Strawberry Anthracnose: Better Understanding and Management

Anthracnose on strawberries is a recurring problem for Mid-Atlantic growers and is especially challenging to manage.

**Strawberry Anthracnose Part 1: Better Understanding and Management**

Dr. Mengjun Hu at the University of Maryland and Kathy Demchak at Penn State have been working to better understand the anthracnose situation in the region. Their work has included collecting diseased fruit and plants, using them to identify the fungal species present, and testing for fungicide resistance to improve management recommendations.

Hu identified four species that cause anthracnose crown, or fruit rot, from these samples. The most common species was also the one most commonly found in samples collected in the South and in California. In other studies, these species have been found on other crop plants, woodland plants, and common weeds such as pigweed and white clover, often without exhibiting symptoms.

Complicating matters further, research has shown that controlling infected weeds with certain herbicides (glyphosate and paraquat) may trigger the fungi to sporulate, perhaps as a survival mechanism. Additionally, inoculum can also be transported on denim clothes and workers' hands. All of these factors make anthracnose especially challenging to manage.

Strawberry plants begin free of disease after they've been multiplied in tissue culture labs. However, as they spend time in the field, they are exposed to inoculum sources. Individual nurseries are trying very hard to keep plants clean and rotate fungicides to avoid resistance development. However, during the multi-season propagation process, some plants become infected and may arrive at your farm with anthracnose present, but without obvious symptoms. When conditions are right for disease development—warm and wet weather here in the eastern U.S.—symptoms will appear. Then all that is needed is splashing water from rain to bounce spores around on the plastic and to fruit in your planting bed, potentially turning a small infection into an epidemic.

Over time, it is very difficult to avoid exposure to inoculum. Because of multiple sources, various steps in the propagation process, and the need for fungicides to keep the disease at bay, plant material may be exposed to the same fungicide mode of action more times than is ideal. In our samples, Hu found widespread resistance to azoxystrobin, a category 11 fungicide that has been the mainstay of many fungicide programs. There is also resistance to other active ingredients within the same FRAC code.

With all of these concerns, what's a grower to do? First, be aware that healthy-looking plants may be infected without anyone knowing, so you should watch for symptoms of dark brown sunken lesions on petioles or leaf tissue, blighted blossoms, and wilting or dying plants.
Blighted flowers can look like those infected by Botrytis. You can pick a few affected blossoms and put them in a plastic bag in a cool location. After a day or two, those infected with Botrytis should exhibit the telltale grayish ‘fuzzy’ appearance of this disease. Berry caps and leaves infected by anthracnose have brown or black lesions with irregular margins (other diseases tend to have round spots) and round or elongated lesions on runners and leaf petioles as well. If conditions are right, small slimy orange spore masses may be seen in any of these lesions. Early fruit infection can show as hard, brown areas on green fruit with blackened seeds and as sunken areas without much color on maturing and ripe fruit.
As infections progress on ripe fruit, these areas will then turn dark brown with an orange or salmon center where spores are being produced. Note that black seeds are very obvious when the fruit is infected with anthracnose, whereas seeds will remain a light color if infected with botrytis.

Second, some cultural controls should help such as keeping fields weed-free, using straw in row middles and tucked up under plants to reduce rainsplash, using good rotations, and managing row covers to avoid heat buildup under them. Berries infected with anthracnose should be removed from fields during harvest, and heavily infected areas should be harvested last to avoid spreading the disease.

Third, with a predicted return to seasonal temperatures, growers should focus on protecting developing fruit from anthracnose with an effective fungicide program. To avoid further resistance development, start with the protectant fungicides captan and thiram either alone as part of the rotation, or as a tank-mix partner with each spray application. Note that thiram has better efficacy against Botrytis but captan can do a much better job for anthracnose. Growers are limited to 5 applications of thiram per year (which has a 3-day preharvest interval), and 8 per year of captan if the maximum rate of captan is used.

Here are effective materials you can use for anthracnose that utilize different fungicide classes for resistance management.

- Check current labels to make sure any applications are allowable for your location and rotation restrictions are followed. Switch (group 9 + 12), and Oso/PhD (group 19) have received good ratings in the South.
- The category 3 products, difenoconazole, and propiconazole have shown very good efficacy against anthracnose based on lab testing. Inspire Super contains difenoconazole with cyprodinil (one of the active ingredients in Switch, so watch rotations if also using Switch).
Strawberry Anthracnose Part 2: A Closer Look at Management and Fungicide Use

In Part 2, we take a closer look at some of the research results discussed in Part I, and additional specific recommendations for management in Pennsylvania.

In the last few years, it became apparent that we needed a better understanding of the anthracnose fruit rot situation on strawberries in the mid-Atlantic region. Thanks to the availability of molecular techniques, good University facilities, and engaged pathology personnel, we are making some significant progress.

Before we get to the results, we need to understand fungicide resistance as it pertains to anthracnose in particular. There is evidence that when we ship plant material around, we also ship around some disease inoculum, and some of it is resistant to certain fungicides. Research in Florida showed this was the case regarding resistant strains of Botrytis.

Even if you work to avoid resistance development on your farm, the resistant disease inoculum that may already be in the plants does not become less resistant over time—at least not in the case of our most common anthracnose species and the fungicide class to which it is most commonly developing resistance. This is because there is no evidence for a "fitness penalty" (i.e., no cost to the fungus) to be resistant, so there is no reason for it to change back to being sensitive to the fungicides we are using. On the other hand, when we spray fungicides, we are always pressuring the fungi to become more resistant to those fungicides.

Rotating chemical classes preserves the effectiveness of a fungicide's mode of action. When you use a fungicide that acts on one particular fungal process, some fungal strains may emerge that are resistant to that chemical, but if you then use a fungicide with a different mode of action, the resistant fungi are wiped out in some other way. Multi-site fungicides act on a fungus in multiple ways. Eventually, resistance could still emerge, but its development is much less likely. If the resistance situation is an unknown, it would be wise to include a multi-site fungicide in the tank when using a single-site fungicide.

Over the past year, 200 isolates of Colletotrichum, the genus of the fruit and crown-rotting organisms that cause anthracnose, were analyzed. These had been collected from North Carolina to Pennsylvania over the past few years. Forty of these isolates were collected in 2019 from Pennsylvania farms that used different cultivars, plant sources, and production systems. When we took a close look at just these isolates, some interesting trends emerged. We do need to keep in mind that this was only 40 isolates—this is a very small number for our state where production is very diverse, and we definitely need to collect more data in the summer of 2020 to solidify any conclusions. However, this information may help in guiding fungicide programs this year, so we felt it was important to discuss this now.

Looking at the results for Pennsylvania samples collected in 2019 (and note, we're talking about only the isolates obtained from PA farms at this point), two fairly obvious trends regarding resistance emerged.

The first was that the isolates collected from the varieties that are the most susceptible to fruit anthracnose ('California varieties', in particular, 'Chandler', 'Camarosa', 'Albion', 'San Andreas', 'Seascape') were frequently resistant to azoxystrobin (the active ingredient in Abound), a category 11 fungicide. We cannot, however, sort out the varieties from plant material origin at this point, as the plant material of these varieties largely originated from either southern propagators or California nurseries. So, is this a variety effect, or a plant source effect? We really don't know.

The second interesting trend was that isolates obtained from "eastern" varieties and from nurseries where plant material was limited in its travels, were much more likely to be sensitive to azoxystrobin. Again, the variety effect, or plant source effect? We don't know. What we do know though, is that we can't rest on our laurels regarding resistance development with strains isolated from these plants either, as some resistance was found there, too.

Hindsight is 20-20 of course, and how this might have unfolded seems obvious now. Susceptible cultivars need to be sprayed more often than others. If they are sprayed over a period of decades (even if only a few times a year with a particular fungicide class), and with a fungicide that has a single site mode-of-action, resistant strains develop. We knew that could happen already, right? Add to this the fact that these varieties that are very susceptible to anthracnose also probably have been producing relatively more inoculum, and we are selecting for resistant strains every time we spray. The only surprise in all of this perhaps is that our fungicides work for as long as they do.

We knew the theories, but to what extent resistance development was happening was really a black box until we had the tools to see what was going on. While the resistance tests mentioned above were done with azoxystrobin, there is known cross-resistance to...
other fungicides in the category 11 fungicide class, so they are at risk, too. We don’t want to lose them when they do work, nor do we want to lose the companion active ingredients that are often included with them in pre-mixes.

It is probably safe to assume that your plants were exposed to some inoculum sources and that they picked up at least a little inoculum along the propagation path. So what’s best to do?

**Cultural Controls for All Growers**

- As always, do anything you can to improve airflow in the planting. This means good site selection with a site that slopes for air drainage if available, possibly increasing plant spacing slightly, and removing row covers promptly.
- Prevent weeds from getting established in the first place for many reasons, including the fact that apparently they can be hosts of *Colletotrichum* species too, and killing them with glyphosate or gramoxone makes the disease sporulate, as discussed in Part I. Remove the weeds from the field if they are large or cultivate lightly when weeds are small to control them. Consider smothering low-growing weeds with straw mulch so they decompose quickly.
- Try to avoid moving inoculum, which is easy to do. Work in infected areas and with susceptible cultivars last. Clean off equipment, hands, and clothes. If you aren’t washing your hands to stay healthy, here’s another reason – to avoid spreading anthracnose.
- Row covers aren’t a likely source of inoculum from season to season if stored relatively clean, but inoculum could be transported on them as they are dragged across an infected field – so try to watch how you move them.
- Anthracnose is primarily a rain-splashed disease, so try keeping straw tucked up close under plants. At a minimum, it will help keep the fruit clean.
- Especially if you are growing organically, consider trying low tunnels or high tunnels. Keeping plants dry equals no anthracnose.

**Key Points Regarding Fungicide Use**

- Think about which fungicides may be providing control, and which aren’t. If you suspect that resistance may exist in your plants to fungicides in category 11 (aka activity group 11, FRAC code 11, strobilurins, or QoI fungicides), avoid using category 11 fungicides because they may not be working, or if they are to a limited extent, they may not be for long. If using a pre-mixed product that combines a category 11 ingredient with one with another mode of action, avoid using the 11 + 7 combination, as the ‘7’ part doesn’t work on anthracnose.
- Regardless of whether you suspect resistance or not, proceed with caution when using category 11 fungicides, or any other single-site fungicides – you can use them, and they may still work really well, but be sure to rotate active ingredients or include a multi-site fungicide like captan with them.
- Make captan an integral part of your spray program either alone, or as part of a tank-mix. It has multi-site activity.
- Rotate fungicide mode of actions as much as you can. This is a “big ask” for some growers because if the fungicide is expensive and the package contains more product than that needed for just strawberries, it’s difficult to spend the money. But it’s important. Consider using effective products that are also labeled for non-Colletotrichum-caused diseases on other crops.
- If using single-site fungicides, use the low to mid-range rate on the label. There are several studies that indicate that using the highest rate for single-site fungicides actually increases resistance development to them.
- See the table below for fungicides grouped into categories by mode of action, and whether they have single-site or multi-site modes of action. Only fungicides receiving ’good’ or ‘excellent’ ratings for anthracnose control are listed in the table below. With a couple of the newer materials as noted in the table, some of these recommendations are based on lab results, not field tests, so use with caution.

**Fungicides for a spray program to control anthracnose fruit rot**

- Be sure to follow all label restrictions—the label is the law. The label supersedes the information presented here.
- Include the following product(s) in rotations or as a tank-mix partner.

<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>Example trade names and rates</th>
<th>Activity (FRAC) Group</th>
<th>Mode of action of a.i.(s)</th>
<th>Resistance risk*</th>
<th>Re-entry interval (hrs)</th>
<th>Pre-harvest Interval (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>captan</td>
<td>Captan 80 WDG**; 3.75 lb/a</td>
<td>M4</td>
<td>Multi-site</td>
<td>Low</td>
<td>24 hours</td>
<td>0 days</td>
</tr>
</tbody>
</table>
**Note that anthracnose fruit rot only appears on certain labels; PA allows the use of products for diseases other than those listed on the label as long as the use pattern remains the same.

If you suspect resistance to group 11 products on your farm, use captan as a "backbone" product for your spray program and rotate with or include the following products, being sure to include products from different activity groups.

<table>
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</thead>
<tbody>
<tr>
<td>cyprodinil + fludioxinil</td>
<td>Switch 62.5 WDG; 11 to 14 fl oz/a</td>
<td>9 + 12</td>
<td>Each is single-site</td>
<td>Medium</td>
<td>12 hours</td>
<td>0 days</td>
</tr>
<tr>
<td>pydiflumetofen + fludioxonil</td>
<td>Miravis Prime; 11.4 to 13.4 fl oz/a</td>
<td>7 + 12</td>
<td>Each is single-site</td>
<td>Medium to High</td>
<td>12 hours</td>
<td>0 days</td>
</tr>
<tr>
<td>polyoxin D zinc salt</td>
<td>Ph-D; 6.2 oz/a</td>
<td>19</td>
<td>Single-site</td>
<td>Medium</td>
<td>4 hours</td>
<td>0 days</td>
</tr>
<tr>
<td>propiconazole**</td>
<td>Tilt; 4 fl oz/a**</td>
<td>3</td>
<td>Single-site</td>
<td>Medium</td>
<td>12 hours</td>
<td>0 days</td>
</tr>
<tr>
<td>difenoconazole + cyprodinil**</td>
<td>Inspire Super; 16 to 20 fl oz/a**</td>
<td>3 + 9</td>
<td>Each is single-site</td>
<td>Medium</td>
<td>12 hours</td>
<td>0 days</td>
</tr>
</tbody>
</table>

*This material is included based on lab results; Field data is insufficient to determine a rating based on fieldwork.

If category 11 fungicides have worked well to control anthracnose in your production system, the following products may be used in addition to those listed above. Rotate chemistries and be sure to include multi-site fungicide (captan) with products that have one single-site mode of action.

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<th>Active Ingredient</th>
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<th>Activity (FRAC) Group</th>
<th>Mode of action of a.i.(s)</th>
<th>Resistance risk*</th>
<th>Re-entry interval (hrs)</th>
<th>Pre-harvest Interval (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>azoxystrobin</td>
<td>Abound; 6.0 to 15.5 fl oz/a (include captan)</td>
<td>11</td>
<td>Single-site</td>
<td>High</td>
<td>4 hours</td>
<td>0 days</td>
</tr>
<tr>
<td>pyraclostrobin</td>
<td>Cabrio EG; 12 to 14 oz/a (include captan)</td>
<td>11</td>
<td>Single-site</td>
<td>High</td>
<td>12 hours</td>
<td>0 days</td>
</tr>
<tr>
<td>trifloxystrobin</td>
<td>Flint Extra; 2.5 to 3.0 fl oz/a (include captan)</td>
<td>11</td>
<td>Single-site</td>
<td>High</td>
<td>12 hours</td>
<td>0 days</td>
</tr>
<tr>
<td>fluxapyroxad + pyraclostrobin</td>
<td>Merivon Xemium; 5.5 to 8 fl oz/a</td>
<td>7 + 11</td>
<td>Each is single-site</td>
<td>High</td>
<td>12 hours</td>
<td>0 days</td>
</tr>
<tr>
<td>fluopyram + trifloxystrobin</td>
<td>Luna Sensation; 4.0 to 7.6 fl oz/a</td>
<td>7 + 11</td>
<td>Each is single-site</td>
<td>High</td>
<td>12 hours</td>
<td>0 days</td>
</tr>
<tr>
<td>azoxystrobin + difenoconazole</td>
<td>Quadris Top; 12 to 14 fl oz/a</td>
<td>11 + 3</td>
<td>Each is single-site</td>
<td>High</td>
<td>12 hours</td>
<td>0 days</td>
</tr>
<tr>
<td>azoxystrobin + propiconazole</td>
<td>Quilt Xcel; 14 fl oz/a</td>
<td>11 + 3</td>
<td>Each is single-site</td>
<td>High</td>
<td>12 hours</td>
<td>0 days</td>
</tr>
</tbody>
</table>

* Derived from fungicide resistance risk determined by the Fungicide Resistance Action Committee. Where more than one active ingredient is contained in a product, the rating for the more at-risk ingredient appears.
References


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