

# Pest Management

*Kenny Seebold, J.D. Green, and Lee Townsend*

Tobacco diseases cause significant losses in yield and quality each year in Kentucky, resulting in lost revenue to growers. The extent of losses varies 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). The most common diseases encountered in field production of burley and dark tobacco are black shank, blue mold, target spot, frog-eye, brown spot, soreshin, Fusarium wilt, black root rot, angular leaf spot (wildfire), virus diseases (virus complex, tobacco mosaic, alfalfa mosaic, ringspot, tomato spotted wilt), and bacterial stalk rot (hollow stalk). Diseases such as brown spot and black root rot are found infrequently in burley tobacco but are more common to dark tobacco, while blue mold appears more often on burley. 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. 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 (of which few are available for tobacco), yield losses can occur and quality of the crop can be affected. The latter 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 have to be carried out or in place before disease appears, and this requires planning ahead. Field selection, picking varieties, and choice of fungicides that will be used 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. The 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 diseases. Where preventive programs aren't in place, best control of diseases will be achieved if action is taken early in an outbreak. Consult your county Extension agent if you are unsure of what is affecting your crop. He or she can help get a correct diagnosis through the UK Plant Disease Diagnosis laboratories located in Lexington or Princeton. Tobacco-related publications from the UK Cooperative Extension service are available at your local county Extension office. You can access information online that can help with identification of disease problems. The Kentucky Tobacco Disease Information page (<http://www.uky.edu/Ag/kpn/kyblue/kyblue.htm>) features up-to-date information on tobacco diseases and recommended

controls, as well as advisories on current disease problems (such as blue mold).

**Avoid 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 can be an effective way to manage black shank, Fusarium wilt, and black root rot. Locating fields away from areas with large, unmanaged populations of weeds can help minimize problems with a number of insect-transmitted plant viruses, such as alfalfa mosaic and tomato spotted wilt. In areas with a history of problems with aphid-transmitted viruses, planting tobacco early will ensure that the crop is older and less susceptible when aphid populations begin to grow. However, early plantings may suffer from black root rot. On the other hand, planting later to avoid early-season activity by thrips may reduce losses to tomato spotted wilt.

**Exclude plant pathogens from the field.** Keep plant pathogens out of "clean" fields by sanitizing equipment (especially if you share equipment or farm in several different areas) and shoes, and by limiting animals' access to fields. This can help reduce the introduction and spread of pathogens that cause black shank and Fusarium wilt. Don't discard stalks from fields with black shank and other diseases in clean fields or near sources of surface water (streams, ponds, etc.) to avoid introduction. Use locally-produced transplants or those grown north of Kentucky to avoid problems with blue mold. Plants produced in the Deep South may become exposed to blue mold at their source, and their importation into Kentucky could start an outbreak early in the season.

**Go to the field with healthy transplants; don't set plants with severe 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 soreshin. Do not set plants that have blue mold—destroy them immediately. Such plants will die, or if they survive they will not thrive and can serve as a source of spores for an outbreak in surrounding fields. Avoid tobacco use during setting to prevent the transmission of tobacco mosaic virus.

**Rotate to non-related crops.** Crop rotation is a highly effective tool for preventing and managing diseases, particularly those that are soilborne (including nematodes) or carry over in crop debris. Regular rotation away from tobacco and related crops deprives pathogens of their preferred source of food, which slows their buildup or causes their numbers to decline over time. Typically speaking, the effectiveness of rotation improves as the length of time away from tobacco is increased. Three to five years out of tobacco after a one- to two-year period in tobacco should provide good control of soilborne diseases for most growers. Do not follow tobacco with tobacco if black shank, black root rot, or Fusarium wilt are observed in a field.

Although less than ideal, even short rotational intervals are usually beneficial and certainly better than not rotating. Short rotations can be used to reduce disease pressure in fields after a serious disease outbreak, although longer intervals between susceptible crops, as discussed earlier, are recommended.

**Table 1.** Relative levels of resistance to disease in burley varieties.

Variety	Black Shank <sup>a</sup>		Black Root Rot <sup>b</sup>	Virus Complex <sup>c</sup>	TMV	Fusarium Wilt
	Race 0	Race 1				
KY 14 x L8 LC	10	0	M	S	R	6
KY 907 LC	2	2	H	R	R	1
KT 200 LC <sup>e(L)</sup>	6	6	H	R	R	0
KT 204 LC	7	7	H	R	R	1
KT 206 LC <sup>e(M)</sup>	10	7	H	R	R	-
NC BH 129	1	1	H	S	R	1
NC 3 <sup>d</sup>	2	2	H	R	R	1
NC 4	2	2	H	R	R	6
NC 5 <sup>d</sup>	10	4	H	R	R	0
NC 6 <sup>d</sup>	10	3	H	R	R	0
NC 7	10	3	H	R	R	5
NC 2000 <sup>e(H)</sup>	0	0	L	S	R	1
NC 2002 <sup>e(H)</sup>	0	0	L	S	R	0
TN 86 LC	4	4	H	R	S	0
TN 90 LC <sup>e(L)</sup>	4	4	H	R	R	0
TN 97 LC	4	4	H	R	R	0
Hybrid 403 LC	0	0	M	S	R	6
Hybrid 404 LC	0	0	H	S	R	-
Hybrid 501 LC	5	5	H	S	R	4
N-126	0	0	M	S	R	3
N-777 LC	2	2	M	S	S	0
N-7371 LC	3*	3*	-	-	-	-
NBH 98	2	2	M	S	R	3
HB 04P LC	0	0	H	S	R	0
HB 3307P LC	10	3	H	R	R	-
R 610 LC	4	4	M	S	-	3
R 630 LC	3	3	M	R	R	4
R7-11	0	0	M	S	R	6
R7-12 LC	0	0	H	S	R	4

<sup>a</sup> Black shank and Fusarium wilt resistance scored on a 0-10 scale where 0=no resistance and 10=high resistance.

<sup>b</sup> L=no resistance, M=medium resistance, H=high resistance.

<sup>c</sup> S=susceptible to virus complex or TMV, R=high level of resistance.

<sup>d</sup> Variety with resistance to root-knot nematode.

<sup>e</sup> Variety with partial resistance to blue mold. L=low resistance, M=medium resistance, H=high resistance.

\* Rating based upon a limited number of trials.

- No data available.

Unfortunately, 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.

**Plant disease-resistant varieties.** Select varieties with resistance to the diseases that you anticipate to be a problem. Using resistant varieties is one of the least expensive management practices—the cost is built into the price of the seed. Burley varieties are available with good resistance to diseases such as black shank, blue mold, Fusarium wilt, virus complex, tobacco mosaic, and black root rot (Table 1). 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 TN 86 and TN 90 have moderate resistance to black shank and none to Fusarium wilt.

**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 to suppress diseases like target spot and blue mold. Do not plant tobacco adjacent to areas where vegetables are produced, as many vegetable crops (especially tomatoes and peppers) can harbor viruses that can be moved into tobacco by insect vectors. By the same token, don't plant tomatoes or peppers in tobacco fields.

**Plow cover crops early.** This practice will ensure that plant matter decomposes thoroughly before setting time. Soreshin and black root rot can be problems in fields with high levels of partially decomposed organic matter. Heavily manured fields may also 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 pH within recommended ranges during the growing season. Allow pH to drop somewhat during rotational periods to promote rapid decline of *Phytophthora* (black shank) populations in soil. Do not over-fertilize, as this favors development of blue mold and black root rot; however, low nitrogen levels can contribute to severe outbreaks of target spot., so be sure to recommended amounts of nitrogen fertilizers for optimal crop production.

**Harvest in a timely manner and manage barns correctly.** Over-mature tobacco is more prone to leaf spotting diseases such as brown spot. Manage humidity levels in barns to avoid house-burn and barn rots.

**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 diseases of tobacco.

- 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 in the products' labels. Pay attention to safety precautions 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 take longer to bring the epidemic under control, or worse may not be successful at all. Maintain recommended application intervals while disease threatens or the weather favors disease. Applying fungicides with a specific mode of action, such as Quadris or Acrobat, when high levels of disease are present could lead to the development of resistance in certain plant pathogens. This is yet another reason to think preventively when using fungicides.
- Use an application volume that gives the best coverage of plants. For most fungicides, this amount will change as the crop grows. In general use 20 gallons per acre early (when plants are small) and increase to as much as 100 gallons per acre for applications made at topping or afterward. Spray pressure should be between 40 and 100 psi, and use hollow-cone nozzles for best effect. As the crop grows, configure your sprayer, 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 canopy.
- Calibrate your sprayer for accurate delivery. This will ensure the crop receives neither too little fungicide (poor disease control) nor too much (extra cost and potential injury). Clean

nozzles regularly, and change them as they become worn. This 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 are more durable and less prone to wear.

## Common Diseases and their Management

**Angular leaf spot & wildfire.** These bacterial diseases are occasionally important in Kentucky and do not cause significant losses in most years. 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; however, many dark varieties are very susceptible to this disease. Refer to Table 2 for a listing of dark tobacco varieties with good resistance to wildfire. Use of chemicals to manage these diseases is rarely necessary; however, agricultural streptomycin (Table 4) can be applied preventively at 100 ppm (8 oz/100 gal) or after symptoms first appear at 200 ppm (16 oz/100 gal). Continue applications while conditions favor disease (typically warm and wet weather).

**Black shank.** Black shank is by far the most important disease of burley and dark tobacco in Kentucky. Use good sanitary practices to prevent introduction and spread of the pathogen. Once introduced into a field, the black shank pathogen (*Phytophthora nicotianae*) can never be eradicated completely. Crop rotation is a key consideration in both prevention and management of black shank. Simply put, there's no better tool for managing black shank. 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 field by depriving them of their preferred host. Rotation away from tobacco for even a year will significantly reduce disease; however, rotations of 3-5 years have the greatest impact on black shank. A number of crops serve as good rotation partners with tobacco, although

grass sods seem to reduce populations of *P. nicotianae* to a greater degree than other crops. Legumes and vegetables may promote the buildup of other soilborne pathogens responsible for diseases like sore shin, damping-off, and black root rot.

Field location is an important consideration—avoid planting in fields that are down-slope from areas that have had black shank in the past or those that could receive 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, particularly if other practices (good rotation, fungicides) are employed. In Kentucky, we deal primarily with two races of *P. nicotianae* on tobacco, race 0 and race 1. Historically, race 0 tended to be the predominant strain present in most fields of burley tobacco, but extensive use of certain varieties ('L8' hybrids) over time has led to many areas having a mixture of race 0 and race 1.

Burley varieties are available with varying degrees of resistance to both races of the black shank pathogen (Table 1). However, no variety is completely resistant to black shank. These varieties can be placed into three groups: completely susceptible, partially resistant to races 0 and 1, and those with "near-immunity" to race 0 (10 on the UK rating scale). No variety possesses "near-immunity" to race 1. Generally speaking, 'Hybrid 403', 'HB04P', 'NC 2002', and 'R7-11' are examples of varieties with no resistance to black shank. Partial resistance ranges from low (1-3 on the rating scale) for varieties like 'NCBH 129' and 'NC 3' to moderate (4-6 on the rating scale) for 'TN 86', 'TN 90', or 'KT 200' or high (7 on the rating scale) for 'KT 204'. Varieties such as 'KY 14 x L8', 'HB 3307P LC', 'NC 5', 'NC 6', and 'NC 7' have near-immunity to race 0, owing to their genetic makeup, but low to no resistance to race 1. However, 'KT 206', which will be available in 2008, has near-immunity to race 0 plus high resistance (7 on the rating scale) to race 1, and is partially resistant to blue mold. Growers of dark tobacco will find that resistance to black shank is limited in these varieties, although 'KT D4', 'KT D6', and 'KT D8' do have moderate levels of resistance to both races of *P. nicotianae* (Table 2).

So which variety should you pick? To answer this, one must consider rotational history of a field along with the presence or absence of black shank if tobacco was part of the rotation. Choose a variety with little or no resistance (0-3 on the rating scale) if planting into fields with no history of disease or where good rotation has been practiced. Varieties with "near-immunity" to race 0 of *P. nicotianae* are practical if populations of race 1 are not present. Without time-consuming tests, though, it is difficult to say which race of the black shank pathogen is present in a field. The safest bet is to assume that both races are present in fields known to be prone to black shank and use varieties with moderate-to-high levels of resistance to race 1 (4-8 on the rating scale) in conjunction with rotation and fungicides.

For suppression of black shank, use products containing mefenoxam (Ridomil Gold or Ultra Flourish) in conjunction with resistant varieties (4 or better on the rating scale) and crop rotation (Table 3). In most cases, mefenoxam will not provide

**Table 2.** Relative levels of resistance<sup>a</sup> to disease in dark tobacco varieties.

Variety	Black Shank		Black Root	Wildfire	TMV	Fusarium
	Race 0	Race 1	Rot			Wilt
NL Madole	S	S	S	S	S	S
TR Madole	S	S	S	S	S	S
Little Crittenden	S	S	S	S	S	S
DF 911	S	S	H	H	H	S
KY 160	S	S	S	S	H	S
KY 171	S	S	H	S	H	M
DT 508	M	M	-	-	-	M
DT 518	M	M	M	-	-	-
DT 592	LM	LM	M	-	-	-
DT 538LC	M	M	-	-	-	-
VA 309	LM	LM	M	-	-	-
VA 359	L	L	-	-	-	-
TN D950	M	M	H	H	H	-
KT D4LC	M	M	S	S	S	-
KT D6LC	M	M	H	H	H	-
KT D8LC	M	M	S	S	S	-
PD 7312LC	S	S	H	-	H	M
PD 7302LC	H	S	H	-	H	-
PD 7309LC	H	S	S	-	S	-

<sup>a</sup> S=completely susceptible, L=low resistance, M=medium resistance, H=high resistance- No data available.

acceptable control of black shank if applied to varieties with little or no resistance to black shank. Good soil moisture is needed for best performance of mefenoxam products against black shank because uptake by roots is required for best control of disease. Where black shank has been severe, consider making a pre-plant application at 1-2 pt/A of Ridomil Gold or 1-2 qt of Ultra Flourish per acre prior to transplanting. Use a volume of water or fertilizer sufficient for good soil coverage and incorporate into the top 2-4 inches of soil by disking or irrigation. Under light-to-moderate disease pressure, apply mefenoxam within 1-2 weeks of transplanting. For extended control of black shank, make a supplemental application (1 pt of Ridomil or 1 qt of Ultra Flourish) of mefenoxam at layby OR at 1st cultivation and again at layby. These applications should be directed toward the soil and incorporated immediately by cultivation. Avoid “over-the-top” applications of mefenoxam later in the season, since any chemical intercepted by tobacco leaves will not be taken up by the roots thereby reducing the effectiveness of the treatment. Do not make supplemental applications if more than 1 pt of Ridomil Gold was used at planting. Do not exceed the equivalent of 1.5 lb a.i./A of mefenoxam per season (3 pt of Ridomil Gold or 3 qt of Ultra Flourish).

**Black root rot.** Once one of the most destructive diseases of burley tobacco in Kentucky, black root 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 Kentucky 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 (Tables 1 & 2).

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 on 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 (Table 3), but their use may not be practical for many producers.

**Blue mold.** Blue mold has caused serious losses in Kentucky in certain years when cool and rainy conditions have prevailed, particularly early in the season. The blue mold pathogen, *Peronospora tabacina*, does not overwinter normally in Kentucky 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 in Kentucky begin generally from introductions of *P. tabacina* from areas outside the state where *P. tabacina* is present year-round. In rare cases, the blue mold pathogen may overwinter in Kentucky on tobacco in protected environments (old float beds or greenhouses) – this 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 transplants that are free of the disease; avoid transplants produced out-of-state (particularly the Deep South). If planting into areas which are prone to blue mold, select a variety with partial resistance to blue mold (Table 1). Two varieties, ‘NC 2000’ and ‘NC 2002’ have moderate-to-high resistance to blue mold, while ‘KT 206’ and ‘TN 90’ have low-to-moderate resistance. Be mindful that some of these varieties may not be resistant to other diseases present in fields around Kentucky.

Chemicals registered for control of blue mold in Kentucky are listed in Table 4. Fungicides are good, but not perfect, tools

**Table 3.** Guide to chemicals available for control of tobacco diseases 2008—soil application (field).

Product Rate Per					
Fumigants	Application <sup>a</sup>	Season	Target Diseases	Label Notes	
Chloropicrin	60-100 lb/A (broadcast)	--	black root rot, black shank	Inject to 8-in. depth. Apply when soil temperatures are >55°F and moisture levels are adequate. Apply a minimum of 3 weeks before setting transplants.	
	150-500 lb/A (broadcast)	--	sore shin, nematodes, Fusarium wilt, bacterial wilt		
Telone C-17	10.8-17.1 gal/A (broadcast)	--	bacterial wilt, black root rot	Inject to 8-in. depth. Apply when soil temperatures are >55°F and moisture levels are adequate. Apply a minimum of 3 weeks before setting transplants.	
Telone C-35	13-20.5 gal/A (broadcast)	--	black shank, nematodes		

  

Product Rate Per					
Non-fumigants	Application <sup>a</sup>	Season	Target Diseases	Label Notes	
Ridomil Gold EC	preplant only	1-2 pt	black shank	Incorporate into the top 2-4 in. of soil after application by disking or cultivation.	
	preplant + layby	1 pt + 1 pt			
	preplant + 1st cultivation + layby	1 pt + 1 pt + 1 pt			
Ridomil Gold SL	preplant only	1-2 pt	black shank	Incorporate into the top 2-4 in. of soil after application by disking or cultivation.	
	preplant + layby	1 pt + 1 pt			
	preplant + 1st cultivation + layby	1 pt + 1 pt + 1 pt			
Ultra Flourish	preplant only	1-2 qt	black shank	Incorporate into the top 2-4 in. of soil after application by disking or cultivation.	
	preplant + layby	1 qt + 1 qt			
	preplant + 1st cultivation + layby	1 qt + 1 qt + 1 qt			

<sup>a</sup> 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.

**Table 4.** Guide to chemicals available for control of tobacco diseases in the field, 2008—foliar applications.

Chemical	Product Rate Per		PHI <sup>b</sup> (days)	Target Diseases	Label Notes
	Application <sup>a</sup>	Season			
Agricultural streptomycin Agri-Mycin 17 Firewall	100-200 ppm (4-8 oz/50 gal H <sub>2</sub> O)	no limit	0	wildfire, angular leaf spot, blue mold	
Acrobat 50WP	2-8 oz	32 oz	0	blue mold	Increase rate and application volume (20-100 gal/A) as crop size increases. According to the product label, Acrobat must be tank-mixed with a product registered for control of blue mold, such as Dithane DF, for resistance management. Neither mefenoxam (Ridomil Gold / Ultra Flourish) nor Actigard are permitted as tank-mix partners for Acrobat.
Actigard 50WG	0.5 oz	1.5 oz (3 apps.)	21	blue mold	Begin applications when plants are >18 inches <sup>c</sup> 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 on a 10-day schedule. Apply in a minimum of 20 gal/A.
Dithane DF	1.5-2 lb	no limit	30	blue mold, anthracnose	Apply on weekly schedule; discontinue sprays when blue mold threat no longer exists. Note: some buyers have expressed concern over residues of Dithane on tobacco. Use this product only as needed.
Aliette WDG	2.5-4 lb	20 lb	3	blue mold	Make first application immediately after transplanting; continue on a 7-10 day schedule. Use a minimum spray volume of 20 gal/A; increase by 20 gal/A weekly to a maximum of 100 gal/A.
Forum	2-8 fl oz	30 fl oz	0	blue mold	See notes for Acrobat.
Quadris 2.08SC	6-12 fl oz	31.2 fl oz	0	target spot, frog-eye, blue mold	Do not apply curatively (when disease is present). Begin applications before symptoms appear. Continue sprays on a 7-14 day schedule (use a shorter spray interval when conditions favor disease. If blue mold is present in the field, apply Acrobat or Forum, tank-mixed with Dithane, prior to using Quadris. Do not make back to back sprays. Alternate with different fungicide labeled for tobacco. Can be used up to the day of harvest; however, due to a lack of post-topping options for product rotation, make only one application after topping.

<sup>a</sup> 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. <sup>b</sup> Pre-harvest interval. <sup>c</sup> Actigard can be applied to dark tobacco varieties at the 12-inch stage.

for managing blue mold if used properly. Begin fungicide applications for blue mold control when the disease is forecasted to threaten your area or has been found nearby. Contact your county Extension agent for disease advisories, or visit the Kentucky Tobacco Disease Information page (<http://www.uky.edu/Ag/kpn/kyblue/kyblue.htm>). Once blue mold has been reported or threatens an area, fungicides should be applied at regular intervals as long as conditions favor development of blue mold to minimize losses.

Quadris received a full (Section 3) label in 2006 for control of blue mold, frog-eye, and target spot. While not as effective against blue mold as Acrobat (or Forum) + Dithane, our results indicate that Quadris provides consistent and effective control of blue mold if applied regularly on a preventive basis. Keep in mind that Quadris is a protectant fungicide, and has limited systemic activity. Do not make curative applications of Quadris! 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 Acrobat or Forum tank-mixed with Dithane and follow with Quadris 7-10 days later. Make sure to not make back-to-back applications of Quadris; rotate to another fungicide or program (Dithane or Acrobat/Forum + Dithane) after each application of Quadris. Good coverage is critical to getting good disease control with this product – the use of drop nozzles is recommended. Quadris can be applied up to the day of harvest, making this material a good option for post-topping control of other leaf spotting diseases. 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 in Kentucky.

Other options for blue mold include Acrobat 50W or Forum, Dithane DF, Aliette WDG, and Actigard. Forum, introduced by BASF in 2006, is a liquid formulation of dimethomorph, the same active ingredient found in Acrobat 50WP. The liquid formulation should be easier to measure and mix than Acrobat 50WP, and will eventually be the only dimethomorph-based product on the market. According to the Acrobat and Forum labels, these products must be tank-mixed with another blue mold fungicide for management of resistance; Dithane DF works well in this role. As with Quadris, good coverage is very important to get best results with Acrobat or Forum, and the application volume and rate must be increased as the crop increases in size (Table 4).

Actigard remains one of our best options for blue mold control. This is a systemic product that functions by inducing plant defenses and is thus 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 4-5 days before tobacco is exposed to the blue mold pathogen. If infection threatens before the 4-5 day activation period, Actigard can 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 provide good protection against blue mold up to topping time. Do not ap-

ply Actigard to burley tobacco until plants are greater than 18 inches tall (12 inches for dark tobacco) to avoid serious injury. Use another fungicide if blue mold threatens tobacco less than the recommended height to protect until Actigard can be applied. Do not apply Actigard if plants are stressed from drought or other environmental factors, as severe injury could occur.

Bayer CropScience received a label in 2006 for Aliette WDG on tobacco for control of blue mold only. The first application of Aliette should be made immediately after transplanting and subsequent sprays can be made on a 7-to-10-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. Our experience with Aliette in Kentucky is limited at this time; however, results suggest that this product does not suppress blue mold as effectively as other labeled options.

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

**Brown spot and ragged leaf spot.** These diseases tend to be problematic on burley and dark tobacco later in the season, and rarely cause economic losses. Proper rotation, deep-turning of crop residues, wider plant spacings, 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 14xL8,' 'NC 7'). We have no fungicides for the moment to manage brown spot and ragged leaf spot. A fungicide program that contains Dithane DF and Quadris may provide some suppression of these diseases.

**Frogeye and target spot.** Frogeye, caused by *Cercospora nicotianae*, is a problem on maturing tobacco and causes few problems on burley unless infections take place immediately before cutting. In these cases, green spots can appear that will affect the quality (and lower the value) of the tobacco. Late-season infections on dark tobacco can cause economic losses due to decreased quality. Target spot, caused by *Thanatephorus cucumeris*, has become increasingly prevalent in Kentucky, and has caused yield reductions of 50% or more in some areas of the state. High humidity and moderate temperatures favor this disease, making target spot a serious problem in fields that are shaded or have poor air drainage. 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 brown spot will also help control target spot and frogeye. Additionally, do not under- nor 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.

Quadris is the only labeled option for management of frogeye and target spot (Table 4). Research over the past three years has shown that where target spot has been historically severe, 1-2 applications of Quadris made at 8-12 fl oz/A, beginning when plants are between 24-36 inches tall, will provide significant control of target spot. Early applications prevent buildup of the target spot pathogen, suppressing disease later in the season;

however, a mid- to late-season application may be required to protect tobacco between topping and harvest. Where disease severity is low, a single application made early (before the canopy closes between rows) may be as effective against target spot as 2-3 applications made at 2-3 week intervals. Greater levels of disease will require at least two applications of Quadris to get good control of disease and improved yield. Growers with recurring losses to target spot should consider applying Quadris to their crops. Dithane is also suppressive to target spot, as is Actigard; however, these materials will not provide acceptable control of target spot if levels of disease are high. As mentioned previously (see section on blue mold), do not make back-to-back applications of Quadris – always rotate to different fungicide product after Quadris is applied. In the case of frogeye and target spot, the only effective choice will be Dithane DF.

**Fusarium wilt.** Caused by *Fusarium oxysporum* f.sp. *nicotianae*, this soilborne disease can cause significant losses, particularly in fields with a history of disease or poor rotations. Warm conditions favor development of Fusarium wilt, and severity of disease can be aggravated by drought. Many of the practices that are useful in combating black shank can be helpful in managing Fusarium wilt. Practice thorough sanitation to avoid introduction of the pathogen into "clean" fields. Crop rotation is equally important as a preventive measure. In fields that have experienced severe outbreaks of the disease, long (5+ years) rotations may be needed to reduce damage to economically acceptable levels, due to the persistent nature of *F. oxysporum* in soil. For some, avoidance of fields with a history of severe Fusarium wilt may be the best plan if at all possible. Certain varieties of burley tobacco have moderate resistance to Fusarium wilt, including 'KY 14xL8' and 'NC 7'. Unfortunately, many of the varieties that are most effective against black shank ('TN 90,' 'KT 200,' 'KT 204,' and 'KT 206') are extremely susceptible to Fusarium wilt. When dealing with both black shank and Fusarium wilt in the same field, 'NC 7' appears to be the best choice at this time.

**Hollow stalk.** This disease is caused by the same bacterium, *Erwinia carotovora* subsp. *carotovora*, that causes black leg on transplants, and is typically found after topping. Warm and humid conditions favor development of hollow stalk. To reduce incidence of this disease, 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. Chemical control of hollow stalk is not possible.

**Virus diseases.** Diseases caused by viruses are common in Kentucky, and their severity depends upon the year and also the varieties being grown. Chemical control of virus diseases is not possible. Host resistance can be effective against many virus diseases of tobacco (see Tables 1 & 2). Control of insect vectors gives variable (and unpredictable) levels of control of aphid-transmitted viruses or TSWV (thrips). Weed control in and around fields can be helpful, as weeds serve as reservoirs of certain diseases; don't plant tobacco near vegetables for the same reason. Tobacco surrounded by, or planted adjacent to corn, soybeans, or other small grains will have less problems with aphid-transmitted diseases, as the insects "lose" the virus as they feed on these crops before moving onto tobacco.

## Chemicals for Disease Control

**Fumigants.** Several fumigants are registered for use on tobacco for preplant suppression of soilborne pathogens and nematodes in Kentucky, but should be considered a measure of last resort. Nematodes have not been a serious problem in Kentucky, and the use of products such as Telone C-17 or C-35 is not warranted under most circumstances due to high material costs and expensive custom application. Chloropicrin used as a pre-plant soil treatment will reduce populations of *P. nicotianae*, *Rhizoctonia*, *Fusarium*, *Pythium*, and *Thielaviopsis*, giving fair control of disease. As with soil nematicides, chloropicrin is

expensive and must be applied with specialized equipment and will not be an economically viable choice for most producers.

Tables 3 and 4 list labeled chemicals that are available to growers in Kentucky for use in the production of burley and dark tobacco in 2008. As always, read all product labels carefully and follow all directions provided by the manufacturers. Each product has specific use directions that should 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.

## Weed Control

Weeds can impact tobacco production by reducing yield and interfering with crop harvest. Many of the common weed problems in tobacco are summer annuals such as foxtails, pigweeds, lambsquarters, and annual morningglories. In addition, some perennials such as johnsongrass, honeyvine milkweed and yellow nutsedge can be particularly troublesome in some tobacco fields. In locations where troublesome weeds are difficult to control it may become necessary to choose an alternative field site to grow tobacco. Table 5 is a guide to the relative response of selected weeds to various herbicides available for use in tobacco.

Land preparation practices such as moldboard plowing and disking are beneficial for initial weed control by destroying early season weeds that have emerged before transplanting. Field cultivation and hand-hoeing are also traditional methods used for obtaining good weed control post-transplant. In more recent years effective herbicide control options have decreased the need for mechanical control method. A foliar burndown herbicide also allows production of tobacco by conservation tillage methods. Specific herbicide options that are currently recommended for use on tobacco fields are discussed in Table 6.

**Table 5.** Guide to the relative response of weeds to herbicides.<sup>1</sup>

	Crabgrass	Fall Panicum	Foxtails	Johnsongrass (seedling)	Johnsongrass (rhizome)	Shattercane (Wild Cane)	Yellow Nutsedge	Black Nightshade	Cocklebur	Gallinsoga, Hairy	Jimsonweed	Lambsquarters	Morningglory	Pigweeds	Common Ragweed	Ragweed, Giant (Horseweed)	Smartweed	Velvetleaf
Command	G	G	G	F	P	F	P	P	F	F	F	G	P	P	G	F	F	G
Devrinol	G	G	G	F	P	P	P	P	N	F	N	F	N	F	F	N	P	P
Prowl	G	G	G	G	P	F	N	N	N	P	N	G	P	G	P	N	F	F
Spartan	F	F	F	P	P	P	G	G	F	F	G	G	G	G	P	P	G	F
Spartan + Command	G	G	G	F	P	F	G	G	F	G	G	G	G	G	G	F	G	G
Poast	G	G	G	G	F	G	N	N	N	N	N	N	N	N	N	N	N	N

G = Good F = Fair P = Poor N = None - No Data Available

<sup>1</sup> This table should be used only as a guide for comparing the relative effectiveness of herbicides to a particular weed. Under extreme environmental conditions, the herbicide may perform better or worse than indicated in the table. If a grower is getting satisfactory results under his conditions, he should not necessarily change products as a result of the information in the table.

**Table 6.** Herbicides recommended for use in tobacco fields.

Herbicide	Weeds Controlled	Remarks and Limitations
<b>Before Transplanting—Burndown Herbicides for Use in Conservation Tillage</b>		
<b>Gramoxone Inteon 2S</b> 2.4 to 3.75 pt/A (paraquat 0.6 to 0.94 lb ai/A) + Non-ionic Surfactant 2 pt/100 gal or Crop Oil Concentrate 1 gal/100 gal	Annual grasses and broadleaf type weeds that have emerged or for burndown of cover crops. Apply when weeds and cover crop are actively growing and between 1" to 6" in height. Vegetation 6" or taller may not be effectively controlled.	<i>A copy of the supplemental label should be in the hands of the applicator at time of application.</i> Apply as a broadcast treatment during the early spring but prior to transplanting tobacco. Use the higher rate on dense populations and/or on larger or harder to control weeds. Weeds and grasses emerging after application will not be controlled. A maximum of 2 applications may be made. Gramoxone may be tank-mixed with other registered tobacco herbicides for improved burndown. Do not graze treated areas or feed treated cover crops to livestock.
<b>Before Transplanting—Soil-applied Herbicides</b>		
<b>Devrinol 50DF</b> 2 lb/A or <b>Devrinol 2EC</b> 2 qt/A (napropamide 1 lb ai/A)	Crabgrass, fall panicum, foxtails.	Apply before transplanting and incorporate immediately, preferably in same operation. Follow incorporation directions on label. To avoid injury to crops not specified on the label, do not plant rotational crops until 12 months after the last DEVRINOL application.
<b>Prowl 3.3EC</b> 3 to 3.6 pt/A (pendimethalin 1.25 to 1.5 lb ai/A) or <b>Prowl H<sub>2</sub>O</b> 3 pt/A (pendimethalin 1.4 lb ai/A)	Crabgrass, fall panicum, foxtails, lambsquarters, pigweeds.	Apply to prepared soil surface up to 60 days prior to transplanting. Incorporate within 7 days after application within the top 1 to 2 inches of soil. Consult incorporation directions on label. Emerged weeds will not be controlled. Tobacco plants growing under stress conditions (cold/wet or hot/dry weather) may be injured where PROWL is used. Wheat or barley may be planted 120 days after application, unless small grains will be planted in a no-tillage system.
<b>Command 3ME</b> 2 to 2.67 pt/A (clomazone 0.75 to 1 lb ai/A)	Crabgrass, fall panicum, foxtails, jimsonweed, lambsquarters, common ragweed, velvetleaf.	Apply COMMAND 3ME as a soil-applied treatment prior to transplanting or over-the-top of tobacco plants immediately, or up to 7 days after transplanting, but prior to emergence of weeds. Off-site movement of spray drift or vapors of COMMAND can cause foliar whitening or yellowing of nearby sensitive plants. Consult label for spray drift precautions and required setbacks when applied near sensitive crops and other plants. Tobacco plants growing under stressed conditions (cold/wet weather) may show temporary symptoms of whitening or yellowing. COMMAND may be tank mixed with other herbicides registered for use in tobacco to broaden the weed control spectrum or with other tobacco pesticides. Cover crops may be planted anytime, but foliar whitening, yellowing, and/or stand reductions may occur in some areas. Do not graze or harvest for food or feed cover crops planted less than 9 months after treatment. When COMMAND 3ME is applied alone, rotational crops which may be planted include soybeans, peppers, or pumpkins anytime; field corn, popcorn, sorghum, cucurbits, or tomatoes (transplanted) after 9 months; sweet corn, cabbage, or wheat after 12 months; and barley, alfalfa, or forage grasses after 16 months following application. See label for rotation guidelines for other crops and when tank mixed with other herbicides.
<b>Spartan 4F</b> 8 to 12 fl.oz/A (sulfentrazone 0.25 to 0.375 lb ai/A)	Black nightshade, jimsonweed, lambsquarters, morningglories, pigweeds, smartweed, yellow nutsedge.	Use the higher rate of SPARTAN when weed pressure is heavy with morningglory or yellow nutsedge. Apply from 14 days before up to 12 hours prior to transplanting tobacco as a soil surface treatment or preplant incorporated (less than 2 inches deep). Perform all cultural practices for land preparation, fertilizer/fungicide incorporation, etc. prior to application of SPARTAN. If the soil must be worked after application, but prior to transplanting, do not disturb the soil to a depth greater than 2 inches. Temporary stunting or yellowing of tobacco and localized leaf burns may be observed under some conditions with this treatment. Unacceptable crop injury can occur if applied post-transplant. <i>Spartan may be impregnated on dry bulk fertilizers (consult label). Proper mixing and uniform spreading of the impregnated fertilizer mixture on the soil surface is required for good weed control and to avoid crop injury.</i> Rotational crops which may be planted include soybeans or sunflowers anytime; wheat, barley, or rye after 4 months; field corn after 10 months; alfalfa and oats after 12 months; and popcorn, sweet corn, and sorghum (for rates above 8 oz/A) after 18 months. See label for rotation guidelines with other crops.
<b>After Transplanting—Postemergence Herbicides</b>		
<b>Poast 1.5E</b> 1.5 pt/A (sethoxydim 0.28 lb ai/A) + Oil Concentrate 2 pt/A	Crabgrass, fall panicum, foxtails, johnsongrass, shattercane.	<i>A copy of the supplemental label should be in the hands of the applicator at time of application.</i> POAST herbicide provides selective postemergence control of annual and perennial grasses. Apply any time from transplanting up to 7 weeks after transplanting tobacco, but avoid applications within 42 days of harvest. For adequate control ensure good spray coverage using a spray volume from 5 to 20 GPA (gallons per acre). Do not cultivate within 5 days before of 7 days after applying POAST. For rhizome johnsongrass more than one application may be needed. Make the first application of POAST (1.5 pt/A) when johnsongrass plants are 20 to 25 inches; followed by a second application of POAST (1 pt/A) when regrowth is 12 inches. A maximum of 4 pt/A of POAST can be applied per season to tobacco. As a spot treatment, prepare a 1% to 1.5% solution (1.3 oz/gal to 2 oz/gal) of POAST plus a 1% solution of Oil Concentrate (1.3 oz/A) and apply to the grass foliage on a spray-to-wet basis. Do not apply more than 4 pt/A per season to tobacco, including POAST applied to seedbeds.

## Insect Control

A variety of insect pests can attack tobacco from transplant until harvest. Most reduce yield directly by feeding on plant leaves. However, sap-feeding by aphids causes more subtle injury by reducing plant vigor and growth. They also may introduce and spread plant viruses in the crop. Tobacco insect pests are potential pests at relatively predictable times during the growing season. Field checks and use of treatment guidelines allow early detection and assessment of problems so that sound pest management decisions can be made.

## Pre-Transplant: Soil Applications

Pre-plant Insecticides	Rate/Acre	Labeled Pests
Capture LFR (17.15%) (bifenthrin)	3.4 to 6.8 fl oz	Cutworms, white grubs, wireworms
Di-Syston 15% G	13.5 to 26.7 lbs	Aphids, flea beetles
Di-Syston 8 E	4 pts	
Furadan 4F * (carbofuran)	1 gallon	Flea beetles
Lorsban 15%G (chlorpyrifos)	13.5 to 20 lbs	Cutworms, wireworms
Lorsban 4E	2 to 3 qts	
Mocap 10% G (ethoprop) or Mocap 15%G	20 lbs	Wireworms only for G
Mocap 6 EC	13 lbs See label	Wireworms only for G
	1-1/3 qts	From 2 weeks before transplant up to transplant
Di-Syston 15% G	27 lbs	Wireworms only

*Broadcast and incorporate spray or granules according to label instructions immediately before transplant.*

## Transplant: Tray Drench Applications

**Acephate 75 SP** or **Orthene 75 SP** can be used at the rate of 1 lb per acre in the transplant water to provide 3 to 4 weeks of control of flea beetles, cutworms and thrips. **Orthene 97** is used at the rate of 3/4 lb per acre. Using more than the label rate may result in plant damage. Orthene 97 has a 2ee label for a transplant water tank mix with Admire. See the label for more information.

**Admire Pro 4F**, **Belay**, and **Platinum** are systemic insecticides that are labeled for application as a drench to float trays or flats prior to transplant. Most rates are expressed as fluid ounces per 1,000 plants. Agitate or mix the insecticide frequently to keep it from settling in the tank. The plants should be watered from above after application to wash the insecticide from the foliage into the potting soil-less media. Failure to wash the insecticide from the foliage may result in reduced control. Adverse growing conditions may cause a delay in the uptake of the product into the plants and delay control.

### Tray Drench Applications

Insecticide	Rate	Comment
Admire 2F	1 fl oz/1,000 plants	Aphids, flea beetles
	1.4 to 2.8 fl oz/1,000 plants	Wireworms
Admire Pro 4F	0.5 fl oz/1,000 plants	Aphids, flea beetles
	0.6 to 1.2 fl oz/1,000 plants	Wireworms
Orthene 97	3/4 lb/A	Flea beetles, cutworms
Acephate 75 SP	1 lb/A	
Orthene 75S		
Belay 16 WSG	5 oz/A	Flea beetles
	10 oz/A	Aphids
Platinum 2 SC	0.8 to 1.3 fl oz/1,000 plants	Aphids, flea beetles
	1.3 fl oz/1,000 plants	Wireworms

## Transplant: Water Applications

For application equipment which has minimal agitation, such as tobacco transplanters, give proper attention to mixing. Keep the water suspension agitated or mix regularly to avoid settling in the transplant tank. Adverse growing conditions may cause a delay in the uptake of Admire into the plants and a delay in control.

**Premix Orthene 97** in water to form a slurry before putting it into the transplant water tank. If premixing is not done, allow time for the product to dissolve. Use of more than the label rate may result in some plant damage. Orthene 97 has a 2ee label for a transplant water tank mix with Admire. See the label for more information.

### Water Applications

Insecticide	Rate	Comment
Admire 2F	1.4 fl oz/1,000 plants	Aphids, flea beetles
	1.4 to 2.8 fl oz/1,000 plants	Wireworms
Admire Pro (42.8%)	0.6 fl oz/1,000 plants	Aphids, flea beetles
	0.8 to 1.2 fl oz/1,000 plants	Wireworms
Orthene 97	3/4 lb/A	Flea beetles, cutworms
Acephate 75 SP	1 lb/A	
Orthene 75S		
Belay 16 WSG	5 to 10 oz/A	Flea beetles
	10 oz/A	Aphids
Platinum 2 SC	0.8 to 1.3 fl oz/1,000 plants	Aphids, flea beetles
	1.3 fl oz/1,000 plants	Wireworms
Capture LFR	5.3 to 8.5 fl oz	Cutworms, wireworms

## Foliar Treatments for Tobacco Fields

The numbers of tobacco pests or infested plants in a field determines whether a control measure is justified. The actual numbers can vary due to a variety of factors, such as weather, natural enemies, and transplant date. Early set fields are prone to attack by flea beetles and tobacco budworms, while late-set fields are at greater risk to tobacco aphids.

Careful field monitoring is necessary to determine whether or not an insecticide application will provide an economic return through yield or quality protection.

The treatment guidelines listed in Table 7 allow proper timing of insecticide applications. Weekly field scouting is necessary to collect the information needed to use them. Check at least 100 plants per field—10 groups of ten or 5 groups of 20 up to 5 acres. Add two locations for each additional 5 acres of field size. Pick your locations randomly. Examine the plants carefully for damage or live insects. Record your counts, calculate the average, and compare them to the table values. Keep these counts so that you can look for trends in insect numbers during the season.

**Table 7.** Insect management calendar—treatment guidelines for key tobacco insect pests.

Insect	Treatment Guidelines
<b>1-4 weeks after transplant</b>	
Cutworms	Five or more freshly cut plants per 100 plants checked.
Flea Beetles	Three or more beetles per plant on new transplants, 10 or more beetles on 2-4 week old plants, 60 or more beetles on plants more than four weeks old.
<b>3-8 weeks after transplant</b>	
Aphids	Colonies of 50 or more aphids on at least one upper leaf of 20% of the plants from three weeks after transplant until topping.
Budworms	Five or more budworms per 50 plants from three weeks after transplant until one week before topping.
<b>3 weeks before, and through topping</b>	
Hornworms	Five or more hornworms (1" or longer) per 50 plants from three weeks after transplant until harvest. Do not count hornworms with white cocoons on their backs.

## Tobacco Aphids

Tobacco aphids may infest tobacco plant beds but populations are usually highest following the flight of winged aphids into fields in mid- to late June. Winged aphid adults descend into fields and to deposit live young on scattered plants across fields. Their offspring will mature in 7–10 days and begin to give birth to 60–70 live young. Aphid numbers increase gradually at first but by 6–8 weeks after transplant they are increasing rapidly; populations of aphids are usually highest in mid-to-late-June. Fields not receiving a preventive treatment at transplant should be checked weekly by examining the bud area of 10 consecutive plants in at least 5 locations for colonies (clusters) of aphids on the undersides of leaves, especially in shaded areas of the field. *An insecticide application is recommended if aphid colonies are found on 20% or more of the plants that are examined.* Thorough coverage with sprays directed to the undersides of leaves at the top of the plant is essential to obtain satisfactory aphid control.

## Budworms

Budworms feed in the buds of young tobacco plants causing rounded holes in developing leaves. Tobacco plants may be topped by these pests resulting in early sucker growth. Infestations tend to be greatest in the earliest-set fields in an area. Moths lay single eggs so infestations are scattered randomly over a field. Examine

**Table 8.** Tobacco aphid control.

Insecticides	Rate/A	Harvest Interval (Days)
Acephate 75 SP	2/3 lb to 1 lb	3
Orthene 75 SP		
Orthene 97	3/4 lb	
Actara 25% WDG	2 to 3 oz	14
Assail 30 G	1.5 to 4.0 oz	7
Assail 70 WP	0.6 to 1.7 oz	
Capture LFR	3.4 to 8.5 fl oz	Do not apply later than layby
Fulfill 50 WDG	2.75 oz	14
Endosulfan 3E	2/3 to 1-1/3 qt	5*
Lannate 90 SP <sup>1</sup>	½ lb	14
Provado 1.6 F	2 to 4 fl oz	14

\* Application of products containing endosulfan within 28 days of harvest can lead to increased residue on the crop. Do not spray in the heat of the day. Contracts offered by certain buyers may prohibit the use of endosulfan; do not apply endosulfan if your contract expressly prohibits these products.

<sup>1</sup> Restricted use pesticide.

the bud area carefully for the black ground pepper-like droppings, small holes, or the caterpillars. Damage will increase as the caterpillars feed and grow. If the bud is destroyed, the plant will be forced to develop new terminal growth. Direct leaf damage and stunting can reduce yields significantly. Examine the buds for feeding damage and the small green to black worms. *Treat if there are 5 or more live budworms (less than 1-1/4 inches long) per 50 plants, and topping is at least one week away.* Do not count the plant as infested if you cannot find a budworm. *Bacillus thuringiensis* baits have given excellent control of this insect in flue-cured areas but there are no efficient ways to apply baits to large acreages. Bt sprays are most effective if applied when larvae are small and feeding actively. Use the highest labeled rates for heavy populations.

## Hornworms

Hornworms eat large amounts of tobacco foliage. They first appear in June and are active throughout the remainder of the growing season. Weekly field

**Table 9.** Budworm control.

Insecticides	Rate/A	Harvest Interval (Days)
Acephate 75	1 lb	3
SPOrthene 75 SP		
Orthene 97	3/4 lb	
Agree WG (3.8% Bt aizawai)	1 to 2 lb	0
Biobit HP (6.4% Bt kurstaki)	½ to 1 lb	0
Biobit F (6.4% Bt kurstaki)	1 to 4 pt	
Capture LFR	3.4 to 8.5 fl oz	Do not apply later than layby
Denim 0.16 EC <sup>1</sup>	8 to 12 fl oz	14
Dipel 10 G	5 to 10 lb	0
Dipel DF	1/2 to 1 lb	0
Dipel ES	1 to 2 pt	
Endosulfan 3E	2/3 to 1-1/3 qt	5*
Lannate SP <sup>1</sup>	½ lb	14
Lepinox WDG	1 to 2 lb	0
Sevin 80S	1-1/4 lb	0
Tracer 45C*	1.4 to 2.9 fl oz*	3
Warrior 1 CS <sup>1</sup>	1.9 to 3.8 fl oz	40
XenTari DF	½ to 2 lb	0

\* Application of products containing endosulfan within 28 days of harvest can lead to increased residue on the crop. Do not spray in the heat of the day. Contracts offered by certain buyers may prohibit the use of endosulfan; do not apply endosulfan if your contract expressly prohibits these products.

<sup>1</sup> Restricted use pesticide.

checks will allow detection of infestations that would benefit from treatment. Examine the upper third of the plant for holes or hornworms hanging from the underside of leaves. Examine the entire plant for signs of damage and live worms. *Treat if there are 5 or more hornworms (1" or longer) per 50 plants, and topping is at least one week away.* Treatments applied before most worms exceed 1-1/2 inches in length will greatly reduce yield loss. Hornworms with white egg-like cocoons on their back are parasitized by a small wasp. These worms will not contribute to yield loss. By late August or early September as much as 90% of the hornworm population may be parasitized.

Check fields for hornworms about one week before harvest. Hornworms pose the greatest threat at the end of the growing season. They are voracious eaters and can continue to feed on harvested tobacco after it is taken to the curing structure. Apply a short residue insecticide if necessary to prevent taking significant numbers of this pest to the barn. There are no treatments to control hornworms effectively on housed tobacco.

**Table 10.** Hornworm control.

Insecticides	Rate/A	Harvest Interval (Days)
Acephate 75 SP	2/3 lb	3
Orthene 75 SP		
Orthene 97	½ lb	
Agree WG (3.8% Bt aizawai)	1 to 2 lb	0
Biobit HP (6.4% Bt kurstaki)	½ to 1 lb	0
Biobit F (6.4% Bt kurstaki)	1 to 4 pt	
Capture LFR	3.4 to 8.5 fl oz	Do not apply later than layby
Denim 0.16 EC <sup>1</sup>	8 to 12 fl oz	14
Dipel 10 G	5 to 10 lb	0
Dipel DF	1/2 to 1 lb	0
Dipel ES	½ to 1 pt	
Endosulfan 3E	2/3 to 1-1/3 qt	5*
Javelin WG	1/8 to 1-1/4 lb	0
Lannate SP <sup>1</sup>	½ lb	14
Lepinox WDG	1 to 2 lb	0
Sevin 80S	1-1/4 lb	0
Tracer 45C*	1.4 to 2.9 fl oz*	3
Warrior 1 CS <sup>1</sup>	1.9 to 3.8 fl oz	40
XenTari DF	½ to 2 lb	0

\* Application of products containing endosulfan within 28 days of harvest can lead to increased residue on the crop. Do not spray in the heat of the day. Contracts offered by certain buyers may prohibit the use of endosulfan; do not apply endosulfan if your contract expressly prohibits these products.

<sup>1</sup> Restricted use pesticide.

## Flea Beetles

Tobacco flea beetles are present in every field each season. Damage tends to be most severe in fields that are set first, especially following a mild winter when beetle survival is greatest. Flea beetles move frequently, chewing small round holes (shot holes) in the leaves. Extensive damage can occur when beetles feed in the bud of the plant. This injury can add to transplant stress and slow plant establishment. Flea beetles can be controlled with systemic insecticides applied in the transplant water or by a foliar spray if a preventive treatment was not used. An average of 3 or more beetles per plant is enough to cause significant damage. *Treat if there are 3 or more beetles per plant during the first 2 weeks after transplant. Established plants rarely need protection from this insect.*

## Occasional Pests

Some feeding by incidental pests, such as Japanese beetles and stink bugs, may be seen but usually are not severe enough to cause economic damage.

**Cutworms** may be present in tobacco fields because of early season weed growth. Often these insects are relatively large by the time tobacco is set in the field. Cutworms feed at the base of trans-

plants and can cut them off at ground level. Moths are active in March and April, laying their eggs on low, spreading weeds. Damage potential is highest in late-set fields where there has been a flush of winter annual weeds. Cutworms will begin to feed on the weeds and switch to transplants when the weed growth is removed.

Soil insecticides used for cutworm or wireworm control should be applied at least one to two weeks before transplant and immediately disked into the top 2"–4" of soil. A soil insecticide should be used when going into established sod. Liquid formulations are more toxic to handlers than are granular formulations.

A foliar spray should be applied if 5 or more cut plants are found per 100 plants checked. Orthene 97 at 3/4 lb (Orthene 75S at 1 lb) or Warrior 1 CS (a restricted use pesticide) at 1.92–3.84 fl oz per acre can be used as a broadcast spray. Proxol 80S, applied in a 12" band over the row can be used as a rescue treatment. Rescue treatments are generally less effective when damage is confined to the underground portion of the plant.

**Grasshoppers** usually remain in hayfields and along waterways but under dry conditions they may move from these into tobacco. Treatment of field borders

to prevent mass migration into the field should be considered. When selecting an insecticide for this use consider the possibility of residues and time from application to cutting or grazing of hay.

*Treat when grasshoppers are active along field margins, or if 10 or more grasshoppers are found per 50 plants.*

**Japanese beetles and green June beetles** can be found on tobacco. Japanese beetles occasionally feed on the plants but green June beetles do not. The damage usually appears worse than it actually is. Sevin 80 S may be used for control at 1-1/4–2-1/2 lb/A if Japanese beetles are causing significant damage. Actara 25% WDG, Orthene 97 and Warrior 1 CS (a restricted use pesticide) are labeled for Japanese beetle control. Provado 1.6F can be used at the rate of 4 fl oz per acre.

**Stink bugs** can feed on tobacco and cause the wilting or collapse of individual leaves which can become scalded. Generally the symptoms do not show until a day or two after feeding. The damage usually appears worse than it actually is. Acephate 75 SP, Orthene 75S and Orthene 97, several products containing endosulfan (Phaser and Thiodan) and Warrior 1 CS (a restricted use pesticide) are labeled for stink bug control. Treatment is not justified unless stink bugs are found in the field.

**Table 11.** Flea beetle control.

Insecticides	Rate/A		Harvest Interval (days)
	Small Plants	Large Plants	
Acephate 75 SP	2/3 lb	1 lb	3
Orthene 75 SP			
Orthene 97	½ lb	½ lb	
Actara 25% WDG	2 to 3 oz	2 to 3 oz	14
Capture LFR	3.4 to 8.5 fl oz	3.4 to 8.5 fl oz	Do not apply later than layby
Endosulfan 3E	2/3 qt	1-1/3 qt	5*
Lannate 90 SP <sup>1</sup>	½ lb	½ lb	14
Provado 1.6 F	4 fl oz	4 fl oz	14
Sevin 80S	1-1/4 lb	2-1/2 lb	0
Carbaryl 4L	1 qt	2 qt	
Warrior 1 CS <sup>1</sup>	1.92 to 3.84 fl oz	1.92 to 3.84 fl oz	40

\* Application of products containing endosulfan within 28 days of harvest can lead to increased residue on the crop. Do not spray in the heat of the day. Contracts offered by certain buyers may prohibit the use of endosulfan; do not apply endosulfan if your contract expressly prohibits these products.

<sup>1</sup> Restricted use pesticide.

**Table 12.** Grasshopper control.

Insecticides	Rate/A		Harvest Interval (days)
	Small Plants	Large Plants	
Acephate 75 SP	1/3 lb	2/3 lb	3
Orthene 75 SP			
Orthene 97	1/4 lb	½ lb	
Capture LFR	3.4 to 8.5 fl oz	3.4 to 8.5 fl oz	Do not apply later than layby
Endosulfan 3E	2/3 qt	1-1/3 qt	5*
Lannate 90 SP1	½ lb	½ lb	14
Warrior 1 CS1	1.92 to 3.84 fl oz	1.92 to 3.84 fl oz	40

\* Application of products containing endosulfan within 28 days of harvest can lead to increased residue on the crop. Do not spray in the heat of the day. Contracts offered by certain buyers may prohibit the use of endosulfan; do not apply endosulfan if your contract expressly prohibits these products.

<sup>1</sup> Restricted use pesticide.

## Appendix 1: Information Summary Table for Tobacco Insecticides

This table is provided for a quick comparison of insecticides labeled on tobacco. Insecticides are listed alphabetically by pesticide common name (usually present in the active ingredients section of the product label). One or more brand names are included along with the Restricted Entry Interval (REI) and Mode of Action Group number.

Use pesticide products only in accordance with their labels and with the Worker Protection Standard. Do not enter or allow worker entry into treated areas during the restricted entry interval. Check the label for Personal Protective Equipment required for early entry to treated areas that is permitted under the Worker Protection Standard and involves contact with anything that has been treated, such as plants, soil, or water. Mode of Action Group

A numerical classification system has been developed to make it easy to recognize the modes of action of insecticide products. Insecticides with the same mode of action belong to groups with unique numbers. Selection of a labeled product from a different number category (different mode of action) will help to slow down the development of resistance to either group. For example, alternate use of pyrethroid insecticides and pyrethrins sprays (Category 3) with labeled organophosphate insecticides (Category 1B). Always avoid tank mixing products with the same mode of action. These Mode of Action Group codes are on many pesticide labels and have been developed by the Insecticide Resistance Action Committee (IRAC).

Common Name	Brand Name	Restricted Entry Interval (hours) <sup>1</sup>	Mode of Action Group
Acephate	Acephate Bracket Orthene	24	1B
Acetamiprid	Assail 30 G Assail 70 WP	12	4A
Bt aizawai	Agree WG Xentari DF	4	11B1
Bt kurstaki	Dipel DF Javelin WG Lepinox WDG, etc.	4	11B2
Carbaryl	Sevin XLR Plus	12	1A
Carbofuran	Furadan 4F <sup>4</sup>	48 <sup>3</sup>	1A
Chlorpyrifos	Lorsban 15 G Govern Nufos Warhawk Whirlwind Yuma	24 <sup>2</sup>	1B
Clothianidin	Belay 16 WSG	12	4A
lambda-Cyhalothrin	Warrior <sup>4</sup> Silencer <sup>4</sup> Taiga <sup>4</sup>	24	3
Disulfoton	Di-Syston 15 G <sup>4</sup>	48 <sup>2</sup>	1B
Emamectin benzoate	Denim EC <sup>4</sup>	48	6
Endosulfan	Endosulfan EC	24	2A
Ethoprop	Mocap 15G <sup>4</sup>	48 <sup>2</sup>	1B
Imidacloprid	Admire 2F Admire Pro Alias Couraze Pasada 1.6F Provado 1.6F	12 <sup>2</sup>	4A
Methomyl	Lannate <sup>4</sup>	48	1A
Pymetrozine	Fullfil	12	9B
Spinosad	Tracer	4	5
Thiamethoxam	Actara Platinum	12	4A

<sup>1</sup> For use in storage bins no reentry is allowed. See label for details.

<sup>2</sup> If the product is soil-injected or soil incorporated, the Worker Protection Standard, under certain circumstances, allows workers to enter the treated area if there will be no contact with anything that has been treated.

<sup>3</sup> Exceptions apply for corn, sunflowers, and sorghum. See label for details.

<sup>4</sup> Restricted use pesticide.

## Appendix 2. WPS Checklist

Prepared by Lee Townsend, Extension Entomologist

This information was prepared to help farmers comply with WPS. It does not cover all details of the requirements. Sources and costs of signs and equipment are given as educational examples, only. Prices vary with source and quantities purchased. See the WPS section of the label for product-specific instructions.

### Notification

#### Signs for Posting

All greenhouse applications require posting. Some labels require field posting. Posting must be done before application and remain until 30 days after REI expires. Signs must be visible from all entrances into treated areas.

- WPS Safety Poster  
Gempler P928 .....\$ 3.85
- Nearest Medical Facility Sign (or make your own)  
Gempler X1584 .....\$ 8.60
- Reusable Pesticide Application Poster (or make your own; see the example below)  
Gempler P942 .....\$ 7.35
- Corrugated WPS Sign  
Gempler 2256.....\$ 2.75

#### Oral Notification

- Inform workers of treated areas before application or before they begin work, tell them not to enter treated areas during the REI. Some pesticide labels require both oral warnings and posting of treated areas.

#### Labeling

- Pesticide handlers must understand all labeling information for the pesticides they are using and must have access to labeling.

### Clean-up

#### Decontamination

- Decontamination facilities must be located within ¼ mile of workers/handlers. Maintained for 7 to 30 days after REI applies (see label).

#### Washing

- Workers must have access to water to wash hands, soap, single use towels. Washing facilities must not be located in the area being treated or under REI.
- Handlers must have access to water to wash entire body, soap, single use towels, clean towels. These supplies must also be provided where personal protective equipment is removed and in mix/load area. Supplies must be enclosed.

### Personal Protective Equipment (PPE)

Employer must provide and maintain clean PPE required by label and pesticide-free area to store and put on and take off equipment. Dispose of heavily contaminated PPE as hazardous waste. Check the label for specific PPE needed for mixing, loading, and application.

- Chemical resistant gloves (15 mil unlined nitrile)  
Gempler 10212 (36 pair) ..... \$79.95
- Unhooded DuPont Tyvek Coverall  
Gempler TC ..... \$ 5.70 each
- Low-cost Anti-Fog Chemical Splash Goggles  
Gempler 10507 .....\$ 3.95
- Moldex Pesticide Respirator  
Gempler G80002.....\$ 25.20  
Replacement cartridges  
Gempler G8100PR ..... \$ 11.15/pair

### Emergency Assistance

Act promptly if any worker/handler may be poisoned.

- Provide transportation to medical facility.
- Supply medical personnel with product name, EPA registration number, and active ingredient(s). Describe pesticide use and give details about exposure.

### Training

Valid for 5 years if records or EPA card is available. Certified pesticide applicators do not need WPS training and can perform WPS training. Training aids are available from CES office.

- Workers need basic training before they begin and complete training within 5 days. A worker is anyone who does tasks such as harvesting, weeding, or watering.
- Handlers mix, load, transfer or apply pesticides. They also may do many other specific tasks, such as incorporating soil-applied pesticides, clean PPE and dispose of pesticide containers.
- WPS Training Receipt  
Gempler G95003 (worker)  
Gempler G95004 (handler).....\$ 7.85/50

**Example pesticide application poster:** *If you choose to make your own poster, be sure to include the following categories.*

Field Location and Description	Product Name and EPA Registration Number	Active Ingredient(s) in Product	Time and Date of Application	Restricted Entry Interval