Preliminary Observations in Blocks Using PAD to Delay the First Apple Scab Fungicide Spray

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Apple growers in the Northeast apply more sprays to manage apple scab than to manage any other disease or any insect problem. Reducing fungicide use in recent years has been difficult for all commercial apple growers. The introduction of the demethylation-inhibitor fungicides, also called sterol inhibitors (DMIs or SIs) fungicides (Nova/Rally, Rubigan, and Procure) in the 1980s allowed growers to adopt a "four-spray" program to manage apple scab. Using DMIs in combination with a protectant fungicide, usually captan or mancozeb, a grower could delay the initial fungicide application until the half-inch green or early tight cluster bud stage, and make subsequent applications at approximately 10-day intervals through to fruit set.

Compare this to a typical program for apple scab before the introduction of DMIs. Programs commonly started at bud break, and continued with sprays every five to seven days through to fruit set, typically requiring five to seven fungicide applications. In other words, DMI fungicides allowed growers to save one to three applications a year.

Unfortunately the apple scab fungus has developed wide-spread resistance to DMIs. With this, growers have been forced to return to using fungicides that need to be applied more frequently, either the older protectants or newer fungicides. As a result, the amounts of fungicides applied in apple orchards today have increased compared to levels used five to fifteen years ago.

New England growers and plant pathologists have collaborated to develop a strategy that can reduce the total number of sprays per season by 2 or 3, and that can allow for better integration of fungicide and insecticide applications at the tight cluster bud stage. The method was developed and tested first in New Hampshire, and simplified by researchers in Vermont (Gadoury and MacHardy, 1986; MacHardy *et al.*, 1993; MacHardy, 2000; Sutton *et al.*, 2000; Reardon *et al.*, 2005). Basically, the approach has three components: (1) Accurate measurement of the expected number of ascospores that might cause scab infections, the potential ascospore dose or PAD; (2) Reduction of any scab inoculum in the orchard through sanitation methods; and (3) Delay of the first fungicide application.

Accurate PAD assessments are critical to success of the approach. Some researchers have used fruit scab incidence of < 2% at harvest as a threshold that allows a delay (Wilcox *et al.*, 1992), but harvest fruit scab does not correlate well with PAD, and can give erroneous recommendations (Cooley and Autio, 1997). The methods for doing a PAD analysis have been well developed, and in their present form require about 40 min. per block. The action thresholds, that is, the PAD levels that allow a delay of the first fungicide spray, depend on following the protocol for assessing PAD.

Later work in New Hampshire coupled PAD assessments to methods that reduce scab inoculum using either urea applications, chopping leaves with a flail mower, or both. Orchard sanitation has value regardless of the type of fungicide program a grower uses, because decreasing inoculum will reduce the chances of scab infection. The PAD analysis has been developed for use with and without orchard sanitation. There is one set of thresholds for blocks in which sanitation will not be done, and another set for blocks in which it will be used.

Yet, even though 10 years ago tests showed that the first fungicide spray could be delayed significantly to as late as pink in blocks that had low PAD counts the previous year, the practice has not been widely adopted by commercial growers. There are several

possible reasons behind this resistance to using PAD and a spray delay:

1. Growers feel PAD evaluations take too much time;
2. The PAD/delay approach has not been proven;
3. Resistance to DMI fungicides (SI fungicides) leaves growers without a way to eradicate early infections in case the method does not work.

The last two points may be related, as much of the early testing of the PAD delay was done when DMI fungicides were in common use. Where they are effective, the DMI fungicides will eradicate early-season infections that might have occurred, as long as they are applied within 10 days from the beginning of those infections. Commonly used older fungicides, such as captan and the EBDCs, and newer fungicides such as Vangard, Scala, Flint and Sovran all have limited post-infection activity, usually about 24 to 48 hours, and never more than 72 hours. If a grower is not using DMIs, or if scab in their orchard has become resistant to them, the margin for error that they provide is no longer there. That means a PAD delay must be demonstrated to work with fungicides that do not have long-term post-infection activity.

It is important to point out that when PAD delay research was first done and reported (MacHardy *et al.*, 1993), care was taken to avoid using DMIs and other fungicides that could eradicate scab. That means that the success of those tests occurred because inoculum was too low to cause infection, not because fungicides eradicated infections. Because PAD delay can eliminate fungicide sprays, we wanted to re-examine it particularly with respect to the issues listed above.

In the fall of 2007, we did a PAD analysis in 16 blocks in four commercial orchards in New England and New York, with limited testing of delayed initial applications of fungicides in 2008. In the fall of 2008, we again did PAD evaluations in 32 blocks of six commercial orchards, and will do fungicide delay programs in appropriate blocks in 2009.

In 2007, 10 blocks had scab levels that were low enough to allow growers to delay the first fungicide spray in 2008, as shown in Table 1. The average block took about 37 minutes to assess for PADs. Based on these results, three of the four growers in the study delayed their initial fungicide applications in 2008. One grower did not feel comfortable with the delay, even though he had very low PAD levels. The other growers delayed their initial fungicide application according to our instructions, which were until tight cluster or until two infection periods had occurred, whichever came first. This is a conservative recommendation, and the initial research demonstrated that in orchards with very low PAD levels, fungicide applications did not need to start until pink or until three infection periods had passed. Of the three orchards in which initial fungicide applications were delayed in 2008, one had no scab in either test or check blocks, one had minimal scab in the test blocks and no scab in the check, while the third had 0.5% scab in the test and 6.5% scab in the check.

Based on these results, we did a more extensive and detailed study over the past year. Thirteen blocks in five orchards were evaluated in the fall of 2008 and fungicide sprays were delayed in the spring of 2009. In most orchards, growers also used either sanitation (leaf grinding) or treated with urea to further reduce inoculum in the orchard. In all of the test blocks, the

Table 1. 2007-2008 PAD assessments and results of the delayed scab spray strategy.

Orchard	Blocks surveyed 2007	Blocks qualified for delay	Blocks delayed 2008	Scab incidence %, 2008		
				Delayed blocks		Check
				Foliar (June)	Harvest	Harvest
A	3	3	0	-	-	-
C	7	4	4	yes	0.1	0.0
E	2	1	1	yes	0.5	6.5
F	4	2	2	yes	0.0	0.0

Table 2. Summary of use of scab inoculum measurement and reduction used to reduce fungicide applications in apples, 2008-2009.

					Delay conditions			Scab incidence %, June, 2009		
Orchard	Block type	Fall 2008 PAD[1]	Delay	Sanitation[2]	Date	Bud stage[3]	Prior infection periods	Terminal	Cluster	Fungicide
NHA	test	0	yes	LC	4/30	TC-P	1	0	0	S
	test	0	yes	LC	4/30	TC-P	1	0	0	S
	test	0	yes	LC	4/30	TC-P	1	0	0	S
MAC	check	2	no	no	4/26	TC	0	1	0	P
	test	0	yes	LC	4/28	TC-P	0	6	2	P
CTL	check	72	no	no	4/13	1/4IG	0	23	14	P+C
	check	-	no	no	4/13	1/4IG	0	23	21	P+C
	test	0	yes	LC & U	4/23	TC	2	0	0	P+C
	test	0	yes	LC & U	4/23	TC	2	2	0	P+C
	test	0	yes	LC & U	4/23	TC	2	0	0	P+C
	test	1	yes	LC & U	4/23	TC	2	3	6	P+C
	test	1	yes	LC & U	4/23	TC	2	0	0	P+C
	test	0	yes	LC & U	4/23	TC	2	2	3	P+C
VTS	check	-	no	no	4/22	1/2IG	0	7	3	V
	test	3	yes	LC	4/27	TC	1	1	0	P
	test	1	yes	LC	4/27	TC	1	1	2	P
VTH	check	0	no	no	4/27	1/2IG	1	0.5	2.5	M
	check	0	no	no	4/19	GT	0	0	2	M+C
	test	0	yes	no	5/1	TC	2	0.5	0.5	C

[1]Potential ascospore dose as estimated by the number of scab-infected leaves per 100 sampled leaves.
[2]Whether sanitation through leaf-chopping (LC) or urea application (U) was done in the block.
[3]Apple growth stage where green tip (GT) is first visible green tissue growth; 1/4- or 1/2-inch green (1/4IG or 1/2IG) is 0.25 or 0.5 inch of new green tissue growth; TC is tight cluster bud; pink (P) is early flower buds.
[4]The first fungicide applied for the season, excluding dormant copper applications. C = captan; M = mancozeb; P = Penncozeb; S = Syllit; V = Vangard

PAD measured in the fall of 2008 was low enough to allow an initial fungicide delay in 2009. Growers who used sanitation or urea were doing so only as an added precaution.

We asked growers to start spraying in at least one block according to their usual practices. We anticipated that would mean that in at least some blocks in each orchard, fungicide applications would begin at about green tip. In addition, all growers were advised to apply a copper spray to all blocks at or around silver tip. We anticipated that this spray offered significant benefits in terms of fire blight management, and would not have

a significant impact on scab in the test blocks. However, weather conditions in 2009 were such that in many orchards, there were no scab infection periods until trees were at half-inch green to tight cluster. Again, our instructions for the test blocks were to apply the first fungicide at tight cluster or after two infection periods, whichever came first. This meant that in one orchard, MAC, the difference in timing between the test and check was minimal, and in another, NHA, there was no difference. In three of the five orchards there were significant timing differences between the test and check blocks.

In the orchards with a significant delay, the test blocks had less scab than the check blocks. All test blocks were delayed until tight cluster, while check blocks first received fungicide applications green tip or half-inch green. In the check blocks, 0 to 1 infection periods had been recorded at the time of the first fungicide, while in test blocks 1 to 2 infection periods had been recorded. Terminal scab in the test blocks ranged from 0 to 3% of terminals infected, with an average of 1%. This compared with a range of 0 to 23% terminal infection, with a mean of 10.7%, in the checks.

Obviously, using a PAD delay would not actually improve scab management. At best, PAD delays should perform as well as conventional fungicide timing, all factors being equal. In this test, all factors were not equal. The high rate of terminal infection in the check blocks is probably related to the particular blocks that were selected for early treatment by growers. That is, in blocks where scab had been a problem, growers wanted to make sure that fungicides were applied early, and in spite of that, high inoculum levels still cause some infections.

It is encouraging that a typical PAD measurement takes about 40 min. per block. However, we believe that PAD measurements need to done in each distinct block in an orchard. Growers should not make a PAD assessment in one block, and assume that it applies to all blocks in an orchard, particularly where the blocks have historically shown differences in scab incidence. We also feel that PAD measurements should be done using a sampling pattern that will insure that if errors are made, they overestimate rather than underestimate the PAD. For example, scab can often be localized in a block, occurring in areas that are difficult to spray or that dry more slowly. Sampling should start in these areas where incidence is potentially higher.

These results should be interpreted to indicate that PAD delay can be used successfully in blocks where the PAD measurements indicate sufficiently low levels of inoculum. This is encouraging, but given the variability in seasons, orchards and our ability to perform statistically valid comparisons to date, we will repeat the evaluation in 2009-2010.

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