MANAGING APPLE DISEASES WITH NEW FUNGICIDES

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Diseases during the NY during the 2015 season

Green tip came on time in mid to late April, but the weather was fairly dry throughout the month of May with few apple scab infections predicted. This left many orchards at bloom with massive amounts of mature ascospores waiting to be released in rains after petal fall in June. Following petal fall, sites in Western and Central NY and some in the Northeastern part of the state received several inches of rain at the end of May and throughout June. Such unprecedented weather during petal fall and early fruit development increased the risk of secondary apple scab infections, latent infections of bitter rot moldy core pathogens that would emerge at harvest or shortly after in storage. Against several inches of rainfall, even best fungicides on the shortest intervals would be of limited use and fungal disease control was likely less than satisfactory for many growers with problems only becoming apparent toward or shortly after harvest.

The warm dry weather prior to petal fall likely favored the development of powdery mildew inoculum, and the high humidity during the weather following the rains in late May and June further promoted secondary powdery mildew infections. By the end of season, powdery mildew seemed unstoppable in the drier areas of western NY particularly in plantings along the lakefront.

As with other seasons, the period from petal fall to 2nd cover remains the critical period for disease management. At the same time, this the key period for thinning and crop load management, which mandates the use of complicated spray mixes of thinners, foliage nutrients, and water conditioners. The use of such mixes at this time increases the risk of injury apples due to product incompatibilities. Due to the prevalence of chemical injury in western NY and New England in 2014, it is becoming important to shift from the use potentially phytotoxic protectant fungicides to low dose single-site fungicides during the period from bloom to 1st/2nd cover.

Overview of key single-site fungicide registered and used for apple disease management

Numerous fungicide chemistries ranging from protectants to single target site-specific systemic fungicides with antisporulant activity are registered for diseases of apples in the United States. Below is a brief list of the fungicide chemistries and the diseases of apple for which they are labeled to control. Several of the new chemistries mentioned have 24(c) SLN labels in NY, but many of the new products only have federal registrations.

Multi-site inhibitors: Mode of Action (MOA): multi-site contact inhibition

Multi-site inhibitor fungicides are generally inexpensive, have good protectant activity, are low risk for resistance development due to non-specific modes of action, but have little or no post-infection activity.

Inorganic: FRAC Codes: M1, M2;

Fungicides in this group include copper and sulfur-based products. These fungicides are inorganic in that they contain no carbon, but confusion may arise as fungicides in this group are labeled for organic production, and hence may be vernacularly referred as organic fungicides. This group includes the copper hydroxide, copper salt, and copper sulfate products, and the liquid lime-sulfur and wettable sulfur products. These fungicides are widely labeled for diseases in apple, but have higher potential for crop injury when concentrated on young plant tissues in slow drying conditions.

Organic: FRAC Codes: M3, M4 M5;
Fungicides in this group include mancozeb, ziram, and thiram (dithiocarbamates), captan (phthalimide), and chlorothalinil (chloronitrile). These have multi-site non-specific action and are at low risk for resistance, hence their persistence in the industry for several decades. With the exception of chlorothalinil, formulated products of these fungicides are widely labeled for apples, but have only protectant properties. In particular the use of captan with other products formulated with oil or penetrating surfactants in low spray volumes (50 gal/A) presents a considerable risk of phytotoxicity to trees with young fruit and leaves.

Single-site inhibitors
Single-site inhibitor fungicides are generally newer and therefore more expensive, have both protectant and post-infection activity, and have propensity for resistance development due to highly specific modes of action.
Thiophanate-methyl (thiophanates); FRAC Code: 1; MOA: Cell division
These fungicides include generics of Topsin-M, which is labeled apple scab, and summer fruit rots including gray mold and a few foliar diseases. They are benzimidazoles in terms of chemistry, which are high risk for resistance development. Benzimidazole resistance is widely prevalent in regional populations of *Venturia*, *Alternaria*, and in *Botrytis*.

Cyprodinil, Pyrimethanil (Anilinopyrimidines); FRAC Code: 9; MOA: Amino acid biosynthesis Scala and Vanguard are formulations of pyrimethanil and cyprodinil labeled primarily for apple scab and *Botrytis* diseases. Despite excellent activity against botrytis in the lab and the field, these AP fungicides are less effective against apple scab except in the early season when the weather is cooler. All of these fungicides have a propensity for resistance development.

Myclobutanil, Fenbuconazole, Flutriafol, Fenarimol, Difenoconazole (Demethylation Inhibitors); FRAC Code: 3; MOA: Sterol biosynthesis inhibition
Sterol demethylation inhibiting (DMI) fungicides are considered to be fairly potent fungicides with good post-infection activity. Rally 40WSP (Myclobutanil) has been the DMI mainstay for the management of apple scab, powdery mildew, rusts, and other fungal foliar diseases. Flutriafol (Topguard) is similar in efficacy to myclobutanil, and as such, is highly effective on powdery mildew and rust diseases. Indar 2F (Fenbuconazole) and Inspire Super (difenoconazle) contain highly potent DMIs and are effective against DMI resistant *V. inaequalis* populations in the region.

Azoxystrobin & Pyraclostrobin (Quinone outside Inhibitors); FRAC Code: 11; MOA: Respiration inhibition

Quinone outside Inhibitors (QoI) (a.k.a. Strobulurins, Strobys) are newer fungicides and are considered slightly less potent than the SIs, but also have good systemic and post-infection activity. Kresoxim-methyl (Sovran) was one of the first QoI fungicides available and is labeled for numerous apple diseases including, apple scab, powdery mildew, and fruit rots. Flint WG (trifloxystrobin), Pristine WG {Pyraclostrobin & boscalid (Dicarboximides; FRAC Code 2)}, and Merivon {pyraclostrobin & fluxapyroxad (Dicarboximides; FRAC Code 2)} are some of the newer QoI fungicides and are widely labeled for apple diseases. Unfortunately, qualitative resistance to QoI fungicides has emerged in *V. inaequalis* populations in MI, NY, and several New England States. At the sites in which it occurs, these fungicides are no longer effective.

New! Fluxapyroxad, Penthiopyrad, & Fluopyram, Isofetamid, Benzovindiflupyr (Succinate Dehydrogenase Inhibitors); FRAC Code: 7; MOA: Respiration inhibition
Succinate Dehydrogenase Inhibitors (SDHIs) are a group of newly developed fungicides in a chemistry previously available on apples in the form of boscalid. The new chemistries are much more potent than the previously available boscalid and are also systemic with post-infection activity. Fluxapyroxad is premixed with pyraclostroin in the product Merivon, which has strong activity against all apple diseases. Similarly, fluopyram is mixed with trfloxystrobin or cyprodinil in Luna Sensation or Luna Tranquility, respectively. Interestingly, pethiopyrad (Fontelis SC), isofetamid, benzovindiflupyr (Aprovia) are formulated singly allowing flexibility of tank mixing for resistant management. Currently, we have been able all of these fungicides on apple scab and powdery. Alone, these fungicides work well on apple scab, but only have some activity against powdery mildew. Qualitative resistance to SDHI fungicides has emerged in *Botrytis* and *Alternaria* populations in strawberries and stone fruit, but *V. inaequalis* populations have been still fairly baseline for the last three years.

Fungicide resistance concerns for apple scab and powdery mildew in NY
Resistance to nearly all of the major classes of fungicides has been reported for the apple scab pathogen in NY. Fortunately, fungicide resistance is highly site specific and growers who have been successfully been using a certain fungicide may effectively continue to do so if: the number of application are kept to no more than four applications, protectant fungicides are included in tank mixes, and fungicide class rotation is practiced. Resistance to the anilinopyrimidine is still rare and resistance to SDHI fungicides has not been confirmed in the apple scab pathogen. The DMI (e.g. Rally 40 WSP, Vintage SC, Indar 2F, and Inspire Super) and QoI (Flint WG and Sovran) fungicides are some of the safest and most effective fungicides for use against apple scab. However, many apple scab populations throughout NY and the Northeastern United States have developed a moderate to high level of resistance to all, but the most highly effective DMI fungicide chemistries difenoconazole (Inspire super) and fenbuconazole (Indar 2F). By comparison, dodine has re-emerged as an effective tool again apple scab, but it restricted to two uses during the pre-bloom season.

Compared to diseases such as apple scab and fire blight, powdery mildew, caused by *Podosphaera leucotricha*, is not a devastating disease of apples in the eastern United States. However, this disease can cause considerable foliar damage on highly susceptible apple cultivars including ‘Cortland’, ‘Idared’, ‘Gingergold’, and ‘Jonagold’ to name a few. Symptoms of infection include a powdery white blight of young leaves and shoots in addition to fruit russeting. Severe mildew infections can lead to reduced yields from aborted blossoms, poor return bloom,

and compromised shoot growth. Apple powdery mildew is managed by fungicide programs applied during apple scab infection periods because susceptible phenological stages for both diseases often overlap. The DMI fungicides with high solubility have excellent activity against powdery mildew, and the widespread use of DMIs in apple scab fungicide programs in NY has likely kept powdery mildew in check. However, DMI resistance in NY apple scab populations has raised concerns regarding DMI resistance in mildew populations. Field trials in NY and West Virginia suggest that SI applications at lower label rates are becoming insufficient to control mildew in the region. Moreover, some the newer DMI fungicides that are more effective against DMI resistant apple scab are less effective against powdery mildew.

Following the development of molecular tools for apple scab, we were able to look for the mutation in cyt b gene in powdery mildew, which is responsible for QoI fungicide resistance. At research blocks in Geneva, more than 50% of the copies of the cyt b gene have the mutation for resistance, but oddly enough, the QoI fungicide flint continues to provide a high level of powdery mildew control.

2015 trial results from Geneva indicated that:

1. Fungicide products containing difenoconazole (Inspire Super) or fenbuconzaole (Indar 2F) are still effective against DMI-resistant apple scab on susceptible cultivars and less effective against powdery mildew. Against powdery mildew, these provide a level of control comparable to a QoI fungicide. These differences in control only become apparent toward the season's end.
2. In an orchard with an apple scab population with both QoI and DMI resistance, Mervion, Aprovia, Luna Tranquility, Fontelis, and Isofetamid provide a fairly high level of apple scab control. Interestingly, the efficacy of the Mervion is not affected by the development of resistance to QoI fungicides in the apple scab population. Of the aforementioned products, only Merivon has consistently provided a high level of control of apple powdery mildew.
3. Fungicide products containing flutriafol (Topguard) or myclobutanil (Rally 40WSP) are weaker against DMI-resistant apple scab, but are still some of the most effective fungicides against powdery mildew, especially on susceptible cultivars. At maximum rate of 8 oz/A, Rally 40WSP performs much more like Inspire Super, but with increased mildew control. Adding sulfur at a rate of 3lbs/100gal from tight cluster to 1st cover seems to improve powdery mildew control of DMIs on highly susceptible varieties.
4. Interestingly, the addition of mixing partner such as captan or mancozeb to a strong mildew fungicide (Topguard, Rally 40WSP, or Merivon, or Luna Sensation) seems to diminish the ability of the fungicide to manage powdery mildew compared to programs where the fungicides were applied alone.
5. Treatment programs that received Inspire Super, Merivon, or Pristine during summer covers had a similar to lower severity of mildew at harvest compared to those receiving a highly effective fungicide such as Topguard or Rally 40WSP in the primary scab season, but only received captan in the summer covers.
6. Take caution with the use of captan, sulfur, and copper fungicides from petal to 10-15mm fruit size. At thinning, timings consider using the DMIs or QoI fungicides which are historically safer to use in complicated tank mixes.

Preparing for apple scab and powdery mildew in 2016

In 2016 growers should be poised to deal with pre-season apple scab inoculum, powdery mildew carry over inoculum in buds, and variable seasonal weather. The level of powdery mildew inoculum and apple scab inoculum will vary from site to site depending on the success of the 2015 program. Regardless, growers along the great lakes with endemic powdery mildew problems should begin proactively managing powdery mildew. Although the newer fungicide chemistries/products like Aprovia and Isofetamid may be available in NY in 2016, growers will need to address both apple scab and powdery mildew with the products currently available. To manage both diseases in 2016, consider matching the fungicide program to either variety susceptibility or seasonal weather. If the acreage is primary planted to scab susceptible varieties such as those with a 'McIntosh' background, use a DMI or newer SDHI material with a strong activity against scab that still provides some mildew control at bloom to 1st cover. On varieties that are highly susceptible to mildew, consider using a DMI or newer SDHI material with strong activity against mildew mixed with an appropriate rate of protectant from bloom to 1st. If your operation is along the great lakes, consider including sulfur 3lbs/100 gal in each application from tight cluster to 2nd cover if there is no modern fungicide product with mildew activity in the tank. When you do choose to use one of the newer single-site fungicides, bear in mind that a single application may not provide a substantial benefit. The successes of the new products in research trials is often contingent using the labeled maximum number of applications allowed for a season (i.e. 4 applications). Finally, take caution with the use of captan, sulfur, and copper fungicides from petal to 10-15mm fruit size. At thinning, timings consider using some of the DMIs or QoI fungicides in combination with mancozeb if possible. In regards to the SDHIs, we've done extensive testing with only some of them in crop response trials. While we've found Merivon to be safest of the SDHI products in our crop response trials, label language prevents its use in large tanks mixes.