/14	Yes	2
3.	10/14	Yes	4
4.	10/11	Yes	0
5.	10/11	Yes	2
6.	10/11	Yes	4
7.	12/17	Yes	0
8.	12/17	Yes	2
9.	12/17	Yes	4
10.	10/14	No	0