Disease Management

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Management of Diseases in the Field

Tobacco diseases are responsible for lost revenue to growers each year as a result of reduced yield and leaf quality. Actual losses vary from year to year and farm to farm, depending upon the weather and diseases present. Tobacco is threatened by disease from seeding until harvest (and even during the curing process). As with transplant diseases, discussed earlier in this guide, the key to success in controlling diseases during field production is prevention. In almost every case, it is far easier to prevent disease than to stop it after an epidemic has gained momentum. And even if an outbreak of disease is brought under control through some type of rescue treatment, few of which are available for tobacco, yield losses can still occur and the quality of the crop can be reduced. Quality is especially important for dark tobacco due to the low tolerance of manufacturers for leaf spots and other disease-related damage.

Implementing a preventive disease management program means that control measures must be carried out, or be in place, before disease appears. Field selection and choosing varieties and fungicides are decisions that should be made well in advance of seeding transplants to ensure availability of land, seed, and chemicals. Choosing the practices to be implemented requires knowledge of field history (previous crops, prevalent diseases, field characteristics) and an awareness of the diseases that affect tobacco. Following are recommended practices and tips for managing tobacco diseases in the field.

General Considerations

Take full advantage of resources to monitor and manage disease. During the growing season, check crops regularly for signs and symptoms of disease. If preventive programs are not already in place, best control of diseases will be achieved if action is taken early in an outbreak. Correct diagnosis of diseases is the first step in bringing these problems under control. If the cause of a problem is in doubt, local extension agents should be consulted. Your agent can help get a correct diagnosis through a plant diagnostic laboratory. Tobacco-related extension publications are available at your county extension office.

Avoid planting tobacco in areas with histories of severe disease problems. One of the best ways to keep a particular disease from affecting a crop is to not plant tobacco in areas where problems have occurred in the past. This practice can be an effective way to manage black shank and Fusarium wilt. If plant viruses have been a significant problem in the past, avoid areas with large unmanaged populations of weeds.

Plant at optimum time for your location and situation. Each area where tobacco is grown has an optimum window for planting depending on the local climate. Planting early in that window may result in more significant problems from black root rot and black shank when varieties susceptible to these diseases are planted. In determining optimum planting date, the length of the growing season must be considered along with the history of past disease problems for the location. Overall, any environmental aspect (soil moisture, compaction, very hot temperatures, etc.) that stresses young transplants has potential to make them more susceptible to disease.

Rotate with non-related crops. Crop rotation is a highly effective tool for preventing and managing diseases, particularly those caused by soilborne pathogens and nematodes or those that result from carry-over in crop debris. Do not follow tobacco with tobacco, especially if black shank, black root rot, or Fusarium wilt are observed in a field. Regular rotation away from tobacco and related crops deprives pathogens of their preferred nutrient source, slowing their buildup or causing their numbers to decline over time. The effectiveness of rotation improves as the length of time away from tobacco is increased. Three to five years out of tobacco after a single season in tobacco should provide good control of soil-associated diseases for most growers. Although less than ideal, short rotational intervals can reduce disease pressure in fields after a serious disease outbreak, but longer intervals between susceptible crops are more effective. Unfortunately, crop rotation is not effective against all diseases. Diseases caused by pathogens that don't overwinter in soil or on plant debris, like blue mold, are not affected by crop rotation.

Select and prepare sites properly. Do not set plants into saturated soils or in areas that tend to accumulate water. Choose a site that is well drained to avoid soil saturation and problems with black shank. Install ditches or drain tiles if needed to promote good soil drainage. Select sites that are not excessively shaded and have good air movement in order to suppress diseases like target spot, frogeye leaf spot, and blue mold. Incidence of alfalfa mosaic virus is often linked to adjacent alfalfa fields. Do not plant tobacco adjacent to areas where vegetables are produced, as many vegetable crops (especially tomatoes and peppers) can harbor viruses that can move into tobacco by insect vectors. By the same token, don't plant tomatoes or peppers in tobacco fields. Manage weeds, both in and directly adjacent to fields, to reduce their influence as sources of viruses and some fungal pathogens.

Exclude plant pathogens from the field. Plant pathogens often travel from infested to clean fields on vehicle tires, farm equipment, farm animals, and shoes. Cleaning and sanitizing equipment and shoes with 10% bleach between fields will reduce disease spread from one field to another, but this is time-

consuming and could be impractical for many growers. Another solution that should reduce soil-associated disease spread would be for a grower to work their least diseased fields first, and end the workday with the most diseased areas. A thorough equipment cleaning at the end of the day is then recommended. This is particularly important when you know that only some fields contain diseases like black shank and Fusarium wilt, and when commercial or shared equipment moves into your field from different areas. To avoid introducing pathogens, don't discard stalks from fields with black shank and other diseases in clean fields or near sources of surface water (streams, ponds, etc.). Use transplants produced as locally as possible. The further south plants are produced, the more likely they may be to have been exposed to blue mold, and their importation could start an outbreak early in the season.

Plow cover crops early. This practice will ensure that plant matter decomposes thoroughly before setting time. Sore shin and black root rot can be problems in fields with high levels of partially decomposed organic matter. Heavily manured fields may have higher severity of black root rot. Turn tobacco roots and stubble under soon after harvest to promote decomposition and a more rapid decline of soilborne pathogens.

Manage soil fertility and pH. Keep soil pH within recommended ranges during the growing season. Do not over fertilize, as it favors development of angular leaf spot, blue mold, and black root rot. However, low nitrogen levels can contribute to severe outbreaks of target spot and brown spot, so be sure to use recommended, moderate amounts of nitrogen fertilizers for optimal crop production.

Go to the field with healthy transplants. Don't set plants with *Pythium* root rot or other diseases. Diseased plants tend to take longer to establish and are more likely to be affected by black shank and sore shin. Do not set plants that have blue mold, and destroy them immediately. Such plants will almost always die. If they do survive, they will not thrive and will serve as a source of spores for outbreaks in surrounding fields. Avoid tobacco use (smoking or chewing) during setting to prevent the transmission of tobacco mosaic virus.

Plant disease-resistant varieties. Select varieties with resistance to the diseases that you anticipate to be a problem. Varieties are available with good resistance to diseases such as black shank, blue mold, Fusarium wilt, virus complex, tobacco mosaic, and black root rot (see the variety selection articles on pages 3 and 7). Look at the entire resistance "package" when choosing a variety, as levels of resistance to individual diseases can vary and may not be appropriate for some fields. For example, NC 2002 has good resistance to blue mold but no resistance to black shank and would be a poor choice to plant in areas where black shank has been a problem. Varieties such as KT 206 and KT 209 are great choices for black shank fields but are completely susceptible to Fusarium wilt. While KT 210 and KT 215 possess increased resistance to Fusarium wilt, in addition to moderate to high resistance to black shank, neither is resistant to aphid-transmitted viruses.

Use fungicides correctly. Timely and accurate application of fungicides is essential for best performance. The following are some general guidelines for successful use of fungicides to manage tobacco diseases:

- **Do not use products that are not approved for tobacco.** By the same token, don't use tobacco-approved products in ways that are not outlined on the products' labels. Pay attention to safety precautions, preharvest intervals, and observe guidelines for resistance management.
- **Apply fungicides preventively, or at the latest when first symptoms of disease appear.** Most products labeled for tobacco are protectants and must be in place before the arrival of the pathogen to suppress infection. Applications made after a disease has become established will be less effective, or worse, may not be successful at all. Maintain recommended application intervals while disease threatens or the weather favors disease. When high levels of disease are present, applying fungicides with a specific mode of action (such as Quadris or Forum) could lead to resistance development in certain plant pathogens, which is another reason to apply fungicides preventatively.
- **Use an application volume that gives the best coverage of plants.** For most fungicides, this amount will change as the crop grows. For foliar fungicides in general, use 20 gal/A near transplanting, increasing to 40 gal/A when plants are knee-high, 60 gal/A when plants are waist-high, 80 gal/A when plants are chest-high, and as much as 100 gal/A for applications made at topping or afterward. Spray pressure should be between 40 and 100 psi. As application pressure increases, so does foliar fungicide coverage as well as the risk of drift. As the crop grows, configure sprayers, if possible, with one nozzle centered over the row and multiple nozzles on drop extensions to allow for good coverage in the middle and lower canopies. Fungicide sprays for soil-associated diseases (e.g. black shank) should be directed toward the base of plants and cultivated in for best results.
- **Calibrate sprayers for accurate delivery** to ensure the crop receives neither too little fungicide (poor disease control) nor too much (extra cost and potential injury). Regularly clean nozzles, and change them as they become worn. Nozzle replacement is an extra expense that will pay for itself in the long run. When purchasing nozzles, consider ceramic or stainless-steel tips. These types of nozzles are more expensive than their brass counterparts but last longer and are accurate.
- **Harvest in a timely manner and correctly manage barns.** Over-mature tobacco is more prone to leaf-spotting diseases, such as brown spot. Manage humidity levels in barns to avoid houseburn and barn rots.

Common Diseases and Their Management

Angular leaf spot and wildfire. In recent years, angular leaf spot has become an influential disease in dark tobacco, but overall these bacterial diseases are minor issues for burley producers. Crop rotation and good sanitation practices can be useful in suppression of angular leaf spot and wildfire. The majority of burley varieties are resistant to wildfire, but not angular leaf spot. Many dark varieties are very susceptible to angular leaf spot, though recent work has suggested that varieties with wildfire resistance tend to have less angular leaf spot. Dark tobacco cultivars DF 911, TN D950, KT D6LC, KT D14LC, and PD 7305LC all possess high resistance to wildfire. See Selecting Dark Tobacco Varieties on page 7 for more information. Use of chemicals to manage these diseases is marginally effective; however, agricultural streptomycin (Table

Table 1. Guide to chemicals available for control of tobacco diseases in the field, 2015—foliar applications.

Chemical (Fungicide FRAC Code)	Product Rate Per		PHI[b] (days)	Target Diseases	Label Notes
	Application[a]	Season			
Agricultural Streptomycin, Agri-Mycin 17, Harbour (25)	100-200 ppm (4-8 oz/50 gal H_2O)	no limit	0	wildfire, angular leaf-spot, blue mold	Use low rate for prevention and higher rate when disease is first observed or in areas with a history of angular leaf-spot.
Actigard 50WG (P1)	0.5 oz	1.5 oz (3 apps.)	21	blue mold	Begin applications when plants are >18 inches[c] in height. Actigard *must be applied 4-5 days prior to infection* to allow for activation of plant defense compounds. *Do not apply to plants that are stressed* from drought or other environmental factors. Make up to 3 applications in at least 20 gal/A on a 10-day schedule.
Forum (formerly Acrobat) (40)	2-8 fl oz	30 fl oz	0	blue mold	Increase rate and application volume (20-100 gal/A) as crop size increases. Forum must be tank-mixed with another blue mold control product, such as mancozeb, for resistance management. Neither Ridomil Gold, Ultra Flourish, MetaStar, Revus, nor Actigard are recommended as tank-mix partners for Forum. Do not mix with surfactants, foliar fertilizers, or sucker control materials.
Revus 2.08SC (40)	8 fl oz	32 fl oz	7	blue mold	Begin applications before blue mold symptoms appear. Continue on a 7-10 day schedule. Make no more than two consecutive sprays before switching to a fungicide with a different mode of action (do not alternate with Forum). Addition of a surfactant (spreader/penetrator or non-ionic) may enhance activity.
Orondis Ultra A (U15)	2.0-4.8 fl oz	19.2 fl oz	7	blue mold	Use higher rates when disease is already present. Increase rate and spray volume (20-100 gal/A) as crop size increases. For resistance management, must be tank-mixed with ½ pt Revus; make no more than 2 sequential applications before rotating to a fungicide with a different mode of action, and do not use if Orondis Gold 200 was applied for black shank control.
Presidio (43)	4 fl oz	8 fl oz	7	blue mold	Apply as a foliar spray prior to disease onset or at first sign that blue mold is in the area. For resistance management, must be tank mixed with another fungicide of different mode of action (FRAC class). A second application can be made with a minimum 7-day interval after the first application. Do not use if Presidio was previously applied for black shank control.
Quadris 2.08SC (11)	6-12 fl oz	32 fl oz	0	target spot, frogeye, blue mold	Begin applications before blue mold symptoms appear. For blue mold, continue sprays on a 7-14 day schedule (use the shorter spray interval when conditions favor disease). If blue mold is present in the field, apply Forum tank-mixed with a mancozeb fungicide, Revus, or Orondis Ultra prior to using Quadris. Do not make back-to-back sprays, but alternate with a different fungicide labeled for tobacco. Can be used up to the day of harvest, but minimize post-topping application, as fungicide residues are a significant industry concern. Do not mix with EC-type pesticides or with sucker control materials.
Mancozeb (Manzate Pro-Stick, Penncozeb DF) (M3)	1.5-2 lb	no limit	30	blue mold, anthracnose	Mancozeb residues are an industry concern, so use this product only as a tank-mix with Forum or Presidio, alternated with Quadris, Revus or Orondis Ultra. To minimize the risk of high residue levels do not apply later than 7 weeks after transplanting. Only Manzate ProStick is labeled in most burley states, while Penncozeb DF and Roper DF Rainshield are labeled in VA.
Aliette WDG (33)	2.5-4 lb	20 lb	3	blue mold	Make first application immediately after transplanting; continue on a 7-10 day schedule. Increase rate and application volume (20-100 gal/A) as crop size increases.

[a] Rate range of product PER ACRE. In general, use the highest labeled rates when disease pressure is high. Refer to product label for application information, restrictions, and warnings.

[b] Preharvest interval.

[c] Actigard can be applied to dark tobacco varieties at the 12-inch stage.

1) can be applied preventively or after symptoms first appear at 200 ppm (16 oz/100 gal). Continue applications while conditions favor disease development (typically warm, wet conditions or frequent thunderstorms with high winds).

Black shank. Black shank is by far the most important disease of burley and dark tobacco. Use good sanitation practices to prevent introduction and spread of the pathogen. Once introduced into a field, the black shank pathogen (*Phytophthora nicotianae*) can never be completely eradicated. Crop rotation is a key consideration in both prevention and management of black shank. Simply put, there's no better tool to manage black shank than crop rotation. The black shank pathogen survives and reproduces mainly on tobacco, so continuous planting of tobacco will lead to increased populations over time. Rotation slows the buildup of *P. nicotianae* and other pathogens in the field by depriving them of their preferred host. Rotation away from tobacco for even a year will reduce disease; however, rotations of three to five years have the greatest impact on black shank. A number of crops serve as good rotation partners with tobacco, including grass hay and pasture, corn, soybean and sorghum. Legumes (soybeans, alfalfa, clover, etc.) and vegetables will reduce black shank levels, but may promote the buildup of other soilborne pathogens responsible for diseases like black root rot.

Field location is an important consideration for managing black shank. Fields with relatively high soil pH levels have been associated with increased disease. Avoid planting in fields that are down slope from areas that have had black shank in the past or those that could receive water runoff from infested fields. Steps should be taken to minimize soil saturation, since these conditions favor infection by *P. nicotianae.* Eliminate areas in fields where water stands, or install tiles to improve drainage. Keep in mind that, if irrigating, water from ponds, rivers, or creeks could be contaminated with the black shank pathogen, and using water from these sources could result in severe problems with black shank in the future.

Using a resistant variety is an excellent tool for managing black shank, and choosing the right variety is one of the most important management decisions a grower will make. Resistant varieties combined with good crop rotation and a sound fungicide program offer the best possible control of this disease. Black shank can be caused by several races of *P. nicotianae,* but in burley tobacco is now almost always caused by race 1. Either race 1 or race 0 may be problematic in dark tobacco. Burley tobacco cultivars KY 14 x L8LC, KT 206LC, KT 209LC, KT 210LC, KT 212LC, KT 215 LC, NC7 LC, HB 3307PLC, and HB 4478PLC, and dark tobacco cultivars KT D14LC, PD 7302, PD 7305, PD 7309, PD 7318, and PD 7319LC all possess a source of black shank resistance (the Ph_1 or Ph_p genes) that provides a resistance rating of "10" for race 0, but vary significantly in their (lower) resistance to race 1. Common burley varieties and their resistance ratings to black shank can be found in Selecting Burley Tobacco Varieties on page 3. See Selecting Dark Tobacco Varieties on page 7 for a list of commonly grown dark varieties and their levels of black shank resistance.

Field history, in terms of crops and varieties grown and previous severity of black shank, should be considered when deciding on a variety to grow. Planting a variety with little or no resistance (0-3 on the rating scale) may be, but is not always, "safe" in fields with no history of disease. Fields with a history of black shank and/or a short crop rotation interval should be planted with cultivars possessing at least moderate to high resistance to race 1 (4-8 on the rating scale). These cultivars also possess resistance to race 0 that is as least as high, or higher, than that to race 1. The safest bet for growers is to also supplement use of black shank resistance with use of a black shank fungicide in transplant water.

For chemical control of black shank, use products containing oxathiapiprolin (Orondis Gold 200), fluopicolide (Presidio), mefenoxam (Ridomil Gold, Ultra Flourish), or metalaxyl (MetaStar), (Table 2) in conjunction with resistant varieties (4 or better on the rating scale) and crop rotation. As with all fungicides, ensure the product intended to be used is labeled for use in your state. In most cases, fungicides will not provide acceptable control of black shank if applied to varieties with little or no resistance, nor will a single fungicide application provide acceptable black shank control. Good soil moisture is needed for best performance of these products because root uptake is required for them to be effective. If black shank fungicides are used pre-plant, they should be applied no more than 7 days before planting, and at the rates found in Table 2. Use a volume of water or fertilizer sufficient for good soil coverage and incorporate into the top 2 to 4 inches of soil by disking or irrigation. The Ridomil Gold and Ultra Flourish labels also allow the initial soil application to be made as soon as possible after transplanting and has the advantage of concentrating the chemical in a band. However, its success depends on adequate soil moisture; irrigation or rainfall may be needed for activation when soils are dry. Transplant water use of Ridomil Gold is labeled at 4 to 8 fluid ounces per acre (depending on soil type), while transplant water application of Orondis Gold 200 should include 4.8 fluid ounces of product plus Ridomil Gold for early season *Pythium* control and to avoid fungicide resistance development. Both transplant water uses require at least 200 gallons of transplant water per acre to avoid damage to plants. Presidio should not be applied in the transplant water. For full season control of black shank, supplemental applications of Ridomil Gold (1 pt), Presidio (4 oz/A), Orondis Gold 200 and Ridomil Gold (4.8 and 4 to 8 fluid ounces, respectively), Ultra Flourish (2 pt), or MetaStar (2 qt) can be made at layby OR at first cultivation and again at layby. The MetaStar label prohibits post-plant applications when more than 2 qt of MetaStar was used prior to planting, or if none was used. Applications of these black shank fungicides should total no more than 3 pt/acre for Ridomil Gold, 38.6 fluid ounces of Orondis Gold 200, 12 fluid ounces of Presidio, 6 pt/acre for Ultra Flourish, or 6 qt/acre for MetaStar. These field sprays should be directed toward the soil and incorporated immediately by cultivation. Do not apply these products over the top later in the season, since any chemical intercepted by tobacco leaves will not be taken up by the roots, reducing the effectiveness of the treatment. Development of fungicide resistance is a real concern for Presidio and Orondis Gold 200. For this reason, rotate the products applied when multiple fungicide applications are made in a single growing season. For example, if Orondis Gold plus Ridomil Gold is applied in transplant water, Presidio should be applied at first cultivation or layby to reduce the risk of fungicide

Table 2. Guide to fungicides available for control of black shank. Do not use for black shank control in Pennsylvania.

Fungicide (FRAC Code)	Season Rate/A	Pre-plant or at-planting applications			Post-plant applications	
		Method	Rate/A*	Remarks	Rate/A*	Remarks
Orondis Gold 200 (49)	36.4 fl oz	transplant water or post-plant	4.8 fl oz	Apply mixed with 6-8 fl oz Ridomil, at planting in-furrow or in transplant water. Rates up to 19.2 fl oz/A are labeled, such as in heavier soils. Apply in no less than 200 gallons of transplant water per acre.	4.8 fl oz	Apply mixed with 6-8 fl oz Ridomil, as a banded post-plant application to the soil at 1st cultivation or layby. Rates up to 19.2 fl oz/A are labeled, such as in heavier soils. Do not use if Orondis Gold has already been applied.
Presidio (43)	8 fl oz	na	NA	NA	4 fl oz	Make banded application directed at soil beneath leaves at 1st cultivation or layby.
Ridomil Gold SL (4)	3 pt	transplant water + post-plant	¼-½ pt	Apply in no less than 200 gallons of transplant water per acre.	1 pt	Make subsequent application(s) at 1st cultivation and/or layby.
		pre-plant + post-plant	1 pt	Apply to soil within 1 week before planting and incorporate into the top 2-4 inches of soil.	1 pt	Make 1st application as near as possible to transplanting if no pre-plant application was made or if black shank is expected early in the season. Otherwise, make application(s) at layby or at 1st cultivation and layby.
		pre-plant only	1-2 pt	Apply to soil within 1 week before planting and incorporate into the top 2-4 inches of soil.	----	----
Ultra Flourish (4)	6 pt	pre-plant + post-plant	2 pt	Apply to soil within 1 week before planting and incorporate into the top 2-4 inches of soil.	2 pt	Make 1st application as near as possible to transplanting if no pre-plant application was made or if black shank is expected early in the season. Otherwise, make application(s) at layby or at 1st cultivation and layby.
		pre-plant only	2-4 pt	Apply to soil within 1 week before planting and incorporate into the top 2-4 inches of soil.	--	--
MetaStar 2E (4)	12 pt	pre-plant + post-plant	4 pt	Apply to soil just prior to planting and incorporate into the top 2-4 inches of soil.	4 pt	Do not make a post-plant application of MetaStar if more than 4 pt was used pre-plant or if none was used pre-plant. Post-plant application(s) may be made at layby or at 1st cultivation and layby.
		pre-plant only	8-12 pt	Apply to soil just prior to planting and incorporate into the top 2-4 inches of soil.	--	--

* Rate range of product. In general, use the highest labeled rates when disease pressure is high. Refer to product label for application information, restrictions, and warnings.

resistance development. Black shank is listed on the labels of some soil fumigants, but these are not intended to replace early fungicide applications for black shank. Overall, fumigation is meant to broaden control of other soilborne pathogens (when present), and fumigation is not cost effective if black shank is the only target.

Black root rot. Once one of the most destructive diseases of burley tobacco, black root rot is now only a sporadic problem. Resistance to black root rot in many burley varieties has reduced the importance of this disease in recent years. However, dark varieties generally lack resistance to black root rot. Despite the decreased importance of black root rot, *Thielaviopsis basicola* is present in soils in many parts of the region and could pose problems to producers who do not rotate routinely or plant varieties with little or no resistance to this disease.

Use good sanitary practices to avoid introduction of *T. basicola*. Once introduced into a field, the black root rot pathogen can persist in soil for a number of years. This disease can be managed successfully through an integrated approach that includes crop rotation and resistant varieties. Do not follow leguminous crops (snap beans, soybeans, clover, alfalfa) with tobacco. By-products from decomposition of rye and barley residues are also believed to increase the susceptibility of tobacco to the black root rot fungus, making these crops a risky choice

for cover crops in areas with a history of the disease. Avoid planting in cool soils and excessive use of lime (keep soil pH between 6.0 and 6.4 for burley). Black root rot can be aggravated by high amounts of undecomposed organic matter. Incorporate manure and cover crops early in the spring to permit as much decomposition as possible before transplanting. Soil fumigants are labeled for suppression of black root rot, but their use may not be economically practical in most situations.

Blue mold. Blue mold has caused serious losses in years when cool and rainy conditions have prevailed, particularly early in the season. The blue mold pathogen, *Peronospora tabacina*, does not normally overwinter in traditional burley growing areas and requires a living host to survive. When tobacco is killed by frosts or freezes in late fall, surviving *P. tabacina* is eliminated as well. Epidemics of blue mold normally begin with the introduction of *P. tabacina* from areas (typically, frost-free areas) where the pathogen may overwinter. In rare cases, the blue mold pathogen may overwinter in burley regions on tobacco in protected environments (old float beds or greenhouses), which is a key reason to ensure that unused tobacco is destroyed after transplanting in the spring. Management of blue mold should begin with the use of disease-free transplants; avoid transplants produced south of Tennessee. If planting into areas that are prone to blue mold, select a variety with partial resistance (see the variety selection articles on pages 3 and 7).

Chemicals registered for control of blue mold are listed in Table 1. Fungicides are good, but not perfect, tools for managing blue mold if used properly. Begin fungicide applications for blue mold control when the disease is forecast to threaten your area or has been found nearby. Contact your county Extension agent for disease advisories. Once blue mold has been reported or threatens an area, fungicides should be applied at regular intervals as long as conditions favor development of the disease.

Quadris is labeled for control of blue mold, frogeye, and target spot. While not as effective against blue mold as Forum + mancozeb, and perhaps Revus, Orondis Ultra, and Presidio, our results indicate that Quadris provides consistent and effective control of blue mold if applied on a preventative basis. Keep in mind that Quadris has limited systemic activity. Do not make Quadris the first fungicide application when blue mold is found in a field. Applications of this product should begin before symptoms are observed in the field, when blue mold threatens. If blue mold is present in a field, apply Forum tank-mixed with mancozeb, or Revus, Orondis Ultra, or Presidio, and follow with Quadris seven to ten days later. Do not make back-to-back applications of Quadris; rotate to another fungicide or program (mancozeb or Forum + mancozeb) after each application of Quadris. Good coverage is critical in getting good foliar disease control, and using drop nozzles is the only way to obtain good coverage of mid-stalk and lower leaves. Boom sprays cannot provide good coverage beyond the upper leaves. Quadris can be applied up to the day of harvest, making this fungicide a good option for post-topping control of other leaf-spotting diseases, but applications after topping can often result in residues on leaf that are unacceptable to the industry. In certain cases, injury in the form of flecking has been associated with the use of Quadris on tobacco and has been severe. However, significant loss of yield or quality is extremely rare. Damage from Quadris is more likely when applied as a tank-mix. Severe damage can occur when it is mixed with sucker control materials or EC pesticides.

Other options for blue mold control include Forum, Revus, Orondis Ultra, Presidio, Manzate ProStick or Penncozeb (mancozeb products), Aliette WDG, and Actigard. Forum is a liquid formulation of dimethomorph, the same active ingredient found in Acrobat 50WP, a product no longer on the market. Resistance management is an important consideration with Forum, Orondis Ultra, Presidio, and Revus. According to the Forum and Presidio labels, these products must be tank-mixed with another blue mold fungicide for management of resistance; mancozeb works well in this role. Revus and Orondis Ultra are labeled only for control of blue mold; Orondis Ultra is a mixture of a new fungicide ("Orondis") with Revus. Revus and Forum have the same mode of action and should never be tank-mixed together or sprayed sequentially with each other. Presidio must not be applied for blue mold control if already applied as a black shank treatment, and Orondis Ultra must not be used for blue mold control if Orondis Gold 200 has already been applied for black shank control. Growers must not make more than two consecutive applications of any of these newer blue mold fungicides, but alternate among fungicides with different modes of action when multiple blue mold sprays are necessary.

Actigard remains one of our best options for blue mold control. It is a systemic product that functions by inducing plant defenses and, thus, is not a true fungicide. Coverage is not as critical with Actigard as with other fungicides, so this product may be applied with standard broadcast-type equipment and will still give good control of blue mold. Activation of host defenses takes several days for full protection, so Actigard should be applied four to five days before tobacco is exposed to the blue mold pathogen. If infection threatens before the four-to-five-day activation period, Actigard should be tank-mixed with another fungicide to protect plants during this critical time. A second application made 10 days after the first has been shown to extend good protection against blue mold. See Actigard remarks in Table 1 for additional information. If blue mold threatens tobacco that is less than the recommended height, use another fungicide until Actigard can be applied. Do not apply Actigard to stressed plants.

Aliette is also labeled only for blue mold. The first application of Aliette should be made immediately after transplanting, and subsequent sprays can be made on a seven-to-ten-day schedule. Aliette should not be tank-mixed with copper compounds, surfactants, or foliar fertilizers, and the pH of the spray solution should not be less than 6.0. Results from Kentucky research suggest that this product does not suppress blue mold as effectively as other labeled options.

Ridomil Gold, Ultra Flourish, and MetaStar are labeled for control of blue mold but should not be relied upon to manage this disease. Resistance to mefenoxam (Ridomil Gold, Ultra Flourish) or metalaxyl (MetaStar) is probably widespread in populations of the blue mold pathogen, making these products a risky choice.

Brown spot and ragged leaf spot. These diseases tend to be problematic on burley and dark tobacco later in the season, but rarely cause economic losses. Proper rotation, deep-turning of crop residues, wider plant spacing, and timely harvesting can help prevent problems with brown spot and ragged leaf spot. In

burley, some varieties are reported to have partial resistance to brown spot (KY 14×L8, NC 7). A fungicide program that contains mancozeb and Quadris should provide some suppression of these diseases.

Frogeye leaf spot. Frogeye, caused by *Cercospora nicotianae*, is a common leaf spot in some burley and dark tobacco production areas. Recent work in multiple states has indicated that reduced sensitivity to azoxystrobin fungicides (Quadris and generics) has been established on many farms, but thresholds for actual control failures have not been established yet. Leaf loss or weight reduction can be severe in rainy seasons, and quality losses can occur from green spots that appear during curing as the result of late infections. Even light cases of frogeye can cause considerable reduction in value of dark tobacco, where leaf quality is of paramount importance.

Target spot. Caused by *Thanatephorus cucumeris*, target spot has become increasingly prevalent, and yield losses of 50% or more have been observed in some areas. High humidity and moderate temperatures favor this disease, making target spot a serious problem under prolonged wet weather and in fields that are shaded or have poor air flow through the plant canopy. Target spot tends to worsen as the crop grows. When the row middles close, significant shading occurs in the lower canopy and humidity increases, favoring development of target spot.

Cultural practices recommended for management of target spot and frogeye include crop rotation, deep-turning of crop residues, wider plant spacing, mowing of weedy field borders, and timely harvesting. Additionally, do not under-fertilize or over-fertilize tobacco. Low nitrogen fertility can predispose tobacco to infection by the target spot pathogen, as can the presence of lush growth brought on by excessive nitrogen.

Azoxystrobin (active ingredient in Quadris and generic products) is the only labeled option for management of frogeye and target spot (Table 1). However, Quadris cannot be applied back-to-back; therefore unrelated fungicides must be applied between Quadris applications. Mancozeb and copper are only slightly effective against frogeye and target spot, but are the only choices for this purpose at this time. Mancozeb residues are an industry concern, to minimize the risk of high residue levels do not apply later than 7 weeks after transplanting. Control of fungal leaf spots using Quadris is dependent on multiple factors, including field history, rainfall, and the type of tobacco grown. Generally, a rate of 8 fl oz/A provides adequate control of fungal spots while minimizing the severity of flecking caused by Quadris. A 10-to-14 day schedule may be needed during rainy periods, utilizing a mancozeb application followed by another Quadris application. This program should be started early for most effective control of the leaf spots. The degree of control needed depends on the expected disease severity (crop rotation history, degree of air flow through the site) and on your tolerance level for leaf spots. For target spot control, Kentucky research has shown that the spray program should begin when plants are 24 to 36 inches tall. Although the leaf spots cause most of their damage after topping, early fungicide applications will minimize late-season damage by suppressing the buildup of the pathogens.

Fusarium wilt. Caused by *Fusarium oxysporum* f.sp. *nicotianae*, this soilborne disease can severely impact tobacco, particularly in fields with a history of disease or continuous tobacco. Warm conditions favor development of Fusarium wilt, and severity of disease can be aggravated by drought. Good management practices can help stave off losses to Fusarium wilt. Sanitation can help prevent introduction of the pathogen into "clean" fields. Planting tobacco after sweetpotato or cotton can increase chances of damage from Fusarium wilt. Avoiding fields with a history of severe Fusarium wilt, if possible, may be the best plan. Unfortunately, many of the varieties that are most effective against black shank (such as KT 204, KT 206, and KT 209) are extremely susceptible to Fusarium wilt. Burley varieties KT 210, KT 215, KY 14×L8, and NC 7 have moderate resistance to Fusarium wilt, but KT 210, KT 215 and KY 14×L8 are susceptible to viruses, while NC 7 has lower resistance to race 1 black shank and KY 14×L8 is very susceptible to race 1 black shank. When dealing with both black shank and Fusarium wilt in the same field, KT 210 and KT 215 (new varieties with good resistance to black shank plus moderate resistance to Fusarium wilt) should be planted.

Bacterial soft rots, including black leg, hollow stalk, and bacterial leaf drop. These diseases are all caused by the same bacterium, *Pectobacterium carotovorum* subsp. *carotovorum*. Hollow stalk and bacterial leaf drop typically occur after topping. Warm and humid conditions, and in particular frequent rains, favor development of hollow stalk. To reduce bacterial disease incidence, ensure that crops are not over fertilized. Minimize mechanical and chemical wounding during topping and sucker control operations, and don't top during rainy or overcast conditions or if plants are wet. Growers should consider cutting tops at an angle to reduce water retention, reducing the potential for infection. Chemical control of hollow stalk is not possible.

Virus diseases. Virus diseases can be damaging, but their severity depends upon the year and the varieties being grown. Chemical control of virus diseases is not possible. Planting a resistant variety is the most effective practice for prevention of most virus diseases of tobacco, and many burley cultivars possess this resistance. Exceptions include TN 86LC, N777LC, HB3307PLC, and KT 215 LC, which have high resistance to black shank and Fusarium wilt, but do not have virus resistance. Control of insect vectors gives variable and unpredictable levels of control of aphid-transmitted viruses or tomato spotted wilt virus (thrips). Weed control in and around fields can be helpful, as weeds serve as reservoirs of some virus diseases; don't plant tobacco near vegetables or alfalfa for the same reason. Tobacco surrounded by, or planted adjacent to corn, soybeans, or other small grains will have fewer problems with aphid-transmitted diseases, as the insects "lose" the virus as they feed on these crops before moving onto tobacco.

Nematodes. Plant-parasitic nematodes are rarely a serious problem in burley and dark tobacco fields and tend to gradually become a yield limiting factor over several cropping cycles. However, nematodes have occasionally been found to damage burley and dark tobacco, often in fields with sandier soils, and particularly in bottom land along streams, or sometimes when tobacco follows legume forages. Above-ground symptoms are typically irregular stunting and slow growth, associated with poor root growth or root galling. Prior to utilizing Table 3, diagnosis by a plant diagnostic lab is recommended, since nematode problems tend to be rare.

Table 3. Nematicides for nematode control on tobacco

Material[a]	Rate/Acre[b]	Method of Application	Waiting Period	Control Rating[b]
Chloropicrin 100 Chlor-O-Pic 100 (chloropicrin)	3 gal	Fumigant—row[c]	21 days	Fair-Good
Pic + (chloropicrin 86%)	4 gal	Fumigant—row	21 days	Fair-Good
Telone II (1,3-d)	6-9 gal	Fumigant—row	21 days	Good-Excellent
Nimitz (Fluensulfone 40%)	3-7 pints/acre	Non-fumigant – preplant incorporated[d]	7 days	Fair

[a] Nematicides can damage plants under certain conditions. Greenhouse-produced plants may be more sensitive to this type of injury.
[b] Control may be variable.
[c] Apply 6 to 8 inches deep. Fumigants work best and cause the least injury when applied at soil temperatures above 50°F and when the soil is moist but not wet. Fumigants should be injected into a pre-formed high, wide planting bed. Rates are based on injection volumes; broadcast fumigant rates will be different than those listed above.
[d] Non-fumigant nematicides must be properly distributed in the soil for full efficacy.

Chemicals for Disease Control

Several fumigants are registered for use on tobacco for preplant suppression of soilborne pathogens and nematodes (Table 3). Chloropicrin used as a preplant soil treatment will also reduce early populations of *P. nicotianae, Rhizoctonia, Fusarium, Pythium,* and *Thielaviopsis,* but the length of control to be expected is uncertain. Soil fumigants are hazardous, expensive, must be applied with specialized equipment, and generally require significant extra safety equipment, an additional pesticide applicators' certification, signage, and documentation. A new non-fumigant nematicide is an option for dark and burley tobacco producers, and is also listed in Table 3.

Tables 1 and 2 list labeled chemicals for use in the production of burley and dark tobacco as of December 2018. As always, read all product labels carefully and follow all directions provided by the manufacturers. Each product has specific use directions that must be followed to minimize the risk of damage to the crop and to maximize the effectiveness of the product. Information provided in the tables is meant to serve as a general set of guidelines to aid in product selection but is not intended to replace product labels.