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Managing Scab-Resistant Apples

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Apple scab, caused by the fungus *Venturia inaequalis*, is one of the most important apple diseases. When conditions are conducive and the disease is improperly managed, losses can approach 100 percent.

Worldwide, apple scab management has focused on two approaches for management: applying fungicides and selecting disease-resistant cultivars. Unfortunately, because little was done to integrate these approaches, growers are faced with the twin problems of fungicide-resistant apple scab populations and disease-resistant cultivars showing signs of scab.

Photo by Janna Beckerman

Figure 1. *Some plants can be "allergic" to a given chemical — this is called phytotoxicity. Always check product labels to reduce the chance of unintentionally injuring plants.*

This publication examines the factors contributing to the development of new strains of the apple scab fungus capable of infecting disease-resistant cultivars and offers recommendations for effectively managing these trees to prevent further erosion of scab-resistance.

Two Kinds of Resistance

Note that there are two kinds of resistance being discussed here, and they can be easily confused. One is the resistance of the fungus to a fungicide, which occurs when fungicide applications are no longer effective in controlling the disease. The other type of breakdown in resistance is the loss of host plant resistance that occurs when the formerly disease-resistant cultivar can now be infected by the pathogen.

Fungicides are the primary means of managing apple scab in commercial orchards. Commercial apple production in the Midwest normally requires 10 to 20 fungicide applications per season to protect the crop from scab. Over time, repeated applications of systemic fungicides have resulted in *V. inaequalis* populations that are resistant to certain fungicide classes.

Even organic production of common commercial apple cultivars ('Gala,' 'Golden Delicious,' 'Fuji') requires 20 to 30 applications of sulfur, lime sulfur, or copper salts per year to control apple diseases — and 12 of these may be needed for primary scab control. These compounds carry a high risk of damaging developing apples (phytotoxicity) and harming beneficial insects, and they do not guarantee successful protection.

One approach to reducing fungicide inputs is to incorporate the use of disease-resistant cultivars, which reduces fungicide use and the risk of any phytotoxicity (Figure 1).

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Unfortunately, relying solely on cultivar resistance for disease management and not integrating other disease management tactics has led to other problems.

Scab-Resistant Varieties

For many growers, selecting apple cultivars with disease resistance is the preferred means for controlling disease. In addition to reducing production costs, lowering pesticide inputs, and minimizing environmental risk, disease-resistant cultivars, when properly managed, provide a more sustainable disease management method.

Most scab-resistant apples trace their origins to a collaboration between Purdue University, Rutgers University, and the University of Illinois. The PRI apple breeding program began in 1926 when crosses made from the crab apple, *Malus floribunda* 821, were found to show some resistance to apple scab. The PRI group then bred the resistant *Vf* gene from *Malus floribunda* 821 into commercial apple cultivars.

Decades of subsequent hybridization and selection produced high-quality, scab-resistant eating apples. Since 1970, approximately 80 percent of the scab-resistant cultivars released worldwide reportedly carry the *Vf* resistance gene from *M. floribunda* 821, including 'Williams' Pride,' 'Jonafree,' 'Liberty', 'Enterprise,' 'Prima,' 'Pristine,' and 'GoldRush.' *Vf*-based scab-resistant apple cultivars allow growers to reduce fungicide use, improve yields and skin quality, and provide better mite and insect pest management.

Consumer acceptance of new apple cultivars depends on both cosmetic appearance (Figure 2) as well as eating quality, and most American consumers seem uninterested in disease resistance or reduced pesticide inputs. While many scab-resistant cultivars have acceptable eating quality, many have only average cosmetic appeal, leading to slow adoption of these cultivars. Instead, these cultivars have been relegated to direct retail marketing orchards or home-fruit growers. Very few apple cultivars carry other sources of scab resistance, although 'Liberty' is one notable exception.

Unfortunately, just as reliance on a few fungicides resulted in fungicide resistance, relying solely on disease-resistant apple cultivars to manage scab has resulted in the breakdown of *Vf*-based scab-resistance worldwide.

In 1993, scab lesions were found on 'Prima,' a *Vf*- selection in an orchard in Germany (Parisi et al., 1993). Although 'Prima' is now susceptible to scab, these scab isolates were not able to infect the resistant parent *M. floribunda* 821 or other scab-resistant apple varieties.

Unfortunately, scab was found infecting *M. floribunda* 821 in England one year later (Roberts and Crute, 1994). It took 13 years before scab was found on *Malus floribunda* 821 in North America in 2007 in Indiana, Illinois, and Ohio. In 2008, scab was found on 'Pristine,' (Figure 3) 'Pixie Crunch,' and 'Jonafree' in Indiana and Illinois. And in 2009, scab was found infecting 'Enterprise' in Indiana.

Integrated Scab Management

Successful apple scab management requires an integrated approach based on the grower's goals. Such an approach combines resistant cultivars, good horticultural practices, sanitation, and fungicides. Growers must decide whether to manage their apples using natural fungicides (referred to as organic) or synthetic fungicides.

In general, disease-resistant cultivars require less intensive chemical management than their susceptible counterparts and are a better choice for the grower interested in producing organic apples. For more information about organic

Photo by Janna Beckerman

Figure 2. *Consumers prefer blemish-free apples, but apple scab mars appearance and quality.*

Photo by Janna Beckerman

Figure 3. *These 'Pristine' apples, a once scab-resistant variety, are infected with the scab pathogen.*

fungicides, see Purdue Extension publication BP-69-W, *Disease Management Strategies for Horticultural Crops: Using Organic Fungicides* (www.extension.purdue.edu/extmedia/BP/BP-69-W.pdf).

Cultural Control

Good horticultural practices can minimize, or even prevent, scab. These practices include:

- Selecting sites that provide more than six hours of sunlight per day
- Spacing trees adequately
- Following proper pruning practices to open the tree canopy (Figure 4)

Used in combination, these practices will ensure leaves dry quickly after a wetting (such as rain or heavy dew) to minimize conditions favorable for scab development.

In addition to standard cultural practices, and perhaps most importantly, growers should not plant *Vf*- resistant varieties together with susceptible apple varieties. Rare mutations in the fungus growing on susceptible cultivars may allow it to infect resistant cultivars. Although the risk of this is quite low, the sheer numbers of spores the fungus produces can be in the millions — making a one in a million (or a one in 10 million or 100 million) chance a very real possibility that has occurred, and will continue — resulting in the complete breakdown of *Vf*-resistance.

Segregating *Vf*-resistant and susceptible cultivars can help growers prevent any "breeding" by the scab pathogen, and reduce the likelihood that a successful offspring (ascospore) can infect a once-resistant tree, leading to resistance breakdown. Unfortunately, the small size of most orchards makes such segregation very difficult to implement.

Photo by Janna Beckerman

Figure 4. *Good horticultural practices, including proper pruning to open the tree canopy, can help minimize or prevent apple scab.*

Sanitation

The fungus that causes apple scab overwinters on fallen leaves and develops fruiting bodies in the spring (Figure 5). Thus, a key step in apple scab management involves preventing fruit body formation.

Unfortunately, removing all fallen leaves is impractical, even in a home orchard. However, growers can increase leaf decomposition and prevent the apple scab fungus from successfully overwintering on fallen leaf litter. Mulch mowing or flail mowing in the fall or early spring (prior to green tip) to shred leaf litter can reduce the risk of scab by 80 to 95 percent if all of the leaf litter is shredded (Sutton et al., 2000).

Additionally, applying a solution of 5 percent urea (42 pounds per acre of urea dissolved in 100 gallons of water) to autumn foliage can increase leaf decomposition, which reduces the amount of fungus that survives the winter. Apply urea applications just before leaves fall or immediately after leaf fall to leaves on the ground to avoid stimulating tree growth and predisposing the trees to winter injury.

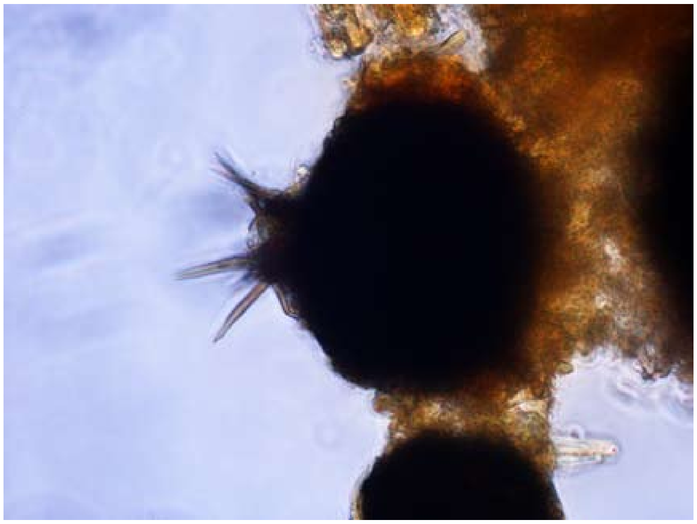

Photo by Tom Cresswell

Figure 5. *The overwintering structure of apple scab produces thousands of spores each spring.*

Alternatively, urea can be applied before or during silver tip as a ground spray with an airblast sprayer using only the bottom nozzles to deliver a spray that completely covers the orchard floor. This urea application will reduce ascospore production 60 to 90 percent. When applying urea to control scab, reduce nitrogen fertilization of the trees to prevent over-fertilization.

Fungicides

Regardless of a cultivar's susceptibility, fungicide applications are an essential component of effective scab management. For disease-resistant cultivars in particular, the most critical step of the process is controlling primary infection by ascospores in the spring. These spores are the "offspring" of the previous year's infection and have the potential to infect even scab-resistant cultivars if they contain the right combination of genes. Using fungicides on scab-resistant cultivars can help prevent infection by any newly virulent strain of the fungus, protecting the tree from primary scab and any successful secondary scab.

Apply fungicides in early spring from green tip and continue on a seven- to ten-day schedule until petal-fall (seven days during wet weather, ten days if dry). After petal fall, scout trees to confirm that no primary infection occurred. If no scab lesions are observed and primary scab control was successful, no further fungicide sprays *for scab* are necessary, although fungicide applications to manage other diseases may be necessary.

For more information on fungicide use, see Purdue Extension publications BP-1-W, *Fruit Diseases: Apple Scab on Tree Fruit in the Home Orchard* (www.extension.purdue.edu/extmedia/BP/BP-1-W.pdf); and BP-72-W, *Disease Management Strategies for Horticultural Crops: Fungicide Resistant Management for Pome Fruit* (www.extension.purdue.edu/extmedia/BP/BP-72-W.pdf).

To maintain the *Vf*-resistance of scab-resistant cultivars in organic or sustainable apple production, it is essential to rigorously apply fungicides to prevent primary infection during key scab periods (when the weather is cool and wet) while leaf tissue is young and susceptible to infection. The simple but conscientious application of one to three sprays to prevent primary infection in the spring should keep resistant cultivars free of scab for the entire season.

To date, these minimal, or organic, practices to control other diseases such as powdery mildew and cedar-apple rust may have contributed to the preservation of scab resistance in these cultivars, and are needed to maintain scab-resistance in the future.

The incorporation of *Vf*-resistance into commercial apples has successfully protected apples against scab since 1926. By implementing and integrating a few minor management tactics, growers can protect this valuable genetic resource for use in future breeding efforts and reduce the amount of pesticides necessary for apple disease management in the home and the commercial orchard.

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