

Disease and Nematode Management

Table of Contents

Disease and Nematode Management in Field Crops.....	3-1
Corn and Sorghum Diseases.....	3-2
Seed and Seedling Diseases of Corn and Sorghum.....	3-2
Foliar Diseases of Corn.....	3-2
Fungicide Efficacy for Control of Corn Diseases.....	3-3
Table 3.1 - Fungicides(s).....	3-4
Foliar, Stalk, and Grain Diseases of Sorghum.....	3-6
Table 3.2 - Foliar applied fungicides.....	3-6
Nematode Diseases of Corn.....	3-6
Table 3.3 - Corn - Nematicide recommendations.....	3-7
Soybeans.....	3-9
Managing Seed and Seedling Diseases of Soybeans.....	3-9
Table 3.4 - Fungicide Efficacy for Control of Soybean Seedling Diseases.....	3-9
Management of Soybean Seedling Diseases.....	3-10
Table 3.5 - Seed treatment products containing seedling disease fungicides.....	3-10
Managing Foliar, Stem, and Pod Diseases of Soybeans.....	3-11
Fungicides for Managing Soybean Diseases.....	3-12
Table 3.6 - Foliar Fungicide Efficacy for Control of Foliar Soybean Diseases—April 2015.....	3-14
Managing Nematodes in Soybean.....	3-16
Table 3.7 - Nematode risk thresholds for soybeans (per 500 cm ³ soil).....	3-16
Table 3.8 - Acceptable Rotations Using Common Crops Grown in Virginia for Several Nematode Species (note that an “X” indicates that the crop is not a good rotational crop).....	3-16
Table 3.9 - Nematode seed treatments for soybean.....	3-17
Small Grains.....	3-19
Small Grain Diseases.....	3-19
Table 3.10 - Effectiveness of Management and Cultural Practices on Diseases of Wheat.....	3-19
Table 3.11 - Effectiveness of Management and Cultural Practices on Diseases of Barley.....	3-19
Table 3.12 - Efficacy of Fungicides for Wheat Disease Control Based on Appropriate Application Timing.....	3-21
Scouting Small Grains for Disease.....	3-22
Diseases of Small Grains.....	3-23
Virus Diseases.....	3-23
Foliar Diseases.....	3-24
Head Diseases.....	3-27
Table 3.13 Deoxynivalenol (DON) Advisory Levels Established by the FDA.....	3-27
Other.....	3-28
Forage Crop Diseases.....	3-31
Table 3.14 - Major Diseases, Probability of Outbreaks and Recommended Minimum Level of Resistance for Alfalfa Cultivars to be Grown in the Mid-Atlantic.....	3-31
Table 3.15- Fungicide Treatment.....	3-32
Tobacco.....	3-33
Disease Management Practices.....	3-33
Table 3.16 - Usefulness of Various Rotation Crops for Tobacco Disease Control.....	3-33

Disease-resistant Varieties	3-34
Disease Control in Tobacco Greenhouses	3-34
Diseases	3-34
Table 3.17 - Interpreting Root-knot Nematode Infestation Levels	3-36
Application Methods	3-38
Table 3.18 - Diseases of Tobacco Seedlings	3-39
Table 3.19 - Foliar Diseases in the Field	3-40
Table 3.20 - Root and Stem Diseases in the Field	3-42
Table 3.21 - Nematodes	3-43
Table 3.22 - No Chemical Available for the Following Diseases	3-43
Peanuts	3-45
Weather-Based Crop Advisories	3-45
Clinical Services	3-45
Predictive Nematode Assay	3-45
Management Inputs	3-45
Sanitation	3-45
Crop Rotation	3-45
Resistant Varieties	3-46
Scouting	3-46
Chemicals	3-46
Table 3.23 - Seed Treatments	3-47
Table 3.24 - Fungicide Sprays	3-48
Table 3.25 - Soil Treatments	3-53
Cotton	3-55
Seed and Seedling Diseases	3-55
Table 3.26 - In-furrow and Hopper-box Fungicides for Cotton	3-55
Foliar Diseases and Boll Rots	3-56
Table 3.27 - Foliar Fungicides for Control of Leaf Spots and Boll Rots	3-56
Nematodes	3-56
Table 3.28 - Nematicides for Use in Cotton	3-57

Disease and Nematode Management in Field Crops

*Hillary L. Mehl, Extension Plant Pathologist, Virginia Tech Tidewater AREC
Nathan Kleczewski, Extension Plant Pathologist, University of Delaware*

Disease control is an essential component of crop management for maximizing yield potential. However, the need for and best tactics for disease control vary by crop, field, and year, and an *integrated* approach to disease management is necessary to minimize unnecessary inputs and maximize profits to the grower. Integrated disease management combines multiple approaches including cultivar selection, cultural practices such as crop rotation, and judicious use of pesticides based on disease advisories and/or scouting. The following points should be considered when making disease management decisions:

- **Susceptibility of crop variety to disease.** Varieties have a high turnover rate so check with your local extension office or seed dealer for current information on which varieties have some level of resistance to diseases in the region. Be aware of the specific diseases your variety is susceptible or resistant to.
- **Yield potential and commodity price.** If yield potential or price received is low, you do not have much to gain and fungicide applications are less likely to be profitable.
- **Previous crop and cropping system (e.g. no till).** Many pathogens are able to survive on crop residues. Tillage and rotation to non-host crops helps bury and decompose this residue. Keep in mind that some require a living plant host and must move in from warmer regions each year (e.g. some rusts).
- **Crop growth stage and timing of fungicide applications.** Diseases are more likely to impact yield at particular growth stages of the crop (typically during development of the grain) so timing fungicide applications accordingly is key.
- **Proper pathogen identification.** Field crops can be affected by numerous fungi, bacteria, viruses, and nematodes. Each type of pathogen requires a different approach for disease management. Proper disease identification is key to avoiding ineffective or unnecessary chemical applications.
- **Disease pressure.** Are diseases present at amounts that require intervention? Scout fields regularly to maximize profits.
- **Weather.** Temperature and humidity greatly influence the onset and development of disease. Even if the crop is susceptible and a pathogen is present, the risk of yield loss to disease may be low if environmental conditions are not conducive pathogen growth and reproduction. Warm, humid conditions are favorable for many foliar diseases in our region. In some cases, the micro-climate within a field may be conducive for disease development even when ambient conditions are relatively dry, especially when high plant populations and a dense canopy are present in a field.

All of these factors should be considered before making plant disease management decisions, especially before applying a fungicide that may or may not be needed. Diseases are most effectively managed by integrating several of the following practices:

1. **Adapted, disease resistant cultivars** - produce plants able to resist disease attack. Every variety has a disease resistance “package” that provides levels of resistance or tolerance to specific diseases. This information can be obtained from seed dealers, commercial companies, and University variety trials such as those conducted at Virginia Tech and The University of Delaware. Some diseases cannot be managed with resistance, and not every variety has adequate resistance to all diseases. However, growers who do not consider disease resistance when selecting varieties are taking a considerable and likely a costly, risk.
2. **Rotation** - avoid presence of pathogens by not continually planting soybean in the same fields year after year. Rotation reduces the amount of residue, and therefore the amount of some pathogens, in fields. Rotation also is essential for reducing populations of some plant parasitic nematodes.
3. **Sanitation** – use tillage and weed management. Deep tillage (not disking) buries plant pathogens, favoring their decomposition and reducing their ability to reach the plant and cause damage. However, many pathogens are “regional” and therefore disking one field may not have any impact on disease if nearby fields contain ample residue. In addition, the widespread use of conservation or no-till agriculture prohibits the use of tillage, making it impractical in many cases.
4. **Planting date** - avoid pathogen or reduce the infection period by avoiding early planting. This is particularly effective in managing seedling diseases.
5. **Seed bed preparation and balanced fertility** - provide good seed to soil contact and fertility to promote vigorous plant stands. Healthy plants are likely to be less stressed and less prone to some diseases.

3-2 Disease and Nematode Management in Field Crops: *Corn and Sorghum*

6. **Good quality, disease-free seed** - promote healthy, vigorous seedling development. In addition, some diseases can move in or on seed. Using clean, certified seed can help reduce the development of these diseases and maximize stands.
7. **Seed treatment fungicides** - depending on fungicide and situation, these can help protect developing seedlings from a number of pathogens.
8. **Seed treatment nematicides/insecticides** – insecticides can sometimes reduce the spread of plant viruses that are spread by insect vectors. Seed treatment nematicides are available for some crops and can help minimize nematode damage to seedling roots.
9. **Foliar applied fungicides** - can protect the yield established when cultural practices and cultivar resistance fail to prevent economically significant losses of yield. However, in order to be most economical these often must be applied preventively and at the appropriate timing.

This section includes lists of fungicides and nematicides that are currently registered for use in field crops in the region. The information in this section is provided as a guide to available products but does not substitute for or supersede the information found on the pesticide label of a specific product. Trade names are included to aid in the identification of the specific active ingredient of a pesticide known to be effective. No discrimination against a similar product is intended or implied by omission. Mention of a commercial product does not constitute an endorsement by the authors or by their respective Extension Services. Consult the pesticide label for any changes in rate, timing, handling, or registration. Use pesticides only as directed.

Corn and Sorghum Diseases

Seed and Seedling Diseases of Corn and Sorghum

Seed treatment for corn continues to be a highly effective and inexpensive disease management tool for early-season seed and soilborne problems. In particular, because corn yield depends on plant population, seed treatments help to protect the yield potential by reducing stand losses from early-season diseases. As a result all major brands of hybrid seed are sold already treated. Similarly, hybrid sorghum production also benefits from seed treatments, as nontillering types depend on emergence to achieve optimum plant populations. Treating sorghum seed is also important to preventing the development of certain seedborne smut diseases and the systemic form of downy mildew and to reducing the introduction of and damage caused by sorghum ergot. Hybrid sorghum seed, like corn, is therefore sold already treated.

Foliar Diseases of Corn

A few chemical control measures are registered for foliar diseases of corn. However, they are generally not necessary when resistant hybrids and proper crop rotations are employed. Occasionally, when a highly susceptible hybrid is planted no-till into corn stubble and favorable conditions develop for a disease such as gray leaf spot, an economic return on a fungicide can be realized. Use resistant hybrids, especially in continuous no-till production systems. Many disease causing organisms are harbored in infested corn debris; thus, they are more readily available to infect corn in systems where debris remains on the soil surface and is allowed to build up. Foliar fungicides do not directly control stalk rots. However, lodging due to stalk rotting can be reduced through the management of foliar diseases. Hybrids with resistance to leaf diseases or susceptible hybrids treated with a fungicide are less likely to have severe stalk rotting. Hybrids with good “stay green” characteristics are also less likely to have severe stalk rotting. Foliar fungicide use in the absence of foliar disease pressure or risk is not recommended.

Gray Leaf Spot of Corn

Foliar disease caused by the fungus *Cercospora zeae-maydis* is of economic importance in many parts of the commonwealth and the mid-Atlantic region. It is recognized by its characteristically long rectangular lesions (1/8 - 1/4 inch wide and 1/2 to 2 1/2 inches in length). These lesions typically show a grayish cast when the fungus is sporulating. As the disease progresses from the lower leaves upward and the disease becomes more severe, lesions may coalesce and cause the death of the entire leaf. (See Virginia Cooperative Extension Fact Sheet: Grayleaf Spot Disease of Corn, Pub. No. 450-612, at <http://pubs.ext.vt.edu/450/450-612/450-612.html>).

Yield Loss

Gray leaf spot is most damaging when leaves are blighted at or just after silking stage. At this critical time it can cause severe yield reduction. Early blighting of the leaves above the ear leaf on susceptible hybrids has led to severe yield losses often exceeding 50% in experimental plots in Virginia. Blighting that does not occur until well into the grain-fill period results in very little grain loss. Premature stalk death and lodging is enhanced by severe leaf blighting and leads to difficulty in mechanically harvesting. Hybrids that are more resistant and slow to blight may prevent significant yield reduction.

Epidemiology

An understanding of the epidemiology of gray leaf spot is helpful in understanding why the disease has increased in intensity, severity, and distribution over the past 25 years. *C. zea-maydis* overwinters in the debris of previously diseased corn plants remaining on the soil surface. In spring, conidia (spores) are produced and disseminated to corn plants by wind and perhaps splashing rain. These conidia require several days of high relative humidity to germinate and infect corn leaves. Several weeks may be required for the development of mature lesions on leaves. Conidia for secondary spread are produced from two to four weeks after initial leaf infection. Tillage systems that leave quantities of previously diseased crop residue on the soil surface provide the primary inoculum to produce severe levels of gray leaf spot in the next season.

Management of Gray Leaf Spot

It is recommended that growers continue to use conservation tillage methods wherever practical. Growers should, however, consider planting different crops in rotation with corn in their farming system. A one- or two-year rotation away from corn would help reduce inoculum levels of *C. zea-maydis*. However, infested (diseased) corn debris on adjacent fields may be plentiful enough to initiate significant disease losses on moderately- to highly-susceptible hybrids. Growers who experience gray leaf spot are encouraged to select one or more of the newer gray leaf spot resistant hybrids for use in fields where the potential for gray leaf spot is high. Selection should be based on yield potential and standability under gray leaf spot pressure.

Fungicide Efficacy for Control of Corn Diseases

The Corn Disease Working Group (CDWG) has developed the following information on fungicide efficacy for control of major corn diseases in the United States. Efficacy ratings for each fungicide listed in the table were determined by field testing the materials over multiple years and locations by the members of the committee. Efficacy ratings are based upon level of disease control achieved by product, and are not necessarily reflective of yield increases obtained from product application. Efficacy depends upon proper application timing, rate, and application method to achieve optimum effectiveness of the fungicide as determined by labeled instructions and overall level of disease in the field at the time of application. Differences in efficacy among fungicide products were determined by direct comparisons among products in field tests and are based on a single application of the labeled rate as listed in the table. **Table includes systemic fungicides available that have been tested over multiple years and locations. The table is not intended to be a list of all labeled products**¹. Efficacy categories: NR=Not Recommended; P=Poor; F=Fair; G=Good; VG=Very Good; E=Excellent; NL = Not Labeled for use against this disease; U = Unknown efficacy or insufficient data to rank product.

Table 3.1 - Fungicides(s)

Class	Fungicide(s)				Anthracnose leaf blight	Common rust	Gray leaf spot	Northern leaf blight	Southern rust	Harvest Restriction ²
	Active ingredient (%)	Product/Trade name	Rate/A (fl oz)	Product/Trade name						
QoI Strobilurins Group 11	Azoxystrobin 22.9%	Quadris 2.08 SC Multiple Generics	6.0 - 15.5		VG	E	E	G	G	7 days
	Pyraclostrobin 23.6%	Headline 2.09 EC/SC	6.0 - 12.0		VG	E	E	VG	E	7 days
	Picoxystrobin	Approach 2.08 SC	3.0 – 12.0		VG	VG-E	F-VG	VG	U	7 days
DMI Triazoles Group 3	Propiconazole 41.8%	Tilt 3.6 EC Multiple Generics	2.0 - 4.0		NL	VG	G	G	G	30 days
	Prothioconazole 41.0%	Proline 480 SC	5.7		U	VG	U	VG	G	14 days
Mixed mode of action	Tebuconazole 38.7%	Folicur 3.6 F Multiple Generics	4.0 - 6.0		NL	U	U	VG	U	36 days
	Tetraconazole 20.5%	Domark 230 ME Multiple Generics	4.0 – 6.0		U	U	E	U	G	R3 (milk)
Mixed mode of action	Azoxystrobin 13.5%	Quilt Xcel 2.2 SE Aframe	10.5 - 14.0		VG	VG-E	E	VG	VG	30 days
	Propiconazole 11.7%	Plus 2.2 SE								
	Cyproconazole 7.17%	Approach Prima 2.34 SC	3.4 – 6.8		U	U	E	VG	VG	30 days
	Picoxystrobin 17.94%									
	Flutriafol 19.3%	Fortix	4.0 -6.0		U	U	E	VG	VG	R4 (dough)
	Fluoxastrobin 14.84%	3.22 SC								

¹Additional fungicides are labeled for disease on corn, including contact fungicides such as chlorothalonil. Certain fungicides may be available for diseases not listed in the table, including Gibberella and Fusarium ear rot. Applications of Proline 480 SC for use on ear rots requires a FIFRA Section 2(ee) and is only approved for use in Illinois, Indiana, Iowa, Louisiana, Maryland, Michigan, Mississippi, North Dakota, Ohio, Pennsylvania, and Virginia.

²Harvest restrictions are listed for field corn harvested for grain. Restrictions may vary for other types of corn (sweet, seed or popcorn, etc.), and corn for other uses such as forage or fodder. Many products have specific use restrictions about the amount of active ingredient that can be applied within a period of time or the amount of sequential applications that can occur. Please read and follow all specific use restrictions prior to fungicide use. This information is provided only as a guide. It is the responsibility of the pesticide applicator by law to read and follow all current label directions. Reference to products in this publication is not intended to be an endorsement to the exclusion of others that may be similar. Persons using such products assume responsibility for their use in accordance with current directions of the manufacturer. Members or participants in the CDWG assume no liability resulting from the use of these products.

Table 3.1 - Fungicides(s) (cont.)

Class	Fungicide(s)				Common rust	Gray leaf spot	Northern leaf blight	Southern rust	Harvest Restriction ²
	Active ingredient (%)	Product/Trade name	Rate/A (fl oz)	Anthracnose leaf blight					
Mixed mode of action	Pyraclostrobin	Headline AMP	10.0 - 14.4	U	E	VG	VG	20 days	
	13.6% Metconazole 5.1% SC	1.68							
	Pyraclostrobin	Priaxor	4.0 - 8.0	U	VG	U	G	21 days	
	28.58% Fluxapyroxad	4.17 SC							
	14.33%								
	Trifloxystrobin	Stratego YLD	4.0 - 5.0	VG	E	VG	VG	14 days	
	32.3%	4.18							
	Prothioconazole	SC							
	10.8%								
	Azoxystrobin	Affiance	10.0 - 17.0	U	U	U	U	7 days	
	9.35%								
	Tetraconazole								
	7.48%								

¹Additional fungicides are labeled for disease on corn, including contact fungicides such as chlorothalonil. Certain fungicides may be available for diseases not listed in the table, including Gibberella and Fusarium ear rot. Applications of Proline 480 SC for use on ear rots requires a FIFRA Section 2(ee) and is only approved for use in Illinois, Indiana, Iowa, Louisiana, Maryland, Michigan, Mississippi, North Dakota, Ohio, Pennsylvania, and Virginia.

²Harvest restrictions are listed for field corn harvested for grain. Restrictions may vary for other types of corn (sweet, seed or popcorn, etc.) and corn for other uses such as forage or fodder. Many products have specific use restrictions about the amount of active ingredient that can be applied within a period of time or the amount of sequential applications that can occur. Please read and follow all specific use restrictions prior to fungicide use. This information is provided only as a guide. It is the responsibility of the pesticide applicator by law to read and follow all current label directions. Reference to products in this publication is not intended to be an endorsement to the exclusion of others that may be similar. Persons using such products assume responsibility for their use in accordance with current directions of the manufacturer. Members or participants in the CDWG assume no liability resulting from the use of these products.

Foliar, Stalk, and Grain Diseases of Sorghum

Diseases impacting sorghum grain production in the mid-Atlantic include anthracnose, stalk rots, and head mold. *Colletotrichum sublineolum*, the causal agent of sorghum anthracnose, infects vegetative portions of the plant (leaf, stalk), the panicle, and the grain, and significant yield losses to this disease have been documented. Stalk rots, caused by fungi including *C. sublineolum* and *Fusarium* spp., can interfere with grain filling and cause lodging of the sorghum plant. Head mold of sorghum, caused by various fungi including mycotoxin-producing *Fusarium* spp., reduces grain mass and quality, has the potential to result in mycotoxin contamination of the grain, and may result in further grain deterioration during storage. Best management practices for controlling fungal diseases of sorghum include selection of resistant hybrids, maintaining soil fertility, and timely harvest so that fungal deterioration and mycotoxin contamination of grain is less likely to occur. Sorghum anthracnose can be controlled with foliar applications of the registered fungicides listed below.

Table 3.2 - Foliar applied fungicides

Active ingredient	Fungicide trade name	Application rate per acre	PHI (days)	Remarks
Azoxystrobin	Quadris	6.0-15.5	14	Group 11 fungicides. To reduce the development of fungi resistant to this group of fungicides, do not apply more than two sequential applications of this or other group 11 containing fungicide per season.
Pyraclostrobin	Headline	6.0-12.0	7	Group 11 fungicides. To reduce the development of fungi resistant to this group of fungicides, do not apply more than two sequential applications of this or other group 11 containing fungicide per season.
Azoxystrobin + Propiconazole	Quilt	10.5-14.0	21	Group 11 fungicides. To reduce the development of fungi resistant to this group of fungicides, do not apply more than two sequential applications of this or other group 11 containing fungicide per season.
Picoxystrobin	Approach	6.0-12.0	Do not apply after flowering.	Group 11 fungicides. To reduce the development of fungi resistant to this group of fungicides, do not apply more than two sequential applications of this or other group 11 containing fungicide per season.
fluxapyroxad + pyraclostrobin	Priaxor	4.0 – 8.0	21	Do not make more than one application. Do not apply more than 8 fl oz/A per season.

Nematode Diseases of Corn

Cultural practices, in particular rotation with non-host crops or fallow, are the most effective nematode management tactics. The length of rotation needed depends on nematode population level and species. Only when these practices are not feasible should chemical control measures be considered. Fumigant nematicides are not recommended. Non-fumigant nematicides will suppress populations and reduce infection but will not provide full-season control. Seed treatments are also appearing in the market place that have early season activity against nematodes. Until more independent test information is available, expect seed treatment control of nematodes to be shorter-lived than soil treatments. Nematode infestations are not uniformly distributed in fields. Therefore, plan to treat problem sites rather than whole fields. Base the need for a nematicide on the results of a soil test for the presence and level of plant pathogenic nematodes and on the site history. The best time to collect samples for nematode testing is fall, immediately after harvest. Before deciding to use a nematicide, consult your county Extension office for information on proper soil sampling procedures for nematode testing and for information on threshold levels. Nematode testing is available for a fee through Virginia Cooperative Extension and some commercial soil testing laboratories.

Table 3.3 - Corn - Nematicide recommendations

Nematodes	Active ingredient	Trade name	Application rate per acre	PHI (days)	Remarks
Southern root-knot, stubby-root, sting, lesion, lance, and stunt	terbufos	Counter 20G	5.0-6.5 oz	7	Apply at planting in seed furrow or 8 in. band over row and incorporate in soil. Use of ALS herbicides on corn treated with Counter may cause crop injury.
	clothianidin + <i>Bacillus firmus</i>	Poncho/ Votivo	2.7 fl oz/80,000 seeds	-	Must be applied to seed by commercial liquid application equipment for suppression of insect pests and nematodes
	abamectin + thiamethoxam	Avicta Duo	Rate based on seed count per bag	-	Application only in Syngenta-certified corn seed treatment facilities having closed transfer and application systems.

Soybeans

Hillary L. Mehl, Extension Plant Pathologist, Virginia Tech Tidewater AREC
 Nathan M. Kleczewski, Extension Plant Pathologist, University of Delaware

Managing Seed and Seedling Diseases of Soybeans

There are several pathogens that can kill seedlings and reduce soybean stands. Seedling diseases that may be problematic in mid-Atlantic soybeans include *Rhizoctonia* spp., *Fusarium* spp., and on occasion, *Pythium* spp. In general, environmental conditions that reduce germination and emergence increase the risk for seedling blights.

Scouting: Examine at least one site per 10 acres of field every week until 3-4 weeks after emergence.

Management: Plant soybeans when the daily soil temperatures at the 4 inch depth average at least 65 F or more. Avoid compaction and improve drainage when practical. Consider seed treatments for seed lots that have less than 85 percent germination (by the warm germination test). There are many commercial seed treatments available that may help with stand establishment, and can help improve stands in some circumstances. Treat seed with a fungicide if germination is lower than 85 percent. Seed with germination below 75 percent generally should not be treated or used for seed. Many of the newer seed treatments have low use rates and must be applied by certified seed treatment applicators. Consult with your chemical or seed salesperson or agricultural supply dealer for product information. Hopper-box or slurry applications are still available. Remember, once seed are treated, they cannot be used for food, feed, or oil.

Table 3.4 - Fungicide Efficacy for Control of Soybean Seedling Diseases

Fungicide active ingredient	Pythium sp. ¹	Phytophthora root rot	Rhizoctonia sp.	Fusarium sp. ^{1,2}	Sudden death syndrome (SDS) (<i>Fusarium virguliforme</i>)	Phomopsis sp.
Azoxystrobin	P	NS	E	G	NR	G
Carboxin	U	U	G	U	NR	U
Chloroneb	U	P	E	P	NR	P
Ethaboxam	E	E	U	U	U	U
Fludioxonil	NR	NR	G	F-E	NR	G
Fluopyram	NR	NR	NR	NR	VG	NR
Fluxapyroxad	U	U	E	G	NR	G
Ipconazole	P	NR	F-G	F-E	NR	G
Mefenoxam	E	E	NR	NR	NR	NR
Metalaxyl	E	E	NR	NR	NR	NR
PCNB	NR	NR	G	U	NR	G
Penflufen	NR	NR	G	G	NR	G
Prothioconazole	NR	NR	G	G	NR	G
Pyraclostrobin	P	NR	F	F	NR	F
Sedaxane	NS	NS	E	NS	NR	G
Thiabendazole	NS	NS	NS	NS	U	U
Trifloxystrobin	P	P	F-E	F-G	NR	G

¹ Products may vary in efficacy against different *Fusarium* and *Pythium* species.

² Listed seed treatments do not have efficacy against *Fusarium virguliforme*, causal agent of sudden death syndrome.

Management of Soybean Seedling Diseases

Fungicide Efficacy for Control of Soybean Seedling Diseases

The members of the Identification and Biology of Seedling Pathogens of Soybean project funded by the North Central Soybean Research Program and plant pathologists across the United States have developed the following ratings for how well fungicide seed treatments control seedling diseases of soybeans in the United States. Efficacy ratings for each fungicide active ingredient listed in the table were determined by field-testing the materials over multiple years and locations by the members of this group, and include ratings summarized from national fungicide trials published in Plant Disease Management Reports (and formerly Fungicide and Nematicide Tests) by the American Phytopathological Society at <http://www.apsnet.org>. Each rating is based on the fungicide's level of disease control, and does not necessarily reflect efficacy of fungicide active ingredient combinations and/or yield increases obtained from applying the active ingredient.

The list includes the most widely marketed products available. It is not intended to be a list of all labeled active ingredients and products. Additional active ingredients may be available, but have not been evaluated in a manner allowing a rating. Products listed are the most common products available as of the release date of the table; all available products may not be listed. Additional active ingredients may be included in some products for insect and nematode control, however; only active ingredients for pathogen control are listed and rated.

Many active ingredients and their products have specific use restrictions. Read and follow all use restrictions before applying any fungicide to seed, or before handling any fungicide-treated seed. This information is provided only as a guide. It is the applicator's and users legal responsibility to read and follow all current label directions. Reference in this publication to any specific commercial product, process, or service, or the use of any trade, firm, or corporation name is for general informational purposes only and does not constitute an endorsement, recommendation, or certification of any kind by members of the group, or by the North Central Soybean Research Program. Individuals using such products assume responsibility for their use in accordance with current directions of the manufacturer. Efficacy categories: E = Excellent; VG = Very Good; G = Good; F = Fair; P = Poor; NR = Not Recommended; NS = Not Specified on product label; U = Unknown efficacy or insufficient data to rank product. Please note: Efficacy ratings may be dependent on the rate of the fungicide product on seed. Contact your local Extension plant pathologist for recommended fungicide product rate information for your area.

Table 3.5 - Seed treatment products containing seedling disease fungicides

Product/Trade name	Active ingredient
Acceleron	DX-612 Fluxapyroxad
	DX-309 Metalaxyl
	DX-109 Pyraclostrobin
Allegiance FL	Metalaxyl
Allegiance LS	Metalaxyl
Apron XL LS	Mefenoxam
ApronMaxx RFC	Fludioxonil
	Mefenoxam
ApronMaxx RTA	Fludioxonil
	Mefenoxam
Catapult XL	Chloroneb
	Mefenoxam
CruiserMaxx	Fludioxonil
	Mefenoxam
CruiserMaxx Advanced or Cruiser Maxx Plus	Fludioxonil
	Mefenoxam
CruiserMaxx Advanced Vibrance	Fludioxonil
	Mefenoxam
	Sedaxane

Table 3.5 - Seed treatment products containing seedling disease fungicides (cont.)

Product/Trade name	Active ingredient
Dynasty	Azoxystrobin
EverGol Energy SB	Metalaxyl
	Penflufen
	Prothioconazole
ILeVO	Fluopyram
Inovate Pro	Ipconazole
	Metalaxyl
Intego	Ethaboxam
Maxim 4FS	Fludioxonil
Mertect 340 F	Thiabendazole
Prevail	Carboxin
	Metalaxyl
	PCNB
Trilex 2000	Metalaxyl
	Trifloxystrobin
Vibrance	Sedaxane
Warden CX	Fludioxonil
	Mefenoxam
	Sedaxane
Warden RTA	Fludioxonil
	Mefenoxam

Managing Foliar, Stem, and Pod Diseases of Soybeans

Foliar fungicides are tools that protect yields from plant pathogenic fungi. Research indicates that foliar applied fungicides do not always increase soybean yields in the mid-Atlantic and may not be economical in the absence of disease.

Scouting: Scout fields for foliar disease at 7 to 14 day intervals from growth stage R1 (flowering) up to R6 (full seed) for early detection of disease and effective timing of fungicide sprays.

Management: Plant varieties with resistance or tolerance to common foliar diseases. Fungicides may be needed to protect yield if a variety is susceptible to disease, disease pressure is high, and/or weather conditions are conducive for disease development (e.g. warm and wet/humid). Fungicides are more likely to be beneficial and economical for soybeans that are grown for seed production, as seed quality can be protected from moderate infestations and/or late season diseases.

Vegetative Growth Stages: Current data indicate that fungicide applications are not needed in the early vegetative growth stages. Spraying just prior to crop flowering (R1) may be prudent if a disease is increasing. Fungicide applications are not recommended after the crop reaches the full pod (R6) growth stage.

R1-R5 Reproductive Stages: Foliar, pod, and stem diseases are most prevalent, and increase most rapidly, during crop reproductive-growth stages. Foliar fungicides may or may not be needed to protect soybean yield. Decisions of whether or not to apply foliar fungicides should be based on susceptibility of the planted variety to disease, disease pressure, weather conditions, and cropping system (see introduction for more information on integrated disease management). In the absence of a need for disease control at growth stages R1-R2, the most likely stages for disease to impact yield would be stages R3, R4, or R5. Consecutive applications of either strobilurins or triazoles alone should never be made due to resistance concerns. For example, resistance to QoI (Group 11) fungicides has been reported in frogeye leaf spot in Virginia and other states where soybean is grown. Refer to fungicide labels for specific directions and restrictions.

3-12 Disease and Nematode Management in Field Crops: *Soybeans*

R6 and later: Spraying at late-growth stages is not recommended due to lack of yield response. In addition, many fungicides have days-to-harvest (preharvest) intervals or growth-stage restrictions. Refer to fungicide labels for specific directions and restrictions.

Fungicides for Managing Soybean Diseases

The North Central Regional Committee on Soybean Diseases and the Regional Committee for Soybean Rust Pathology (NCERA-212 and NCERA-208) have developed the following information on foliar fungicide efficacy for control of major foliar soybean diseases in the United States. Efficacy ratings for each fungicide listed in the table were determined by field-testing the materials over multiple years and locations by the members of the committee. Efficacy ratings are based upon level of disease control achieved by product, and are not necessarily reflective of yield increases obtained from product application. Efficacy depends upon proper application timing, rate, and application method to achieve optimum effectiveness of the fungicide as determined by labeled instructions and overall level of disease in the field at the time of application. Differences in efficacy among fungicide products were determined by direct comparisons among products in field tests and are based on a single application of the labeled rate as listed in the table, unless otherwise noted. Table includes systemic fungicides available that have been tested over multiple years and locations. The table is not intended to be a list of all labeled products.

Table 3.6- Foliar Fungicide Efficacy for Control of Foliar Soybean Diseases—April 2015

Class	Fungicide(s)		Aerial web blight	Anthracnose	Brown spot	Cercospora leaf blight ²	Frogeye leaf spot ³	Phomopsis/ Diaporthe (Pod and stem blight)	Soybean rust	White mold ⁴	Harvest Restriction ⁵
	Active ingredient (%)	Product/Trade name									
QoI Strobilurins Group 11	Azoxystrobin	Quadris 2.08 SC	6.0-15.5 VG	VG	G	F	P	U	G-VG	P	14 days
	Fluoxastrobin 40.3%	Aftershock 480 SC Evito 480 SC	2.0-5.7 VG	G	G	F	P	U	U	NL	R5 (beginning seed) 30 days
	Picoxystrobin	Approach 2.08SC	6.0-12.0 VG	G	G	F	P	U	G	G ⁸	14 days
DMI Triazoles Group 3	Pyraclostrobin 23.6%	Headline 2.09 EC/SC	6.0-12.0 VG	VG	G	F	P	U	VG	NL	21 days
	Cyproconazole 8.9%	Alto 100 SL	2.75-5.5 U	U	VG	F	F	U	VG	NL	30 days
	Flutriafol 11.8%	Topguard 1.04SC	7.0-14.0 U	VG	VG	F	VG	U	VG-E	F	21 days
MBC Thiophanates Group 1	Propiconazole 41.8%	Tilt 3.6EC Multiple Generics ⁶	2.0-4.0 P	VG	G	NL	F	NL	VG	NL	R5 (beginning seed)
	Prothioconazole 41.0%	Proline 480SC ⁷	5.0-5.7 NL	NL	NL	NL	VG	NL	G-VG	F	21 days
	Tetraconazole 20.5%	Domark 230ME Multiple Generics	4.0-5.0 NL	VG	VG	F	G	U	VG-E	F	R5 (beginning seed)
SDHI Carboximides Group 7	Thiophanate-methyl	Topsin-M Multiple Generics	10.0-20.0 U	U	U	F	VG	U	G	F	21 days
	Boscalid 70%	Endura 0.7 DF	3.5 - 11.0 U	NL	VG	U	P	NL	NL	V-G	21 days

Table 3.6 - Foliar Fungicide Efficacy for Control of Foliar Soybean Diseases—April 2015 (cont.)

Class	Fungicide(s)		Aerial web blight	Anthracnose	Brown spot	Cercospora leaf blight ²	Frogeye leaf spot ³	Phomopsis/Diaporthe (Pod and stem blight)	Soybean rust	White mold ⁴	Harvest Restriction ⁵
	Active ingredient (%)	Product/Trade name									
	Azoxystrobin	Quadris Top	U	U	U	U	VG	U	VG	NL	14 days
	18.2%	2.72 SC	8.0 – 14.0								
	Dificonazole										
	11.4%										
	Azoxystrobin	Avaris 1.66 SC	U	U	G	U	F	U	VG	NL	21 days
	7.0%	Quilt 1.66 SC	14.0								
	Propiconazole	HM-0812 1.66 SC	– 20.5								
	11.7%										
Mixed mode of action	Azoxystrobin	Quilt Xcel	E	VG	G	F	F	U	VG	NL	R6
	13.5%	2.2 SE	10.5 - 21.0								
	Propiconazole										
	11.7%										
	Fluoxastrobin	Evito T	U	F	VG	P-F	F	U	U	NL	30 days
	18.0%	3.99 F	4.0 - 6.0								
	Tebuconazole										
	25.0%										
	Pyraclostrobin	Priaxor	E	VG	E	F	F	U	VG	P	21 days
	28.58%	4.17 SC	4.0 – 8.0								
	Fluxapyroxad										
	14.33%										
	Trifloxystrobin	Stratego YLD	VG	VG	VG	F	F	U	VG	NL	21 days
	32.3%	4.18 SC ⁸	4.0 – 4.65								
	Prothioconazole										
	10.8%										
	Cyproconazole	Approach Prima	U	U	U	U	G	U	U	NL	14 days
	7.17%	2.34 SC	5.0-6.8								
	Picoxystrobin										
	17.94%										
	Flutriafol 19.3%	Fortix	U	U	U	U	G	U	U	U	R5 (beginning seed)
	Fluoxastrobin										
	14.84%										

Table 3.6 - Foliar Fungicide Efficacy for Control of Foliar Soybean Diseases—April 2015 (cont.)

Class	Fungicide(s)		Aerial web blight	Anthracnose	Brown spot	Cercospora leaf blight ²	Frogeye leaf spot ³	Phomopsis/Diaporthe (Pod and stem blight)	Soybean rust	White mold ⁴	Harvest Restriction ⁵
	Active ingredient (%)	Product/Trade name									
	Pyraclostrobin 28.58%	Priaxor D 4.17 SC	U	U	U	U	G	U	U	U	21 days
	Fluxapyroxad 14.33%	SC 1.9 SC	U	U	U	U	U	U	U	U	R5 (beginning seed)
	Tetraconazole 20.50%		U	U	U	U	U	U	U	U	
	Trifloxystrobin 32.3%	Stratego YLD	U	VG	VG	F	F	U	VG	NL	21 days
	Prothioconazole 10.8%	4.18 SC ⁸	U	VG	VG	F	F	U	VG	NL	21 days
	Tetraconazole 7.48%	Affiance SC	U	U	U	U	U	U	U	U	14 days
	Azoxystrobin 9.35%		U	U	U	U	U	U	U	U	

The table is not intended to be a list of all labeled products¹. Efficacy categories: NR=Not Recommended; P=Poor; F=Fair; G=Good; VG=Very Good; E=Excellent; NL = Not Labeled for use against this disease; U = Unknown efficacy or insufficient data to rank product efficacy.

¹Multiple fungicides are labeled for soybean rust only, powdery mildew, and Alternaria leaf spot, including tebuconazole (multiple products) and Laredo (myclobutanil). Contact fungicides such as chlorothalonil may also be labeled for use.

²Cercospora leaf blight efficacy relies on accurate application timing, and standard R3 application timings may not provide adequate disease control. Fungicide efficacy may improve with earlier or later applications. Fungicides with a solo or mixed QoI or MBC mode of action may not be effective in areas where QoI or MBC resistance has been detected in the fungal population that causes Cercospora leaf blight.

³In areas where QoI-fungicide resistant isolates of the frogeye leaf spot pathogen are NOT present, QoI fungicides may be more effective than indicated in this table. t. ⁴White mold efficacy is based on an R1-R2 application timing, and lower efficacy is obtained at an R3 application timing, or if disease symptoms are already present at the time of application.

⁵Harvest restrictions are listed for soybean harvested for grain. Restrictions may vary for other types of soybean (edamame, etc.) and soybean for other uses such as forage or fodder.

⁶Multiple generic products containing this mode of action may also be labeled in some states.

⁷Proline has a supplemental label (2ee) for soybean, only for use on white mold in IL, IN, IA, MI, MN, NE, ND, OH, SD, WI. A separate 2ee for NY exists for white mold.

⁸Stratego YLD has a supplemental label (2ee) for white mold on soybean only in IL, IN, IA, MI, MN, NE, ND, OH, SD, WI. Many products have specific use restrictions about the amount of active ingredient that can be applied within a period of time or the amount of sequential applications that can occur. Please read and follow all specific use restrictions prior to fungicide use. This information is provided only as a guide. It is the responsibility of the pesticide applicator by law to read and follow all current label directions. Reference to products in this publication is not intended to be an endorsement to the exclusion of others that may be similar. Persons using such products assume responsibility for their use in accordance with current directions of the manufacturer. Members or participants in the NCERA-137 group assume no liability resulting from the use of these products.

Managing Nematodes in Soybean

Scouting and sampling: Scout every other week from flowering (R1) through maturity. Affected plants often occur in circular patches, in sandy soils, and raised areas of the field. Symptoms include stunting, wilting, yellowing of leaf margins, and reduced nodulation of roots. In severe cases plants may die. In order to determine if nematodes are present, growers should collect soil samples and have them assessed by a nematode diagnostic lab. In Virginia, the Nematode Advisory Program provides this service at a charge per sample of \$11.00 (vermiform) or \$19.00 for vermiform and cysts. Growers interested in this program should note that soil samples must be collected in the fall no later than November 20. More information can be found at <https://www.ppws.vt.edu/extension/nematode-laboratory/index.html>. Consult your local Extension office for more information on proper sampling procedures for nematode testing. Once nematodes are identified and quantified, management decisions can be made based on whether or not nematode populations present in the field exceed economic risk thresholds.

Table 3.7 - Nematode risk thresholds for soybeans (per 500 cm³ soil)

	LOW	MODERATE	HIGH
Soybean cyst larvae	0-20	20-60	>60
Cysts	0	-	>1
Soybean cyst eggs	0-500	500-4,000	>4,000
Lance	0-300	300-1,000	>1,000
Lesion	0-100	100-500	>1,000
Ring	0-200	200-700	>700
Root-Knot	0-50	50-170	>170
Spiral	0-1000	>1,000	-
Sting	0-10	10-20	>20
Stubby Root	0-90	>90	-
Stunt	0-300	300-1,000	>1,000

Low = nematodes will not likely cause crop damage.

Moderate = borderline populations in which crop damage may occur if other factors stress the crop

High = populations likely to cause crop damage and significant yield loss

Prevention and Sanitation: The best management tactic can be those that prevent the spread of nematodes. Equipment, especially tillage equipment, will spread nematodes from one field to another. Reducing tillage has been an effective means of control. All equipment should be cleaned thoroughly after coming out of a field known to be infected with nematodes.

Rotation: Crop rotation is the best option for reducing nematodes. However, many nematodes can survive, reproduce and/or increase in numbers in other crops. For rotation to work, the rotational crop must not be a host to that particular nematode. Unfortunately, soybeans host nearly all damaging species. Use the table below to help choose good rotational crops.

Table 3.8 Acceptable Rotations Using Common Crops Grown in Virginia for Several Nematode Species (note that an "X" indicates that the crop is not a good rotational crop).

Nematode	Corn	Cotton	Peanut	Soybean	Perennial grass forage
Soybean Cyst				X	
Dagger			X	X	
Lance	X	X		X	X
Lesion	X	X	X	X	
Ring	X		X	X	X
Northern Root- Knot			X	X	
Southern Root-Knot	X	X		X	
Spiral				X	
Sting	X	X	X	X	
Stubby Root	X	X	X	X	X
Stunt				X	

Resistant Varieties: Use of resistant or tolerant varieties, when available, is an effective strategy for managing nematodes. One year of a rotation to a non-host crop may not reduce nematode populations below thresholds. Depending on the nematode species and one’s crop rotation, variety selection may be the only option. Integrating a resistant variety with effective rotation will result in a greater response than just one tactic. Before purchasing seed review local reports of cultivar performance and characteristics for the region. Most soybean varieties have soybean cyst nematode resistance and a few have root-knot nematode resistance. Check seed-company guides or contact your seed provider for a list a nematode resistance and other traits.

Chemical control: The use of nematicides should be considered as a last resort due to economic factors and performance inconsistencies. Thus, growers should not rely solely on nematicides or seed treatments to control nematode populations. Seed treatments are generally applied to seed by commercial liquid application equipment and the rate is based on the seed count per bag.

Table 3.9 - Nematode seed treatments for soybean

Product	Nematode	Activity	Nematicide a.i.
Avicta Complete Beans	Root knot, soybean cyst, others	Fungicide Insecticide Nematicide	Abamectin
ILeVO	Root knot, soybean cyst, others	Fungicide Nematicide	Fluopyram
Clariva	Soybean cyst	Biological nematicide	<i>Pasteuria</i>
Poncho/VOTIVO	Root knot, soybean cyst	Biological nematicide	<i>Bacillus firmus</i>

Small Grains

Hillary L. Mehl, Extension Plant Pathologist, Virginia Tech, Tidewater AREC
Nathan Kleczewski, Extension Plant Pathologist, University of Delaware

Small Grain Diseases

Disease management is critical for those interested in maximizing small grains yields and grain quality. Many diseases attack small grains in the mid-Atlantic and several can and do significantly impact yields in disease favorable years. This section discusses how to manage many of the diseases growers and consultants will encounter in mid-Atlantic small grains fields. Remember, management starts with accurate diagnosis. Contact your local extension agent, Plant disease diagnostic clinic, or Extension Specialist for assistance with identifying and diagnosing issues in your small grains.

Table 3.10 - Effectiveness of Management and Cultural Practices on Diseases of Wheat

Diseases	Sanitation	Crop rotation	Planting date	Balanced fertility	Disease free seed	Resistant cultivars	Fungicide Seed	Fungicide Foliar	Insecticide Seed
Powdery mildew	-	-	2 ¹	3	-	1	1	1	-
Leaf rust	-	-	3	-	-	1	3	1	-
Leaf and glume blotch	2	2	-	-	2	3	2	1	-
Tan spot	2	2	-	-	-	3	-	2	-
Loose smut	-	-	-	-	1	-	1	-	-
Head scab ²	3	2	3	-	-	2	-	2	-
Take-all	2	1	3	3	-	-	-	-	-
Barley yellow dwarf	-	-	1	-	-	2	-	-	1
Wheat spindle streak	-	-	2	-	-	1	-	-	-
Wheat streak mosaic virus	1	2	-	-	-	-	-	-	-

¹1 = highly effective; 2 = moderately effective; 3 = slightly effective; and - = no effect in reducing disease.

²Seed infested with the head scab fungus will produce weak seedlings that are prone to seedling blight. A fungicide seed treatment may be of some benefit if germination rates are acceptable. Scabby seed does not produce head-scabbed plants.

Table 3.11 - Effectiveness of Management and Cultural Practices on Diseases of Barley

Diseases	Sanitation	Crop rotation	Planting date	Balanced fertility	Disease free seed	Resistant cultivars	Fungicide Seed	Fungicide Foliar	Insecticide Seed
Covered smut	-	-	-	-	1 ¹	2	1	-	-
Loose smut	-	-	-	-	1	2	1	-	-
Powdery mildew	-	-	2	3	-	1*	2	1	-
Leaf rust	-	-	2	-	-	1	3	1	-
Barley scald	1	1	-	-	-	1	-	1	-
Net blotch	1	1	-	-	-	1	2	1	-
Head scab ²	1	2	3	-	-	-	-	2	-
Barley stripe	2	3	-	-	1	2	1	-	-
Barley yellow dwarf	-	-	2	-	-	1	-	-	1

¹1 = highly effective; 2 = moderately effective; 3 = slightly effective; and - = no effect in reducing disease.

²Seed infested with the head scab fungus will produce weak seedlings that are prone to seedling blight. A fungicide seed treatment may be of some limited benefit if germination rates are acceptable. Scabby seed does not produce plants with head scab.

* The powdery mildew population has been shifting and some varieties that were previously resistant may now be susceptible to this disease. An example of this occurring can be seen in Thoroughbred.

Managing Seed and Seedling Diseases of Small Grains

Some diseases such as loose smut, stinking smut, ergot, and some Fusarium diseases can be transmitted in or on seed. These diseases can potentially cause losses, although infrequently, in Mid-Atlantic small grains. Fungicide seed treatments, properly applied, can be considered inexpensive stand establishment insurance. Seed treatments minimize losses from seed decay, seedling blights, and seed and soil borne diseases, and for small grains are the only means of combating the smut diseases. There are currently numerous seed treatment fungicides that are available for small grains. Many of these chemicals must be applied by certified seed treatment applicators. Consult with your chemical or seed salesperson or agricultural supply dealer for product information. Hopper-box or slurry applications are still available.

Foliar Fungicides in Small Grains

The North Central Regional Committee on Management of Small Grain Diseases (NCERA-184) has developed the following information on fungicide efficacy for control of certain foliar diseases of wheat for use by the grain production industry in the U.S. Efficacy ratings for each fungicide listed in the table were determined by field testing the materials over multiple years and locations by the members of the committee. Efficacy is based on proper application timing to achieve optimum effectiveness of the fungicide as determined by labeled instructions and overall level of disease in the field at the time of application. Differences in efficacy among fungicide products were determined by direct comparisons among products in field tests and are based on a single application of the labeled rate as listed in the table. Table 3.11 includes most widely marketed products, and is not intended to be a list of all labeled products.

Table 3.12 - Efficacy of Fungicides for Wheat Disease Control Based on Appropriate Application Timing

Class	Fungicide(s)		Rate/A (fl. oz)	Powdery mildew	Stagonospora leaf/glume blotch	Septoria leaf blotch	Tan spot	Stripe rust	Leaf rust	Stem rust	Head scab	Harvest Restriction
	Active ingredient	Product										
Strobilurin ¹	Picoxystrobin 22.5%	Approach SC	6.0 - 12	G ¹	--	VG ²	VG	E ³	VG	VG	NL	Feekes 10.5
	Fluoxastrobin 40.3%	Evito 480 SC	2.0 - 4.0	G	--	--	VG	--	VG	--	NL	Feekes 10.5 and 40 days
	Pyraclostrobin 23.6%	Headline SC	6.0 - 9.0	G	VG ²	VG ²	E	E ³	E	G	NL	Feekes 10.5
	Metconazole 8.6%	Caramba 0.75 SL	10.0 - 17.0	VG	VG	--	VG	E	E	E	G	30 days
Triazole	Propiconazole 41.8%	Tilt 3.6 EC ⁴	4.0	VG	VG	VG	VG	VG	VG	VG	P	Feekes 10.5
	Prothioconazole 41%	Proline 480 SC	5.0 - 5.7	--	VG	VG	VG	VG	VG	VG	G	30 days
	Tebuconazole 38.7%	Folicur 3.6 F ⁴	4.0	NL	NL	NL	NL	E	E	E	F	30 days
	Prothioconazole 19%	Prosaro 421 SC	6.5 - 8.2	G	VG	VG	VG	E	E	E	G	30 days
Mixed modes of action ⁵	Metconazole 7.4%	TwinLine 1.75 EC	7.0 - 9.0	G	VG	VG	E	E	E	VG	NL	Feekes 10.5
	Pyraclostrobin 12%											
	Fluxapyroxad 14.3%	Priaxor	4.0 - 8.0	G	VG	VG	E	VG	VG	G	NL	Feekes 10.5
	Pyraclostrobin 28.6%											
Mixed modes of action ⁵	Propiconazole 11.7%	Quilt Xcel 2.2 SE ⁴	10.5 - 14.0	VG	VG	VG	VG	E	E	VG	NL	Feekes 10.5
	Azoxystrobin 13.5%											
	Prothioconazole 10.8%	Stratego YLD	4.0	G	VG	VG	VG	VG	VG	VG	NL	Feekes 10.5 35 days
Mixed modes of action ⁵	Trifloxystrobin 32.3%											
	Cyproconazole 7.17%	Approach Prima SC	3.4-6.8	VG	--	VG	VG	E	VG	--	NR	45 days
Mixed modes of action ⁵	Picoxystrobin 17.94%											

¹Efficacy categories: NL=Not Labeled; NR=Not Recommended; P=Poor; F=Fair; G=Good; VG=Very Good; E=Excellent; -- = Insufficient data to make statement about efficacy of this product.

²Product efficacy may be reduced in areas with fungal populations that are resistant to strobilurin fungicides.

³Efficacy may be significantly reduced if solo strobilurin products are applied after stripe rust infection has occurred.

⁴Multiple generic products containing the same active ingredients also may be labeled in some states. Products including tebuconazole include: Embrace, Monsoon, Muscle 3.6 F, Onset, Orius 3.6 F, Tebucon 3.6 F, Tebustar 3.6 F, Tegrol, and Toledo. Products containing propiconazole include: Bumper 41.8 EC, Fitness, Propiconazole E-AG, and PropiMax 3.6 EC. Products containing propiconazole + azoxystrobin include: Aframe Plus, Avaris 2XS.

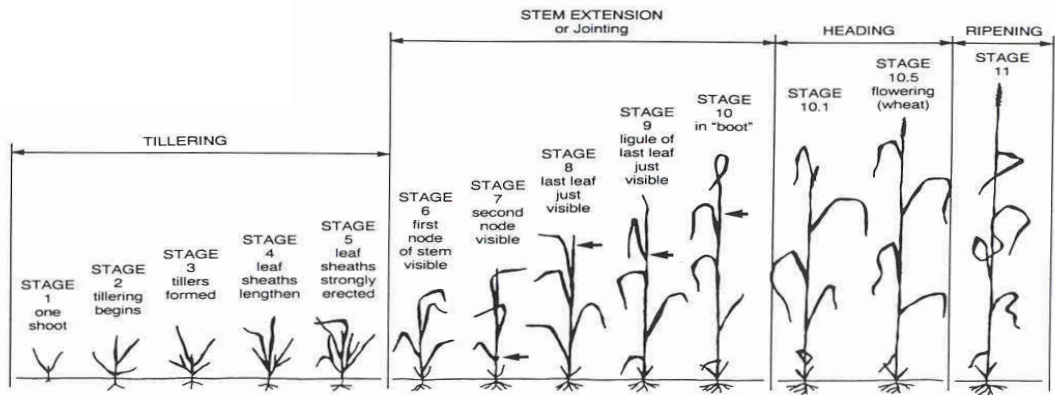
⁵Products with mixed modes of action generally combine triazole and strobilurin active ingredients. Priaxor is an exception to this general statement and combines carboxamide and strobilurin active ingredients.

3-22 Disease and Nematode Management in Field Crops: *Small Grains*

Fungicides are not needed in every field every year and the use of fungicides may not always be profitable. Although some individuals claim that fungicides may boost yield in situations where diseases are absent, university research indicates this not to be the case. Foliar fungicides are likely to be most profitable in 1) high yield settings (70+ bu/A); 2) fields where susceptible varieties are planted and scouting indicates threshold levels of disease are present; 3) the stage of crop growth is suitable for treatment; and 5) the forecast indicates that conditions will be favorable for continued disease development, in particular long periods of humid or rainy weather.

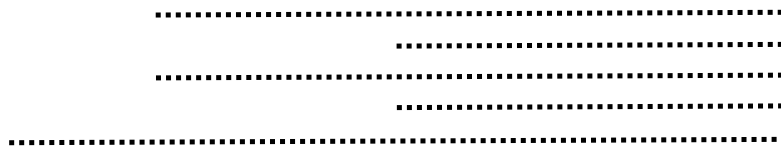
Scouting Small Grains for Disease

Scouting fields is an easy way to ensure that you are staying on top of yield-robbing diseases. Growers that scout their fields will benefit from scouting by 1) being able to make or not make pesticide applications in a timely manner and 2) learning about the disease issues associated with a particular field or variety. This information can be used in future seasons to better maximize productivity. There are many diseases that can impact mid-Atlantic small grains, but seldom do they all attack at the same time. Often, specific diseases occur at certain times of the year when the environment or plant is conducive for disease development.



Foliar Diseases

- Powdery Mildew
- Rusts
- Leaf Blotch Complex
- Tan Spot
- Viruses



Head Diseases

- Glume Blotch
- Fusarium Head Blight
- Loose Smut



Other

- Take All
- Root/crown rots



Scouting Calendar for Major Diseases of mid-Atlantic Small Grains

Diseases of Small Grains

Virus Diseases

Scouting: Examine fields at least once a month during active growing periods from Feekes' 2 through Feekes' 10.5. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: Stunted, deformed plants. Foliage may be streaked or mottled. Leaf discoloration (red/orange). Often entire fields are not affected. Instead look for single plants or plants in small groups or patches.

Diagnosis: Specialized tests that can be conducted by the Plant Disease Clinic or special testing services such as Agdia Inc.

Barley Yellow Dwarf

Barley yellow dwarf is the most widely distributed and destructive of the viral diseases that affect wheat. Symptoms of barley yellow dwarf are often confused with various nutritional or non-biological disorders. Leaf discoloration induced by the virus infection typically ranges from shades of yellow to red and sometimes purple, especially extending from the leaf tip to the base and from the leaf margin to the mid-rib. Seedling infections reduce yields most. Plants infected in the fall of the year may not survive the winter or are severely stunted and discolored when growth resumes in the spring. These diseased plants often occur in circular patches within the field. These patches are associated with the feeding and colonization by the aphid vectors in the fall and early spring. Grain yields from such plants have been shown to be reduced by 30 to 35 percent in experimental plots in Virginia. The virus can be transmitted by more than 20 species of aphids (five species of which are known to occur in Virginia). The virus persists in small grains (barley, oats, rye, and wheat), in corn, and in over 80 species of perennial and annual grasses. The spread of this virus is entirely dependent on the activity of the aphid vectors. The environmental conditions that favor barley yellow dwarf epidemics are cool temperatures (50° to 65°F) with rainfall that favors wheat and grass growth as well as aphid reproduction and movement. Infections can occur throughout the season and are most abundant where high populations of aphids survive the winter. The leaf discoloration symptoms indicating virus infection develop within about two weeks of inoculation at temperatures between 65° to 70°F. When infections occur at temperatures above 85°F, symptoms do not develop.

Management: Plant after the Hessian fly-free date. Plant varieties tolerant to BYDV. Manage aphids in the fall via insecticide seed treatments. Foliar insecticides may provide some benefit if aphid populations increase past threshold levels in the fall, within a month of planting, or early spring.

Wheat Spindle Streak Virus (Wheat Yellow Mosaic)

Wheat spindle streak virus is common in some fields in Virginia. Symptoms are typically expressed in leaves as yellow-green mottling with parallel dashes or streaks with tapered ends—hence the name wheat spindle streak. The virus is transmitted to wheat by a soil-borne fungus, *Polymyxa graminis*, which, in the absence of wheat, is associated with the roots of grassy weeds and other monocot crops (e.g., barley, corn, millet, rye, sorghum, etc.). Most significant infections take place during cool, wet periods in the fall. Often large areas of a field may be affected. Infection does not occur at temperatures above 68°F. Thus, an increase in temperature allows the plant to outgrow the virus and may mask symptoms later in the growing season. The optimal temperature for symptom expression is between 48° and 55°F. The earlier in the life of the wheat plant that infection occurs, the more severe the symptom expression. During cool spring conditions, the yellow spindle streaks may become necrotic. Affected plants may be mildly stunted and produce fewer tillers and seeds per head.

Management: Plant resistant wheat varieties. Plant after the Hessian fly-free date. Improve soil drainage and improve compaction in problem fields.

Wheat Streak Mosaic Virus

Wheat streak mosaic virus (WSMV) was observed for the first time in more than 25 years during the 2000 growing season. The incidence and severity of this disease depends on the environment, vector survival, distribution and frequency of volunteer wheat plants that serve as a source of virus and a haven for the vector, and wheat cultivar susceptibility. Symptoms of wheat streak mosaic virus typically appear in the spring. These symptoms can look very similar to wheat spindle streak caused by wheat spindle streak mosaic virus. However, the field pattern of wheat streak mosaic is related to the distribution and activity of the vector, the wheat curl mite, *Aceria tulipae*. As the wheat crop develops, plants affected with WSMV are typically severely

3-24 Disease and Nematode Management in Field Crops: *Small Grains*

stunted with yellow mottled and streaked leaves. These yellow streaks are often seen as discontinuous dashes running parallel to the leaf veins. As the season progresses, plants affected and colonized by the curl mites may develop “leaf rolling.” Leaves appear upright while the margins roll inward. This symptom of mite feeding looks like drought stress in the affected plants. Wheat streak mosaic symptoms tend to become more severe as the weather warms, and severely affected plants may produce sterile heads or die prematurely. The mite requires living hosts such as volunteer wheat or corn to survive and move to emerging wheat in the fall. Mites can then move to nearby or distant sources into wheat fields, feed on wheat, and can spread the virus.

Management: Eliminate volunteer wheat and corn before wheat emerges in the fall.

Foliar Diseases

Leaf Blotch Complex

Examine the following leaf positions at the indicated growth stage:

Flag-4 and Flag-5 for Zadoks’ growth stages 31 to 37 and Feekes’ growth stages 6 to 8 (jointing to flag leaf emergence)

Flag-3 for Zadoks’ growth stages 38 to 45 and Feekes’ growth stages 9 to 10 (flag leaf fully expanded to boot)

Flag-2 for Zadoks’ growth stages 46 to 59 and Feekes’ growth stages 10.1 to 10.5 (boot splitting to heading)

Scout fields weekly from Zadoks’ growth stage 31 through 59 (Feekes’ 6 through 10.5). Randomly select 10 locations within a wheat field. At each location, examine and record the number of indicator leaves out of ten main tillers with one or more leaf and glume blotch lesions. If 25 percent of the 100 indicator leaves in the field have one or more lesions, then a fungicide application may be beneficial.

Scouting: Examine fields at least every other week during active growing periods from Feekes’ 5 through Feekes’ 10.5. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

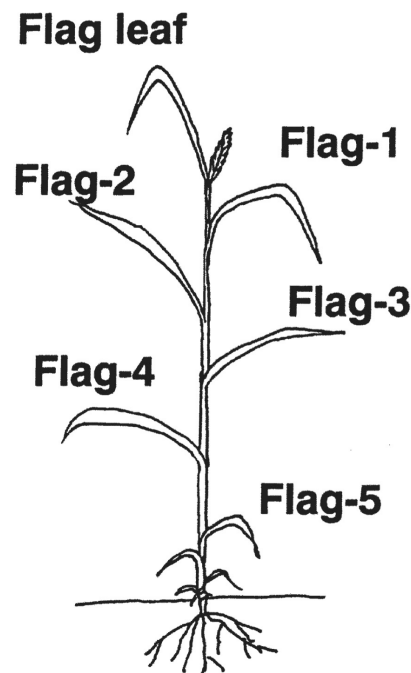


Fig 3.1 Determination of treatment threshold for septoria leaf and glume blotch in wheat.

General Symptoms: Lesions that may be blocky, oblong, or cats-eye in shape and surrounded by a thin yellow halo. *Septoria tritici* lesions tend to follow leaf veins and often contain multiple, black fungal structures within a lesion. Cream-colored cirri can be produced under extended periods of wet or humid weather. Lesions caused by *Stagonospora nodorum* are shaped like a cats-eye and contain very small, brownish colored fungal structures within the lesion. Lesions may be hard to see and can be embedded in the plant tissue. Cirri can also be produced under humid conditions but unlike *S. tritici*, they are salmon colored.

Diagnosis: May be diagnosed by trained individuals in the field with the aid of a hand lens. Confirmation through culturing or other techniques can be carried out by a Plant Diagnostic Clinic.

Description:

Leaf blotch complex is caused by two fungal diseases: *Stagonospora nodorum*, which also causes Glume Blotch, and *Septoria tritici*. Both diseases are residue- and seed-borne and develop first on lower leaves and move up the plant under favorable environmental conditions. *S. tritici* is a cool weather pathogen and is favored by high humidity and temperatures between 59-69°F. *Stagonospora nodorum* does best under warmer conditions (69-81°F) and humid weather. Epidemics of both diseases can originate from wind or rain dispersed spores, either from local or distal sources. Infection by *S. nodorum* tends to occur later in the stages of plant development. Both diseases can significantly reduce yields in susceptible varieties and under appropriate environmental conditions. Test weights may also be reduced.

Management: Plant resistant varieties. Varieties with resistance to *Stagonospora* leaf blotch may not be resistant to glume blotch and vice versa. Plant certified disease free seed and use recommended fungicide seed treatments. Destroy weeds and volunteer wheat or barley in fields prior to planting. If a susceptible variety is planted, foliar fungicides applied after flag leaf emergence can be beneficial if the disease is present and the environment conducive for further disease development.

Tan Spot

Scouting: Examine fields at least every other week during active growing periods from Feekes' 5 through Feekes' 10.5. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: Tan spot is caused by *Pyrenophora tritici-repentis* and produces symptoms very similar to Leaf Blotch Complex. Tan spot lesions are cats-eyed shaped but unlike *S. nodorum*, lesions do not often coalesce. The lesions will have dark centers but do not have black or brown fungal structures within lesions.

Diagnosis: May be diagnosed by trained individuals in the field with the aid of a hand lens. Confirmation through culturing or other techniques can be carried out by a Plant Diagnostic Clinic.

Description: *Pyrenophora tritici-repentis* is a residue-borne organism that can infect wheat, barley, rye, and numerous other grassy hosts. Disease occurs over a wide temperature range, but symptoms are often more pronounced at later stages in crop growth. Depending on the variety, as few as 6 hours of leaf wetness may be needed for disease development. The disease spreads through the dissemination of spores in wind and rain.

Management: Same as for Leaf Blotch Complex

Powdery Mildew

Scouting: Examine fields at least every other week during active growing periods from Feekes' 2 through Feekes' 10.5. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: White fuzzy growth on stems and foliage of plants. Over time black pinhead-like structures can be observed in and on the white growth. Very old infections appear grey to brown.

Diagnosis: Easily identified with the naked eye in the field.

Description:

Erysiphe graminis f.sp. *tritici* (wheat) and *E. graminis* f.sp. *hordei* (barley) are common throughout the mid-Atlantic. The fungus overwinters in small grain stubble as well as overwintering wheat and barley. Powdery mildew is favored by cool temperatures (60-68°F) and high relative humidity (>90% RH). Unlike other foliar diseases, free water on the leaf surface may inhibit spore germination and infection. Disease progress ceases at temperatures above 77°F. Disease increases with nitrogen fertilization and lush growth. Spores of powdery mildew can be dispersed on air currents over large distances. Infection can cause lodging as well as yield losses resulting from foliar infection. Population shifts have overcome previously effective resistance genes in barley and this may occur in wheat.

Management: Plant resistant varieties. Avoid planting wheat or barley early in the fall. Avoid excessive nitrogen levels. Foliar fungicides, especially when a susceptible variety is planted and the disease is detected early in the growing season, may be beneficial in some years. Protection of the flag leaf is key.

Rusts (Stripe and Leaf)

Scouting: Examine fields every week during active growing periods from Feekes' 2 through Feekes' 10.5. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius. Consider a fungicide application for a high yield crop when rust covers 1 percent of upper, fully expanded leaves prior to heading, Fig 3.2.

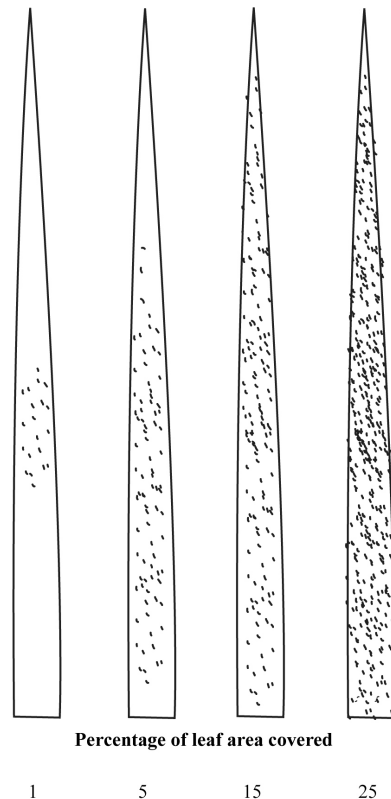


Fig 3.2

Percentage of leaf area affected by leaf rust. (James, C. 1971. A Manual of Assessment Keys for Plant Diseases. Publication 1458. Canada Department of Agriculture.)

General Symptoms: Early infections appear as small yellow/orange spots on the foliage. Spots eventually develop into brown/orange raised pustules that will leave a brown/red rusty residue on fingers when pustules are rubbed between fingers. Leaf rust appears on the upper leaf surface and is generally brown in color. Stripe rust follows the leaf veins and is light orange in color.

Diagnosis: Easily identified with the naked eye in the field.

Description:

Puccinia recondita f.sp *tritici* (leaf rust) and *P. striiformis* f.sp *tritici* (stripe rust) occur frequently in the mid-Atlantic. These rusts may overwinter as mycelium in dormant wheat in the southernmost areas of the mid-Atlantic, particularly following a mild winter. More commonly rusts blow in from the south and therefore arrive later in the growing season. Leaf rust does well under moderate temperatures (60-70°F) whereas stripe rust is favored by cool weather (50-60°F). Temperatures above 68°F inhibit stripe rust. Spores produced from pustules are wind distributed over large distances and are deposited by rain onto plants. When the environment is favorable, epidemics can develop rapidly and cause losses approaching 50% in susceptible varieties. Early season infections have the most impact on yield and can reduce root and tiller formation. Late season infections, which are common in many parts of the mid-Atlantic, are unlikely to cause significant yield reductions. New races of stripe rust have been identified that can better tolerate warm temperatures and ever-changing populations have overcome resistance in some varieties.

Management: Plant resistant varieties. Foliar fungicides applied before disease is present or reported in the area may be beneficial, particularly if a susceptible variety is planted. Avoid planting a variety in a subsequent year if stripe rust was detected in that variety the previous season.

Head Diseases

Glume Blotch

Scouting: Examine fields every week from Feekes' 9 through Feekes' 10.5. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: Gray to brown spots form the chaff, typically starting on the upper ¾ of the glumes. Over time lesions can grow and brownish fungal structures form within gray centers of the lesion.

Diagnosis: Can be confused with other disorders such as bacterial diseases or chemical injury. Fungal structures are diagnostic but difficult to see without the aid of a hand lens.

Description:

Glume blotch is caused by *Stagonospora nodorum*, a component of Leaf Blotch Complex, which is described in the previous section.

Management: Plant resistant varieties. Varieties with resistance to *Stagonospora* leaf blotch may not be resistant to glume blotch and vice versa. Plant certified disease free seed and use recommended fungicide seed treatments. Destroy weeds and volunteer wheat or barley in fields prior to planting. Foliar fungicides applied before disease is present on the glumes may be beneficial if the environment is favorable for disease development.

Fusarium head blight

Scouting: Examine fields every week from Feekes' 10.5 to Feekes' 11. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: Heads completely or partially bleached. Under humid conditions, masses or orange spores may be present at the base of infected kernels. Severely infected kernels may be shrunken, chalky, and shriveled. Infected heads may have elevated levels of deoxynivalenol (DON) a mycotoxin.

Diagnosis: Can be confused with other disorders such as insect injury, eyespot, or frost damage

Description:

Fusarium head blight (FHB) in the mid-Atlantic is caused predominantly by *Fusarium graminearum*. This is a reemerging disease that is likely to increase in incidence and severity due to widespread no-till and corn acres. This fungus overwinters in small grain or corn residue and produces spores under wet conditions (>70 % RH) and over a wide temperature range (60-85°F). Longer periods of wet weather are required for severe epidemics to occur under cool conditions. Approximately 70% of spores are ejected and carried long distances on wind currents and deposited at night. The remaining spores (30%), called macroconidia, are locally dispersed via rain splash. FHB only causes disease on heads and disease is most severe when appropriate conditions occur at or around flowering (Feekes' 10.5.1-yellow anthers observable at the center of heads). Once spores germinate, they can enter the head, resulting in kernel abortion and characteristic head bleaching. Depending on the environment, variety, and fungal strain, mycotoxins (DON and others) may be produced. Elevated levels of DON can result in dockage or rejection at the grain mill. Bleaching does not always indicate elevated DON levels in grain.

Table 3.13 Deoxynivalenol (DON) Advisory Levels Established by the FDA

Maximum Allowable DON Level (ppm)	Consumer
1	Humans
5	Swine and all animal species except cattle and poultry (Not to exceed 20% of the diet for swine and 40% for other animals)
10	Ruminating beef and feedlot cattle older than 4 months and poultry (Not to exceed 50% of diet).

3-28 Disease and Nematode Management in Field Crops: *Small Grains*

Management: Plant moderately resistant varieties with good tolerance to DON accumulation. DON management should be the focus when selecting a variety as DON levels do not correlate well with levels of bleaching, although bleached heads may indicate elevated levels of mycotoxins in a field. Research indicates that overall, the use of a locally adapted, moderately resistant variety can reduce DON by over 50% compared to susceptible varieties. Virginia Tech screens commercial and experimental wheat varieties for DON accumulation and growers should refer to these ratings when selecting a variety. FHB does not grow as well on soybean residue, so planting wheat after soybeans may help reduce local inoculum levels. Burial of residue through tillage may also help reduce local levels of inoculum. However, because the pathogen can be dispersed over long distances, local residue management may only have a minor effect on overall suppression of FHB and DON, particularly during severe epidemics. Staggering planting date may help reduce the likelihood that all fields will enter a susceptible stage when the environment favors FHB, although differences in flowering are likely to be subtle in warm environments. Several fungicides are available for suppression of FHB and DON. These products should be applied at least 10-15 gallons per acre at 35 psi with nozzles angled in a forward direction (30° optimal) if travelling above 10 mph in a ground rig. Aerial applicators should apply at 5 gallons per acre. The lowest labeled rate of a non-ionic surfactant may improve coverage of the head. Maximum product efficacy is obtained if fungicides are applied when plants have entered Feekes' 10.5.1. Fungicides can be applied up to 6 days after the start of Feekes' 10.5.1 without a notable drop-off in efficacy. Research trials indicate that currently, the best fungicides for suppression are Prostar®, Caramba® and Proline®. If applied properly these products reduce DON by approximately 45% compared to untreated controls. The use of moderately resistant varieties and recommended fungicides applied around Feekes' 10.5.1 has been shown to reduce DON levels by 70% relative to untreated susceptible varieties in replicated national trials. The Fusarium Head Blight Prediction Center uses multiple sources of environmental weather data to determine the probability of FHB epidemics for wheat at a susceptible stage of growth: <http://www.wheatscab.psu.edu/>. This site can be used to help determine if a fungicide application is likely to be needed during the growing season. Remember, fungicide use alone is not likely to bring down DON levels to a manageable level if a susceptible variety is planted in an FHB-favorable year. Therefore, growers should integrate multiple practices to manage this disease.

Loose Smut

Scouting: Examine fields every week from Feekes' 10.5 until harvest. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: Heads will contain a black/brown dusty mass of spores in the place of kernels and chaff. These spores eventually blow away, leaving a bare spike with a sooty appearance. Heads of infected tillers emerge from the boot earlier than healthy tillers and prior to heading diseased plants may appear darker than healthy plants.

Diagnosis: Easily identified in the field.

Description:

Loose smut is a disease that is infrequent in the mid-Atlantic, mostly as a result of seed treatment fungicides in wheat production systems. The disease is caused by the fungus, *Ustilago tritici* and yield losses can be significant in some situations. Spores of the fungus often enter the field on infested seed. After seed germination, the fungus grows within the plant without producing symptoms. When the head emerges the fungus invades the contents of the head, converting everything except the pericarp membrane and rachis to a mass of black fungal spores. Wind then disperses spores over long distances where they may land on flowering wheat or barley. Light rains and temperatures between 60 and 72°F favor germination of spores and infection. Once the fungus has established itself in the kernel it goes into dormancy. Infected seeds cannot be distinguished from healthy seeds. The fungus only becomes active again when the infected kernel germinates.

Management: Plant certified disease-free seed. Utilize recommended seed treatment fungicides.

Other

Take-All

Scouting: Examine fields every other week from Feekes' 5 through harvest. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: Around head emergence leaves may become yellow and plants may be stunted or uneven. The most conspicuous symptom is premature white tillers. Take all often occurs in patches but can also be uniform in distribution in some fields. The roots of infected plants will be brittle and rotten. If the outer leaf sheath is removed from the stem a shiny discoloration of the basal stem will be evident.

Diagnosis: Can be confused with other disorders such as head blight, sharp eyespot, frost injury, and insect damage. The shiny black appearance of the basal stem is diagnostic for the disease.

Description:

Take all is caused by the fungus *Gaeumannomyces graminis*. This pathogen survives in fields on residue from infested small grains or grassy weeds. During the growing season, the fungus invades plant roots, compromising nutrient and water uptake. The pathogen is often most active in cool soils. Poorly drained soils, low soil fertility, and alkaline conditions may favor infection by *G. graminis*. Take all is not often an issue due to the crop rotations that are commonly practiced in the mid-Atlantic.

Management: Rotation away from small grains for 2 years will reduce inoculum levels in the soil. Apply fertilizers and lime according to soil test recommendations. Minimize compaction and drainage issues.

On a related note, growers may have heard of a phenomenon known as, “Take-all decline.” This has been observed in other regions where wheat monocultures are used extensively. In these cases, several years of wheat monoculture allows for the accumulation of antagonistic bacteria that compete with the pathogen for soil nutrients and resources.

Forage Crop Diseases

Hillary L. Mehl, Extension Plant Pathologist, Virginia Tech, Tidewater AREC

Disease management in perennial forage crops is based on planting locally adapted, disease-resistant cultivars and using good cultural practices to help reduce losses from diseases. Disease resistance ratings of alfalfa cultivars are compiled by the National Alfalfa & Forage Alliance and are updated annually. The list can be viewed on the web at <http://www.alfalfa.org>. You may download the list for free, or purchase a copy of the list for a nominal fee from the organization. Note that at this time no commercially available alfalfa cultivars have an acceptable level of resistance to Sclerotinia crown and stem rot.

Sclerotinia crown and stem rot is best managed by avoiding no-till seeding of new stands in the fall. Stand establishment of forage legumes may benefit from the use of seed-protectant fungicides, particularly in spring no-till seeding, when conditions slow the germination process. In general, cool, wet soil conditions favor seed decay and damping-off diseases. Most seed companies now sell alfalfa seed treated with a fungicide for damping-off management. However, most other forage crops are not commonly pretreated.

Table 3.14 - Major Diseases, Probability of Outbreaks and Recommended Minimum Level of Resistance for Alfalfa Cultivars to be Grown in the Mid-Atlantic

	Bacterial wilt	Verticillium wilt	Fusarium wilt	Anthrax-nose	Phytophthora root rot	Root-knot nematode	Aphanomyces root rot	Sclerotinia crown and stem rot	Leaf & stem spots
Outbreak probability	Low	Moderate	Moderate	Moderate	Moderate	Low	Unknown ³	No-till fall seeding High	High
Recommended minimum resistance ¹	MR	MR	MR	R	R	Soil test ²	MR	NA	NA

¹Always get the highest level of resistance available whenever possible. Recommended minimums will not prevent serious losses in the event of a major outbreak. Consider the recommendation as a guideline for choosing between varieties when HR is not available across the board.

²Nematode risk can be determined with a soil test prior to planting. When root-knot nematode is a threat and you must plant alfalfa, choose a variety with as high a level of resistance as you can find.

³Aphanomyces root rot has not been formally identified or surveyed for in the mid-Atlantic. It is, however, likely to be a problem. In general, plant cultivars that have at least an MR rating, except if planting in spring in which case select cultivars with at least an R rating.

Key: MR = moderately resistant, R = resistant, NR = resistance varieties not available.

Table 3.15- Fungicide Treatment

Crop	Disease	Active ingredient	Trade name	Remarks
<i>Seed treatment fungicides</i>				
Alfalfa, forage beans, forage cowpeas, forage soybeans, forage velvet beans, lespedeza clover, pea vine, hay, trefoil, and vetch	Damping-off and early season Phytophthora root rot	Metalaxyl Mefenoxam	Allegiance FL Apron XL LS	Registered for application by commercial seed treaters only. Excellent control of Pythium damping-off.
Alfalfa, clover, and other small-seeded legumes	Seed decay and damping-off	Thiram	Thiram	Control of Pythium damping-off is less effective than metalaxyl or mefenoxam. Apply seed treatment materials in a slurry or with commercial mist-type equipment. Follow instructions on label.
<i>Soil treatment fungicides</i>				
Alfalfa	Damping-off and early season Phytophthora root rot	Mefenoxam	Ridomil Gold SL	Soil treatment generally is not necessary if seed is treated with Allegiance or Apron. Consider soil treatment only where there is a history of Phytophthora, soil is heavy, cold and wet conditions are expected after seeding, and the variety is relatively susceptible. Most alfalfa seed is treated with Apron. Use the low rate of Ridomil with Apron-treated seed. Apply 1/4 to 1/2 pints per acre of SL formulation as a broadcast surface spray at planting in a minimum of 20 gallons of water per acre. Do not feed green forage or cut hay for 60 days following application.

Tobacco

Charles S. Johnson, Extension Plant Pathologist, Southern Piedmont AREC

Reliable and efficient control of tobacco diseases and nematodes **depends** upon accurate identification of the problems in each field and the simultaneous use of multiple disease management approaches (crop rotation, resistant varieties, sanitation, early stalk and root destruction, etc.).

Disease Management Practices

Crop Rotation

The use of the proper rotation crop can be **critical** to avoid losing yield and quality to diseases and nematodes. Tobacco following tobacco should be avoided.

Table 3.16 - Usefulness of Various Rotation Crops for Tobacco Disease Control¹

Rotation Crop	Black Shank	Granville Wilt	Root-Knot Nematodes	Tobacco Cyst Nematodes	Tobacco Mosaic Virus	Black Root Rot
Fescue	H	H	H	H	H	H
Small grain	H	H	H	H	H	H
Lespedeza 'Rowan'	H	H	H	-	H	L
Soybean	H	H	L ²	H	H	L
Corn	H	M	L	H	H	H
Sweetpotato	H	M	L ³	-	H	H
Cotton	H	M	N	-	H	L
Milo	H	M	L	H	H	H
Peanuts	H	L	N	H	H	L
Pepper	H	N	N ⁴	L	N	H
Potato, irish	H	N	L	L	H	H
Tomato	H	N	N ²	N	N	M

¹Adapted from Flue-Cured Tobacco Information, North Carolina Cooperative Extension Service. Ratings indicate the value of each rotation crop for reducing damage caused by each disease in the subsequent tobacco crop, and assume excellent weed control in each rotation crop; H = highly valuable, M = moderately valuable, L = Little value, N = no value – may be worse than continuous tobacco, - = unknown.

²However, root-knot resistant cultivars can be highly effective as rotation crops for managing root-knot nematodes on tobacco.

³Root-knot resistant sweetpotato cultivars are moderately effective rotation crops for tobacco.

⁴May be highly valuable for some species or races of root-knot nematodes

Early Stalk and Root Destruction

Helps reduce disease, insect, and weed infestation levels that will carry over into future tobacco crops. *Most effective when tobacco stalks and roots are destroyed immediately after final harvest.*

The following steps should be completed to gain maximum benefit: 1) **flue-cured** - cut stalks into small pieces with bushhog or similar equipment the day that harvest is completed in each field; 2) **all types** - disc or plow-out roots the day harvest is completed. Roots must be exposed to air for about 2 weeks to obtain maximum drying of roots; 3) after 2 weeks, re-disc field to provide additional root kill and to bury crop refuse; 4) plant a cover crop when root systems are killed and plant debris is buried.

Disease-resistant Varieties

Offer excellent control of most of the major diseases of tobacco. However, growers should consider the major disease problems and the level of infestation when selecting a resistant variety. In severe disease situations, disease control chemicals may also be required to obtain satisfactory results. The Virginia Cooperative Extension Tobacco Production Guides summarize the latest disease resistance information on the most current tobacco cultivars.

Disease Control in Tobacco Greenhouses

Disease causing organisms can enter a greenhouse in soil or plant debris. Entrances should be covered with asphalt, concrete, gravel, or rock dust. Footwear should be cleaned or disinfected before entering a greenhouse. Float bays should be re-lined with fresh plastic each year and be free of soil and plant debris. Greenhouse equipment should also be sanitized periodically. A 1:10 solution of household bleach and water is sufficient for these purposes, as are most disinfectants.

If tobacco mosaic (TMV) may have occurred in the previous year, greenhouse surfaces that may come in contact with plants should be disinfected. Such surfaces include side-curtains, center walkways, and the 2x6 boards that form the float bays. There is no need to spray the purline supports or the plastic covers over the greenhouse. *Relatively new float trays that may have been used when TMV may have been present should be washed and rinsed thoroughly before being fumigated.* Older trays should be discarded and replaced with new trays. Mosaic has a number of weed hosts (horsenettle, ground cherry) which should be removed from the vicinity of tobacco greenhouses.

As of late 2015, methyl bromide can no longer be purchased for sanitizing tobacco float trays, although growers who already possess methyl bromide can use what they have to sanitize their trays. Float trays should always be thoroughly cleaned before fumigation. Dry trays should be loosely stacked no more than 5 ft high and completely enclosed in plastic. Three pounds of methyl bromide will fumigate 1,000 cubic feet (1,200 trays). Trays should be fumigated 24 to 48 hours, and then aerated for at least 48 hours before use. Be sure to read the label for space fumigation and follow it exactly. If float trays are to be sanitized by steaming, they should remain in aerated steam at 140°F to 175°F for at least 30 minutes in order to minimize *Rhizoctonia* damping-off and sore shin, as well as *Pythium* damping-off.

Do not fill float bays with water from streams or ponds as these sources may be contaminated. To reduce the potential spread of water-borne pathogens, do not move water from one bay to another. Be careful to avoid introducing disinfectants into water intended for plant uptake.

To avoid spreading TMV, mower blades and decks should be sanitized with a 1:1 bleach and water solution between greenhouses and after each clipping. Plant debris left on trays after clipping is one of the primary causes of collar rot problems. High vacuum mowers should be used to clip tobacco seedlings. Clippings, unused plants, and used media should be dumped at least 100 yards from the greenhouse.

Condensation on the underside of the greenhouse top and on leaf surfaces create conditions that favor disease. This condensation results from a difference in temperature between the inside and outside of the greenhouse, particularly at sunset. **Increasing air exchange near dusk by temporarily lowering the side curtains will reduce such differences in air temperature. Ventilating the greenhouse with horizontal airflow fans will also help reduce potential condensation.** Minimize overhead watering and potential splashing of media from one tray cell to another. Correcting drainage problems in and around the greenhouse will also help avoid excess humidity.

Bacterial soft rot causes a slimy, watery rot of leaves and stems and can easily be confused with damage from collar rot. Greenhouse management practices that help minimize collar rot will also help prevent bacterial soft rot. Management practices for angular leaf spot and wildfire (two other diseases caused by bacteria) can also help reduce bacterial soft rot as a side effect.

Waiting to seed tobacco greenhouses and float beds until March, and eliminating any volunteer tobacco plants within these structures, should be an essential component of each grower's disease control plan. As a general rule, plants closely related to tobacco (tomatoes, peppers, etc.) should not be grown in greenhouses used for transplant production.

Diseases

Blue Mold

Unused tobacco transplants should be destroyed as soon as possible after transplanting has been completed. If possible, fields

that seem to favor blue mold development (shady areas with poor air drainage) should be avoided. Fields should be irrigated early enough in the day that leaves can dry before nightfall. Suspected blue mold should be reported to Virginia Cooperative Extension.

Black Shank and Granville Wilt

Calculating and recording the percentage of diseased plants in each field at the end of each season can enable growers to evaluate the cost-effectiveness of their disease control program.

Severity Level	Black Shank or Granville Wilt
Low	Less than 1%
Moderate	1-5%
High	More than 5%

Black Shank

Caused by a fungus-like pathogen that lives in the soil and attacks tobacco roots and stalks. Disease losses can be minimized by planting highly resistant cultivars in fields that have been rotated in and out of tobacco production. The longer the interval between tobacco crops, the less black shank to be expected. Black shank-infested fields used to produce burley or dark-fired tobacco should be rotated out of tobacco for longer periods of time than normally used with flue-cured tobacco. **Some tobacco cultivars are highly resistant to race 0 of the black shank pathogen, but are susceptible to other races. Because most tobacco fields in Virginia now contain mostly race 1 of the pathogen, tobacco cultivars should be chosen for their resistance to RACE 1. Current tobacco varieties are always at least as resistant to race 0 as they are to race 1, but many are much less resistant to race 1 than to race 0. If black shank is present in fields to be planted with tobacco, ALWAYS know the resistance to RACE 1 before planting a variety.** Several highly effective black shank fungicides are currently available, but don't forget that maximum use of a soil fungicide will not necessarily protect a variety with low black shank resistance against significant damage, particularly in fields where tobacco was planted the previous year. Consistently reliable black shank control, especially with less resistant tobacco cultivars, will likely require 2-3 fungicide applications during the growing season, starting at or near transplanting. Ridomil Gold, Orondis Gold B, and/or Orondis Gold 200 are all labeled for application at or near transplanting. Follow-up field sprays should alternate to a black shank fungicide with a different mode of action (for example, Presidio). See Table 3.19 for these products and directions for their use. Soil fumigation is not as effective against black shank as it is for the management of Granville wilt or nematodes.

Granville (Bacterial) Wilt

Caused by a soil-inhabiting bacterium that invades tobacco plants through roots and subsequently kills the entire plant. The pathogen can also invade tobacco plants through wounds, such as those caused by cultivation, mechanical topping, and mechanical harvest. For this reason, early, shallow cultivation and topping by hand can help reduce this disease in infested fields. Although symptoms are somewhat similar to those associated with black shank, intermediate symptoms of Granville wilt involve wilting on only one side of affected plants. Leaves of infected plants will tend to wilt more quickly (while still green) and take longer to yellow than plants with black shank. Crop rotation (particularly with soybeans) and the use of resistant varieties are *essential* for Granville wilt control. Disease reduction and yield increases are generally much larger from the use of resistant varieties than from using soil fumigation. However, Granville wilt-resistant varieties are not available in burley and dark-fired tobacco. These types of tobacco generally should *not* be planted in fields infested by the Granville wilt pathogen.

Nematodes

Nematodes are microscopic roundworms. Many live in soil and parasitize plant roots. Root-knot, lesion, and tobacco-cyst nematodes are important pests of all tobacco types grown in Southside Virginia. Because symptoms of nematode injury are often confused with other problems, nematodes may go undetected for years. The specific pesticides, rotation crops, and resistant varieties vary among the different types of nematodes that damage tobacco. A Nematode Assay Clinic at Virginia Tech provides a *Diagnostic Nematode Assay* and a *Predictive Nematode Assay*. The *Diagnostic Nematode Assay* determines if plant-parasitic nematodes are the cause of stunted or unthrifty plants. Plant roots should always accompany soil samples submitted for the assay. When nematodes are found to be the cause of problems, it is usually impractical to initiate control measures until the year following the diagnosis. The *Predictive Nematode Assay* focuses on sampling for nematodes in the fall to identify fields with damaging nematode populations so that control measures can be initiated before or at the time of planting. Any soil

3-36 Disease and Nematode Management in Field Crops: Tobacco

samples submitted for this assay should be obtained by a systematic sampling procedure. Each soil sample should represent an area no larger than 2 acres and should consist of at least 25 cores or subsamples taken 6 to 8 inches deep. Predictive nematode assay samples must be received by Virginia Tech by November 30 for results to be available by planting. Assay results indicate the presence or absence of economically significant nematode populations. If damaging nematodes are not found, the producer can choose not to use a nematicide. In addition, the type and number of nematodes will influence the choice of nematicide if one is needed. Contact your local Cooperative Extension agent for information on methods of collecting samples and interpreting assay results.

Lesion Nematodes

Early root and stalk destruction and crop rotation can significantly reduce populations of these nematodes. Use of a nematicide rated good (G) or excellent (E) may be profitable when a soil assay detects 50-100 lesion nematodes/500 cc of soil. A combination of crop rotation and soil fumigation should be used when populations of lesion nematodes are greater than 100 nematodes/500 cc of soil.

Root-knot Nematodes

Root-knot nematodes are common in Virginia tobacco fields, and several types of root-knot can be present in damaging numbers in the same field. Most “root-knot resistant” tobacco cultivars are only resistant to races 1 and 3 of the southern root-knot nematode (*Meloidogyne incognita*), but other types or species are now common. Any root galling on a “root-knot resistant” cultivar indicates the presence of these other types of root-knot. Rotating tobacco with pasture grasses and small grains reduces populations of all types of root-knot, but be careful to rotate tobacco with root-knot resistant cultivars for row crops such as soybean. Forage legumes can increase root-knot nematode populations to damaging levels. Flue-cured tobacco cultivars CC 13, CC 33, CC 35, CC 37, CC 65, and PVH 2275 claim resistance to several types of root-knot. Consult the flue-cured tobacco production guide for more information on these varieties. A preplant nematicide may be necessary when root-knot populations are high, as indicated in the following table.

Table 3.17 - Interpreting Root-knot Nematode Infestation Levels

Risk of Crop Loss	% Roots Galled	Nematodes/500 cc of soil		Control Options ¹
		Fall Sample	Spring Sample	
Very Low	1-10	1-200	1-20	Practice crop rotation and/or plant a resistant variety.
Low	11-25	201-1,000	21-100	Use crop rotation in combination with a resistant variety or a nematicide rated ‘G’ or higher.
Moderate	26-50	1,001-3,000	101-300	Use crop rotation in combination with a resistant variety and a nematicide rated ‘G’ or higher.
High	Over 50	Over 3,000	Over 300	Increase rotation interval if at all possible. Use a resistant variety and a nematicide rated ‘E’.

¹Be aware that most “root-knot resistant” tobacco varieties are only resistant to the most common types of root-knot nematodes. **Risks of crop loss are high if galling on roots of root-knot resistant varieties is greater than 20%.** Rotation intervals should be increased as long as possible and soil fumigation should be used when galling has been observed on root-knot resistant varieties.

Tobacco-cyst Nematode (TCN)

Tobacco-cyst nematode (TCN) (*Globodera tabacum* subsp. *solanacearum*) is present in most tobacco-producing counties in Southside Virginia. Taking soil samples for a Predictive Nematode Assay of tobacco fields on a regular basis (before rotating a field to another crop) will help avoid detecting TCN populations “the hard way.” **Varieties of flue-cured tobacco that possess the *Php* gene will reduce TCN populations to non-damaging levels after several years of use;** TCN populations will increase very quickly to damaging levels when fields are planted continuously with flue-cured tobacco cultivars without the *Php* gene. Crop rotation with corn, sorghum, small grains, or pasture grasses will also significantly improve TCN control, particularly when used in addition to TCN-resistant varieties.

Tobacco Mosaic Virus (TMV)

Anything that moves sap from diseased to healthy plants will also move TMV. TMV can spread via contaminated clipping mowers in the greenhouse and from manufactured tobacco products, old tobacco sheets, tobacco roots and stalks left in the soil from previous crops, and from weed hosts such as horse-nettle and ground cherry. Washing hands regularly with detergent can help reduce TMV incidence early in the season. Roguing infected plants before layby will reduce spread of the virus within a field. TMV cannot be eliminated without faithful use of crop rotation and early root and stalk destruction. All burley varieties are resistant to TMV except KY 8959, HB 3307PLC, N 777LC, TN 86LC, VA 509, and HY 502. Flue-cured tobacco cultivars CC 27, CC 37, CC 67, CC 304, NC 102, NC 297, PVH 2310, and PVH 2275 are TMV-resistant”. After this phrase, the sentence should end as, “as are the dark-fired tobacco cultivars KT D6LC, PD 7312LC, PD 7302LC, and VA 312. *TMV-resistant varieties should be planted in flue-cured tobacco fields with a history of 30 to 50 percent of the plants being infected with TMV by the topping stage. If a TMV-resistant variety is used in an infested field, the entire field should be planted with the resistant variety. Planting resistant and susceptible varieties together in TMV problem fields can result in significant crop losses due to a severe hypersensitive reaction in the resistant cultivar that can actually kill plants.*

Tomato Spotted Wilt Virus (TSWV)

Spread by various species of thrips from wild weed hosts to tobacco and other crops. Removing infected plants from a tobacco field will not reduce damage. Crop rotation does not reduce the incidence of TSWV. All commercial tobacco varieties are equally susceptible to the virus. Spraying foliar insecticides is also ineffective. However, application of imidacloprid or thiamethoxam prior to or at transplanting can significantly reduce the damage caused by TSWV to tobacco, as will preplant use of Actigard. Application of Actigard, in addition to imidacloprid or thiamethoxam, before transplanting significantly improves TSWV control compared to use of a single product. Be aware, however, that some risk of significant stunting has been associated with preplant use of Actigard. For this reason, do not apply Actigard before transplanting unless 10% to 15% of the tobacco crop is expected to become infected with TSWV. See the PMG section on tobacco insect control for more specific information on use of imidacloprid or thiamethoxam.

Other Viruses

Tobacco etch virus (TEV), Tobacco vein mottling virus (TVMV), Cucumber mosaic virus (CMV), Peanut stunt virus (PSV), Potato virus Y (PVY), Alfalfa mosaic virus (AMV) - TVMV and TEV are the most common viruses found in burley tobacco, frequently occur together, and are often referred to as a virus complex. Other less common viruses found in the burley virus complex are AMV, CMV, and PSV. All of these viruses are transmitted by aphids that feed on infected weeds and then move into tobacco. Overwintering hosts of these viruses include horsenettle, ground cherry, curly dock (for TVMV), alfalfa (for AMV), and clovers for CMV and PSV. Symptoms of virus infections vary greatly depending on the virus involved, time of infection, and variety. Virus infected plants may show mosaic, vein clearing, stunt, chlorosis, vein banding, etch, and death of veins. The earlier the plants become infected the more severe the stunting, chlorosis, and necrosis. There are no known methods to prevent infection, nor are chemicals available to cure a virus-infected plant. “Consult the KY, TN, VA and NC regional publication *2015-2016 Burley and Dark Tobacco Production Guide* (Virginia Cooperative Extension publication 436-050) for information on resistance to these viruses in currently-grown burley varieties.

Fusarium Wilt

Can become a serious problem when roots are injured, particularly by tobacco cyst or root-knot nematodes, so effective nematode control is critical to controlling this disease. Early destruction of tobacco stalks and roots and crop rotation (for as long as possible, but not with cotton or sweet potato) will also help reduce problems with Fusarium wilt. Soil fumigation using a product that contains more than 2% chloropicrin may be required when significant stand loss occurs.

Application Methods

The performance and safety of a chemical is dependent on following the proper application methods. Proper application procedures will avoid crop injury and poor disease control.

Preplant Incorporated (PPI)

Refer to section under weed control.

Foliar Spray (FS)

Greenhouse sprays should not begin until seedlings are at least the size of a dime, but if repeated should be applied at 5- to 7-day intervals up to transplanting. Use flat-fan, extended-range tips at approximately 40 psi to maximize results. Flat-fan spray tips and spray volumes of 25-50 gallons per acre should generally be used for **field sprays** targeting the soil surface. Foliar field sprays should apply spray volumes of at least 20 gallons/acre at layby, gradually increasing to 100 gallons of spray solution/acre at topping, to maximize spray coverage as tobacco plants increase in size. Hollow cone or similar spray tips should be used for foliar field sprays to reduce spray droplet size, which improves coverage of leaves. Spray pressures should generally range between 40 and 100 psi. Both the tops and bottoms of leaves need to be covered. The use of drop nozzles will significantly improve disease control after layby by improving spray coverage on bottom leaves, where foliar diseases are usually concentrated. Fungicides applied using air-blast sprayers should be mixed at a two-times concentration but only half the spray volume (gal mix/acre) should be delivered compared to a hydraulic sprayer.

Fumigation

Labels for products that contain chloropicrin and metam sodium now require respirator fit-testing, full-face respirators (chloropicrin products only); completed “fumigant management plans” or FMPs *prior to application*; increased posting of treated areas, as well as buffer zones around fumigated fields; minimum distances between treated fields and “difficult to evacuate” sites (schools, etc.), 5-day “entry restricted periods” (ERPs) after soil fumigant application, and official notification requirements. *Special grower meetings will be held in late winter or early spring of 2016 to re-certify growers so that they understand and comply with all of these new label requirements. This recertification is required in order to purchase tobacco fumigants that contain chloropicrin or metam sodium.*

Field Procedures - Performance of all or most field procedures must be documented in the GAP section of the FMP for chloropicrin products, Telone C-17, and metam sodium products. Soil should be in good seed bed condition, free of clods and undecomposed plant material, and with soil moisture at about 1/2 of field capacity when fumigants are applied. If undecomposed plant material is present, plow down and allow to decompose before applying fumigant. Soil temperature should be 50° to 80° F at the depth of injection. Fumigants can be applied by the following procedure: 1) **Row treatment** - inject the fumigant 6-8 inches deep with one chisel-type applicator in center of the row. In the same operation as fumigant application, seal the soil by bedding the fumigated row area with enough soil to bring the soil surface 14-16 inches above the point of infection; 2) **Broadcast treatment** - Space chisels 8 inches apart and inject fumigant 10 to 12 inches below the soil surface. Immediately seal in the fumigant with a roller, drag, disc, or similar equipment.

After fumigation, leave soil undisturbed for an ‘exposure period’ of 7-14 days. Cold, wet soil retards diffusion of fumigants and requires a longer exposure period. Soil should be aerated at the end of the exposure period. Planting is generally considered safe when a residual odor of the fumigant is no longer detectable in the soil root zone. This condition is usually reached within 3 weeks after fumigation. *The following procedures can be used to hasten aeration, especially if rains or cold temperatures occur during the exposure period: 1) Row - Use a chisel in the bed without turning the soil; 2) Broadcast - Plow or cultivate above the depth of the treatment zone. Caution: In both types of treatment, avoid contamination of treated soil with untreated soil. Do not rehill row if there is a danger of contamination with untreated soil. Do not use tools, equipment, and/or residues that are contaminated with soil-borne pathogens. Remember, plant injury will occur if fumigant is still present in the soil at transplanting.*

Precautionary and Restriction Statements

Read and follow all directions, cautions, precautions, restrictions, and special precautions on each product label. This publication must not be used as the only source of precautionary and restriction statements.

Table 3.18 - Diseases of Tobacco Seedlings

Disease	Material	Rate	Remarks
Blue mold (<i>Peronospora tabacina</i>)	Aliette (for blue mold)	0.5lb/50 gal 8 fl oz/acre	Foliar spray; apply no more than 0.6 lb/1,000 sq ft; can burn plants if washed into media or float water ; no more than 2 sprays/ greenhouse season. Begin applications prior to disease development and continues on a 7-10 day interval. Make no more than 2 consecutive applications before switching to an effective non-Group 40 fungicide. May be tank-mixed with another blue mold fungicide with a different mode of action. Adding a spreader-penetrator, such as a non-ionic surfactant, may increase activity. Thorough coverage is needed for maximum activity.
Tomato Spotted Wilt Virus (TSWV)	Actigard 50WG	1.0-2.0 oz/100,000 plants (~347-288-cell trays)	<i>Must submit liability waiver to receive a copy of the label, which is required for use. One</i> foliar application in the greenhouse 5-7 days prior to transplanting in sufficient water to ensure good coverage (~6 gal/1,000 sq ft); use of accurate rate is CRITICAL to avoid crop injury . A 10% to 15% stand loss due to TSWV should be expected before considering use. Systemic insecticides such as imidacloprid or thiamethoxam as well as Actigard will significantly improve control of TSWV. Tank mixtures are not recommended, but product may be left on foliage or washed off into the root ball.
		0.5 oz/A	Field application as a banded, foliar spray in sufficient water (at least 20 gal/A) to provide thorough coverage. The initial spray should be made within 7 days of transplanting or whenever plants have recovered from transplant shock, whichever comes first. A total of 3 such field applications may be made, 10 to 14 days apart.
Angular Leaf Spot or Wildfire (<i>Pseudomonas</i>)	Agrimycin 17, etc. Harbour, Fire-Wall 17WP, etc.	100-200 ppm 2-4 tsp/3 gal or 4-8 oz/50 gal	Foliar Spray; preventive use: 100 ppm = 4.0 oz/50 gal or 0.5 lb/100 gal; curative use: 200 ppm = 0.5 lb/50 gal or 1.0 lb/100 gal
Anthracnose (<i>Colletotrichum gloeosporoides</i>) Blue Mold (<i>Peronospora tabacina</i>) Target Spot (<i>Thanatephorus cucumeris</i>)	Penncozeb 75DF	0.5 lb/100 gal (1 level tsp/gal)	Apply as a fine spray to the point of run-off to ensure thorough coverage. For best results, begin applications before disease has been observed, but not before seedlings are the size of a dime. Use 3 gal of spray mixture/1000 sq ft when plants are about the size of a dime. Use 6 gal/1,000 sq ft. when the canopy has closed and plants are close to ready for transplanting. Repeat applications on a 5-day interval to protect new growth.

3-40 Disease and Nematode Management in Field Crops: *Tobacco*

Table 3.18 - Diseases of Tobacco Seedlings (cont.)

Disease	Material	Rate	Remarks
Target Spot (<i>Thanatephorus cucumeris</i>)	Quadris	0.14 oz (4 cc)/1,000 sq ft	One application to tobacco seedlings in transplant greenhouses is allowed. Use enough water for thorough coverage (3-5 gal/1,000 sq.ft.). Follow-up applications are allowed in the field according to the Quadris field label.
Pythium Root Rot (<i>Pythium spp.</i>)	Terramaster 4EC	Preventative: 1.0 fl oz/100 gal Sequential: 1.0 fl oz/100 gal Curative: 1.4 fl oz/100 gal 2nd Curative: 1.0-1.4 fl oz/100 gal	Can be used before or after symptoms appear, but no earlier than 2 weeks after seeding. If symptoms reappear, a second application can be made no later than 8 weeks after seeding. No more than 2.8 fl oz/100 gal of water may be applied to any crop of transplants, regardless of the number of applications. Must be evenly distributed ; when mixing, first form dilute slurry, then distribute slurry evenly and thoroughly in float bed water.

Table 3.19 - Foliar Diseases in the Field

Disease	Material	Rate	Remarks
Blue mold (<i>Peronospora tabacina</i>)	Actigard 50WG	0.5 oz/20 gal/A	Begin applications when blue mold threatens and plants are tall enough (12 inches for flue-cured and dark-fired tobacco, 18 inches for burley). Up to 3 sprays may be applied on a 10-day schedule. Spray weekly for complete coverage until blue mold no longer threatens. Increase spray volume as the crop grows. Spray volumes should range from 20 gal/A for 1- 3 weeks after transplanting to 40 gal/A for tobacco near layby, to 60 gal/A for waist-high tobacco, to 80-100 gal/A for tobacco near topping or thereafter. If using an air blast sprayer, mix fungicide at 2X concentration, but calibrate sprayer to apply 1/2 the spray volume (gal/ acre) used with hydraulic sprayers. Do not spray within 21 days of harvest for flue-cured tobacco or within 30 days of cutting burley tobacco.
	Forum (formerly Acrobat) +	7.0 fl oz/100 gal	
	Penncozeb 75DF	2.0 lb/100 gal	
	Revus or Orondis Ultra B	8 fl oz/acre	Begin applications before disease develops and continue spraying on a 7-10 day interval. Spray no more than twice before switching to another effective fungicide that's not in FRAC Group 40. Revus and Orondis Ultra B may be tank-mixed with another effective blue mold fungicide that has a different mode of action. Thorough spray coverage is important in maximizing disease control; adding a spreader-penetrating adjuvant may improve activity.
Blue mold (<i>Peronospora tabacina</i>)	Presidio	4 fl oz/A	Two foliar sprays are allowed, the first before or at disease onset. The second spray should be at least 7 days after the first Presidio application. Presidio must be tank-mixed with another blue mold fungicide for resistance management.

Table 3.19 - Foliar Diseases in the Field (cont.)

Disease	Material	Rate	Remarks
	Orondis Ultra A	2.9-4.8 fl oz/A	Do not use if Orondis Gold 200 has previously been applied to soil. Begin applications before disease development and continue on a 7-to 10-day interval. Use higher rates when disease is present, for longer application intervals, or more susceptible varieties. Make no more than 2 sequential applications before rotating to a fungicide with a different mode of action. See label for additional use restrictions.
	Aliette	2.5-4.0 lb/A	Foliar spray; no more than 5 sprays allowed, 3-day preharvest interval; don't tank mix.
	Penncozeb 75DF	2.0 lb/100 gal	Spray weekly for complete coverage until blue mold no longer threatens. Gradually increase spray volume as the crop grows. Spray volumes should range between 80 and 100 gal/A on tobacco ready to be topped. If using an air blast sprayer, mix fungicide at 2X concentration, but calibrate sprayer to apply 1/2 the spray volume (gal/acre) used with hydraulic sprayers. Don't spray within 21 days of harvest for flue-cured tobacco, or within 30 days of cutting burley tobacco.
	Ridomil Gold SL UltraFlourish MetaStar 2E AG	0.5-1.0 pt 1.0-2.0 pt 2.0-4.0 pt	Flue-Cured – Apply low rate for early season control. Burley & dark-fired — Apply high rate for early season control. Note: Apply broadcast & incorporate in top 2-4 inches of soil preplant. Do not use in plant beds or float systems.
	Ridomil Gold SL UltraFlourish MetaStar 2E AG	0.5 pt 1.0 pt 2.0 pt	Apply to soil beneath plants just before layby cultivation - don't spray leaves. Do not apply if mfenoxam or metalaxyl-insensitive pathogen strains have been reported to be present.
Blue mold (<i>Peronospora tabacina</i>); Frogeye (<i>Cercospora nicotianae</i>); Target Spot (<i>Thanatephorus cucumeris</i>)	Quadris	6.0-12.0 fl oz	First application should be made prior to disease development or at first indication of disease development in the area; sprays should be applied every 7-14 days, with shorter intervals when weather is conducive for disease, in sufficient water volume for complete coverage and canopy penetration; may enhance weather flecking, but this does not affect yield or quality; up to 4 applications/year allowed; may be applied up to the day of harvest; tank mixing with insecticides formulated as ECs or containing high amounts of solvents may cause some crop injury.

Table 3.20 - Root and Stem Diseases in the Field

Disease	Material	Rate/Acre	Remarks
Black shank (<i>Phytophthora nicotianae</i>)	Ridomil Gold SL	4.0-8.0 fl oz (0.25-0.5 pt)	Apply Ridomil Gold and/or Orondis Gold 200 in at least 100 gal (200 gal for burley and dark tobacco) transplant water/A. Transplant water use carries a risk of plant injury. Use higher rates if disease pressure is expected to be severe. Ultra Flourish and Meta Star are not registered for transplant water application. Season-long disease control usually requires an additional black shank fungicide application at 1st cultivation and/or layby. Orondis Gold 200 must not be applied sequentially (back-to-back).
	Orondis Gold 200	4.8-19.2 fl oz (0.30-1.2 pt)	
Flue-Cured			Apply preplant sprays broadcast, then incorporate into the top 2-4 inches of soil. Presidio and Orondis Gold 200 are not labelled for this use. Black shank fungicides should always be used in conjunction with crop rotation and resistant varieties. Failure to control nematodes in treated fields may result in poor black shank control.
	Ridomil Gold SL	1.0-2.0 pt	
	Ultra Flourish	2.0-4.0 pt	Direct banded sprays to soil beneath plants during field cultivation. If significant disease is likely, use after a pre- or at-plant black shank fungicide application. Do not apply Presidio and Orondis sequentially (back-to-back), but alternate each with another black shank fungicide. Later application during cultivation usually extends disease control further through the harvest season. Do not exceed 3.0 pt of Ridomil Gold, 6.0 pt of Ultra Flourish, 12.0 pt of Meta Star, 8.0 fl oz of Presidio/acre, or 38.6 fl oz Orondis Gold 200.
	MetaStar 2E AG	4.0-8.0 pt	
Burley and Dark			
	Ridomil Gold SL	2.0-3.0 pt	
	Ultra Flourish	4.0-6.0 pt	
	MetaStar 2E AG	8.0-12.0 pt	
	Ridomil Gold SL	1.0-2.0 pt	
	Ultra Flourish	2.0-4.0 pt	
	MetaStar 2E AG	4.0-8.0 pt	
	Presidio	4.0 fl oz	
	Orondis Gold 200	4.8-19.2 fl oz	
Ridomil Gold SL			For no-till tobacco, split between 2 sprays, before and 30-35 days after transplanting. See comments in tobacco weed control section for directions in calculating rates for band applications.
	Ultra Flourish	3.0 pt	
	MetaStar 2E AG	6.0 pt	
	Chlor-O-Pic	3.0 gal	Inject 8 inches deep with one shank in center of row when soil temperatures are above 50° F. Wait 2-3 weeks after fumigation before planting. Fumigants should always be used in conjunction with host resistance and crop rotation. Soil fumigants should always be used with a soil fungicide if applied for black shank control.
	Chloropicrin 100	3.0 gal	
	Pic+	4.2 gal	
	Telone C-17	10.5 gal	
Fusarium Wilt (<i>Fusarium oxysporum</i> f. sp. <i>nicotianae</i>)	Chlor-O-Pic	3.0 gal	In severe cases, use a multipurpose chemical, and apply a soil fumigant containing more than 2% chloropicrin, and rotate the field out of tobacco for at least 2-3 years between tobacco crops. Do not rotate with sweet potatoes, since the same fungus attacks both crops.
	Chloropicrin 100	3.0 gal	
	Pic+	4.2 gal	
Granville Wilt (<i>Pseudomonas solanacearum</i>)	Chlor-O-Pic	3.0 gal	Fumigants should always be used in conjunction with host resistance and crop rotation.
	Chloropicrin 100	3.0 gal	
	Pic+	4.2 gal	
	Telone C-17	10.5 gal	

Table 3.21 - Nematodes^{1,2}

Material	Rate/A	Application Method	Root-Knot And Others	Tobacco Cyst	Remarks
Non-Fumigants					
Vydate C-LV	68 fl oz	PPI	F	F	With spray volume at least 40 gal/A; best if within 24 hr transplanting.
Vydate L	1 gal	PPI	F	F	With spray volume at least 40 gal/A; at least 48 hr before transplanting.
Fumigants					
Chlor-O-Pic	3.0 gal	Row	E	G	
42% metam sodium	20.0-25.0 gal	Row	nd	G	Metam CLR, Vapam, Sectagon, etc.
Pic+	4.2 gal	Row	E	G	
Telone II	9.0-10.0 gal	Row	E	G	
Telone C-17	10.5 gal	Row	E	G	

¹ Control rating – E = Excellent; G = Good; F = Fair; P = Poor, - = no control or not labeled for disease; nd = no data

² **PPI** – Applied broadcast, preplant-incorporated. **Row** – Inject 8 inches deep in row with single shank – 21 day waiting period before planting.

Table 3.22 - No Chemical Available for the Following Diseases

Disease	Comments
Botrytis Blight (<i>Botrytis cinerea</i>)	This disease occurs more commonly in “organic” than “conventional” tobacco greenhouses, and only very rarely in the field. A wet rot is often first observed on stems or leaves. A gray, downy material may be present on the surface of diseased areas. Management practices effective for collar rot and target spot also help reduce incidence and severity of Botrytis blight.
Collar Rot (<i>Sclerotinia sclerotiorum</i>)	Symptoms of this disease (occurring only in greenhouse systems) resemble damping-off. Small groups of plants have brown, wet lesions near the base of stems. Leaf rot may appear to progress from leaf margins or tips toward the stem. White, cottony mold may be visible. Irregularly shaped, white to black objects (sclerotia) may also be found attached to severely infected plant parts. Infected plants, as well as plants immediately adjacent to diseased areas, should be discarded as soon as possible. Proper clipping procedures, improving ventilation, and reducing excess moisture will help reduce spread of the causal organism.
Frenching (nonpathogenic causal agent)	This disorder has been associated with toxins produced by a nonpathogenic bacterium (<i>Bacillus cereus</i>) and other nonpathogenic microorganisms. Frenching is more prevalent on wet, poorly aerated soils. This problem can be more severe on neutral or alkaline soils and is sometimes associated with lack of available nitrogen or other minerals. Proper soil drainage and fertilization can be beneficial. Do not plant in alkaline soils and avoid heavy application of lime.
Weather fleck (ozone)	This disorder appears as small brown to tan leaf spots in the plant bed and field. The major cause of this problem is ozone from thunderstorms and air pollution. Burley and flue-cured tobacco are more susceptible than dark-fired varieties.

Peanuts

Hillary L. Mehl, Extension Plant Pathologist, Virginia Tech, Tidewater AREC

Weather-Based Crop Advisories

The Peanut/Cotton Weather Network system is designed to electronically collect data from remote weather stations in the peanut and cotton producing areas of Southeastern Virginia. The data are used to provide daily summaries (air and soil temperature, rainfall), peanut leaf spot and Sclerotinia blight advisories, heat unit reports for peanuts, and degree-day reports for cotton. The Peanut Frost Advisory is another weather-based program that is provided during the fall-harvest period. Each program is designed to guide growers in making decisions that maximize yield, quality, and net profit. Because of constant changes in weather and pest populations during the growing season, information must be updated daily and made readily available to growers. The Tidewater Agricultural Research and Extension Center (AREC) in cooperation with Extension agents, growers, and industry make this information available in the following ways:

- **Peanut/Cotton InfoNet:** Information from four weather monitors is available on the Internet at <http://www.ipm.vt.edu/infonet/>. Up-to-date leaf spot and Sclerotinia fungicide advisories, heat units, and frost advisories are reported.
- Contact your local Extension agent or call (757) 657-6450 and ask for Dr. Hillary Mehl or Linda Byrd-Masters if you need assistance.

Clinical Services

Diagnostic services for plant diseases are provided by the Tidewater AREC in Suffolk. Plant samples should be submitted with the required forms by unit Extension agents. A period of 3 to 5 days is needed to complete biopsy tests and email reports. Diagnostic tests for nematodes and soil fertility problems during the season are also performed in cooperation with laboratories at Virginia Tech. Diagnostic assays are provided free of charge for agents and growers.

Predictive Nematode Assay

This program provides data on the numbers and kinds of nematodes in soil and recommendations on needs for control. Soil samples must be collected in the fall no later than November 20. Local Extension offices have instructions, sample information sheets, and bags for packaging samples. A service charge of \$11 per sample is required at the time of sample submission.

Management Inputs

The most effective and economical strategy for disease control combines the benefits of sanitation, crop rotation, resistant varieties, scouting, and judicious use of pesticides. For example, changing from a 2-year to a 3-year rotation of peanut with corn or cotton can reduce disease losses to leaf spot, Sclerotinia blight, and *Cylindrocladium* black rot by as much as 50 percent in as few as two or three cycles. Inputs for disease control should be determined on the basis of field history, scouting, disease advisory programs, and recommendations by Virginia Cooperative Extension. This approach to disease management will enable the judicious use of chemicals while providing for a maximum return on investments.

Sanitation

The decay of excess crop residues can be enhanced by disking fields after harvest. Plant debris may contain residual inoculum of organisms that cause disease and improve their capability for long-term survival in fields. Wash equipment frequently to avoid transport of inoculum from field to field. Peanut combines should be cleaned to remove loose soil and plant material after harvesting fields with heavy infestations of soil-borne diseases. Attempts at removal and/or destruction of peanut vines after harvest have some value in disease management, but this practice negates a significant part of the soil fertility benefits of peanut hay in the following year.

Crop Rotation

Using a 4-year rotation of peanuts with corn, grain sorghum, fescue, and other grass-type crops is beneficial to control of peanut diseases. Cotton is also a good rotational crop for peanuts in Virginia, but growers should not apply potash (K) in excess of recommended rates of the soil test report. Elevated levels of potash can interfere with calcium uptake and result in pod rot

3-46 Disease and Nematode Management in Field Crops: *Peanuts*

by fungi such a *Rhizoctonia* and *Pythium* species. Soybean and other leguminous crops share many of the common destructive diseases with peanuts and should be avoided. Where soybean is grown in a peanut rotation, double crop soybean with wheat and follow with either cotton, corn, or another grass-type crop.

Resistant Varieties

No peanut varieties are immune to disease, but there is a wide range in susceptibility. Some important differences are noted below with respect to the most common diseases.

- **Cylindrocladium black rot (CBR):** Bailey, Sugg, Sullivan, and Wynne are resistant to CBR. Disease severity in other varieties in other varieties can be reduced by good nematode control and delayed planting to May 10 or later. Cool, wet conditions after planting favor epidemics of CBR.
- **Sclerotinia blight:** Sullivan and Bailey are partially resistant to this disease. Early planting at seed rates of 110 lb/A or lower can reduce the susceptibility of varieties in some years. However, this practice will increase the risk of tomato spotted wilt disease.
- **Early leaf spot:** Sullivan, Bailey, and Wynne are moderately susceptible. All other Virginia-type varieties are susceptible.
- **Tomato spotted wilt virus:** Bailey, Wynne, and Sullivan are resistant to TSWV. Sugg, Champs, and Gregory are moderately less susceptible, but can sustain significant damage in early plantings before May 1 in years of heavy disease pressure.

Scouting

Peanut fields should be scouted once a week for disease after pegging. Scouts should use different entry and exit points as well as travel patterns across fields at each visit. After a canopy of foliage covers the soil, scouts should part the vines and look for signs of soilborne diseases on plant stems at the soil surface.

Chemicals

A wide array of chemicals are registered for disease control in peanuts. Selection of the most effective/economical chemical requires knowledge of the target disease and other diseases in the field. Whenever the cause of disease is uncertain, plant samples should be submitted for diagnostic tests in the plant pathology clinic at the Tidewater AREC. Whenever nematode or soil fertility problems are suspected, a 1 pt sample of soil should be submitted. The Peanut/Cotton InfoNet is an important source of information for timing of fungicide applications to control leaf spot and Sclerotinia blight. The following tables provide listings of approved chemicals for control of specific disease problems. **Read the label instructions attached to the pesticide containers before application.**

Table 3.23 - Seed Treatments

Disease	Product and Formulation	Rate of Formulation/100 lb seed	Method and Timing of Application	Precautions and Remarks ¹
Seed decay and seedling disease	Allegiance-FL (metalaxyl)	0.1-0.375 fl oz	Apply as water-based slurry with commercial seed treatment equipment.	Controls Pythium seed rot and damping-off. Use in combination with a broad spectrum fungicide.
	Apron XL LS (mefenoxam)	0.16-0.64 fl oz	Same as above.	Same as above.
	Protégé (azoxystrobin)	0.153-1.53 fl oz	Same as above.	Controls Aspergillus crown rot and Rhizoctonia damping-off.
	Maxim 4FS (fludioxonil)	0.08-0.16 fl oz	Same as above.	Protects against seed decay, damping-off, and seed transmission of <i>Cylindrocladium</i> black rot.
	Captan 30DD OR Captan 400	6.0 fl oz 3.0-6.0 fl oz	Same as above.	Same as above.
	RTU-PCNB	1.75-2.5 fl oz	Same as above.	Controls damping-off by <i>Rhizoctonia sp.</i>
	42-S Thiram	3.0 fl oz	Same as above.	Protects against seed decay, damping-off and seedling blights.
	Vitavax-30C	3.0 fl oz	Same as above.	Controls Sclerotium rot and damping-off. Use in combination with a broad spectrum fungicide.
	Thiram 50WP	4.5 oz	Apply with dust treater.	Controls seed decay, damping-off, and seedling blights.
	Vitavax PC (captan + PCNB + Vitavax)	4.0-5.0 oz	Same as above.	Same as above.
	Trilex Optimum DS (captan, trifloxystrobin, metalaxyl)	4.0 oz	Same as above.	Same as above.
	Trilex Star DS (captan, trifloxystrobin, thiophanate methyl, metalaxyl)	4.0 oz	Same as above.	Same as above, and suppresses seed transmission of CBR.
	Dynasty PD (azoxystrobin + fludioxonil + mefenoxam)	3.0-4.0 oz	Same as above.	Controls seed decay, seedling diseases, and seed transmission of <i>Cylindrocladium</i> black rot.

¹Do not use treated seed for food, feed, or oil purposes. Bags with treated seed should bear a tag or label cautioning against their use for these purposes as well as the reuse of bags.

Table 3.24 - Fungicide Sprays

Disease	Product and Formulation	Rate of Formulation/Acre	Method and Timing of Application ¹	Precautions and Remarks ²	
Early and late leaf spot web blotch	Bravo 720	1.5 pt	Apply according to leaf spot advisory program.	Caution: Sclerotinia blight will be more difficult to control when these products are applied repeatedly for foliar disease control.	
	Bravo Ultrex WDG	1.4 lb			
	Echo 720	1.5 pt			
	Echo 90DF	1.2 lb			
	Equus 720 (chlorothalonil)	1.5 pt			
	Bravo 720 +	1.0-1.5 pt	Same as above.		Same as above.
	SoyOil 937	0.5-1.0% (v/v)			
	Tilt/Bravo Twin Pak (propiconazole + chlorothalonil)	Use contents to treat 10 acres.	Same as above.		Do not add Latron AG-98 or Latron B-1956 as phytotoxicity may result.
	Tilt/Bravo SE	1.5 pt	Same as above.		Same as above.
	Echo Propimax (tetraconazole + chlorothalonil) Co-Pack	Use contents to treat 10 acres	Same as above.		Same as above.
	PropiMax EC +	2.0 fl oz	Same as above.		Same as above.
	Echo 720 (Co-Pack)	1.0 pt			
	Stratego 2.08EC (trifloxystrobin + propiconazole)	7.0 oz	Same as above.		Label also allows up to 2 sprays at 14 oz/A for control of Rhizoctonia limb rot in addition to foliar diseases.
Folicur 3.6F (tebuconazole) +	7.2 fl oz	Same as above.	Also controls stem rot and suppresses pod rot diseases. Apply chlorothalonil as final season spray.		
surfactant	Use lowest rate recommended on label of surfactant.				
Fontelis 1.67SC (penthiopyrad)	12-24 fl oz (Use higher rate when disease pressure is high)	Apply prior to disease onset and continue on 14- to 21-day interval or according to leaf spot advisory. Do not apply more than three consecutive sprays before rotation to a different mode of action fungicide.	Also controls Sclerotinia blight, Rhizoctonia pod and limb rot, and suppresses CBR. Do not apply more than 72 fl oz/A per season.		
Priaxor 4.17SC (pyraclostrobin + fluxapyroxad)	4-8 fl oz	Same as above, except do not apply more than two consecutive sprays before rotation to a different mode of action fungicide.	Higher rate also controls Rhizoctonia limb and pod rot, southern stem rot, and suppresses CBR. Do not apply more than 24 fl oz/A per season.		

¹For best results, apply sprays according to leaf spot advisory program in a volume of 12.0 to 15.0 gal/A by ground sprayers or 5.0 gal/A with aircraft.

²Read labels and observe all precautions and restrictions on application, pre-harvest interval, and restrictions on feeding treated hay, vines, or hulls to livestock.

Table 3.24 - Fungicide Sprays (cont.)

Disease	Product and Formulation	Rate of Formulation/Acre	Method and Timing of Application ¹	Precautions and Remarks ²
Early and late leaf spot and web blotch (cont.)	Provost 433SC (prothioconazole + tebuconazole)	7-8 fl oz	Apply according to leaf spot advisory program followed by chlorothalonil as final spray for resistance management.	Also controls southern stem rot, <i>Rhizoctonia</i> limb and pod rot, and suppresses CBR. Label allows up to four sprays or total of 42.8 fl oz/A per season.
	Proline 480SC (prothioconazole)	5-5.7 fl oz	Same as above	Label allows up to four sprays or total of 22.8 fl oz/A per season.
	Evito 480SC	3.8-5.7 fl oz	Same as above.	The number of sprays must be no more than one-half the total, and each spray should be followed by a non-strobilurin fungicide.
	Absolute 500SC (tebuconazole + trifloxystrobin)	3.5-7.0 fl oz	Same as above.	Do not make more than four applications, and apply chlorothalonil as final season spray.
	Abound 2.08F (azoxystrobin)	9.0-12.3 fl oz	Apply according to leaf spot advisory program, but make only two applications.	Do not apply within 50 days of harvest. Not recommended for last spray.
	Headline 2.09EC (pyraclostrobin)	6.0-9.0 fl oz	Apply according to leaf spot advisory program. Makes no more than two sequential sprays, then follow with a non-strobilurin fungicide for resistance management.	Not recommended for last spray. See label for further instructions.
	Endura 70 WG (boscalid)	6.5-10.0 oz	Apply according to <i>Sclerotinia</i> advisory program for suppression of leaf spot and control of <i>Sclerotinia</i> blight.	Do not apply more than 2 sequential sprays or more than 3 sprays per season.

¹For best results, apply sprays according to leaf spot advisory program in a volume of 12.0 to 15.0 gal/A by ground sprayers or 5.0 gal/A with aircraft.

²Read labels and observe all precautions and restrictions on application, pre-harvest interval, and restrictions on feeding treated hay, vines, or hulls to livestock.

Table 3.24 - Fungicide Sprays (cont.)

Disease	Product and Formulation	Rate of Formulation/Acre	Method and Timing of Application ¹	Precautions and Remarks ²
Southern stem rot (<i>Sclerotium rolfsii</i>) and Rhizoctonia pod and limb rot	Folicur 3.6F (tebuconazole) + surfactant	7.2 fl oz Use lowest rate recommended on label of surfactant for sustaining control of foliar diseases.	Apply with leaf spot nozzles at spray volume of 15 gal/A on 14-day schedule starting at pegging. Four applications may be required to control soil-borne diseases. The total seasonal dose must not exceed 28.8 fl oz/A.	Also controls leaf spot and suppresses web blotch and pod rot by CBR. Apply chlorothalonil as final season spray.
Southern stem rot (<i>Sclerotium rolfsii</i>) and Rhizoctonia pod and limb rot	Tebuzone 3.6F (tebuconazole) + surfactant	7.2 fl oz Use lowest rate recommended on label of surfactant.	Same as above.	Same as above.
	Artisan (flutalonil + propiconazole)	18.5-24.6 fl oz	Apply 2 times starting 45 to 60 days after planting.	Also controls leaf spot.
	Convoy 3.8F (flutalonil)	1.0 pt	Apply at 50 to 70 days after planting and 30 days later.	Does not control leaf spot. OR Apply once only at 50 to 70 days after planting.
		2.0 pt		
	Moncut 70DF (flutalonil)	0.7-1.4 lb	Band over row in spray volume of 40 gal/A. Two applications may be necessary depending on disease pressure.	Does not control leaf spot or other foliar diseases.
	Abound 2.08F (azoxystrobin)	18.5-24.6 fl oz	Make two applications in spray volume of 15 gal/A between 60 and 90 days after planting.	Do not use more than 49.2 fl oz/season. Abound also controls early leaf spot and web blotch. Do not apply within 50 days of harvest.
	Headline 2.09EC (pyraclostrobin)	9.0-15.0 fl oz	Make no more than two sequential applications, then apply a non-strobilurim fungicide for resistance management.	Also controls leaf spot and web blotch.

¹For best results, apply sprays according to leaf spot advisory program in a volume of 12.0 to 15.0 gal/A by ground sprayers or 5.0 gal/A with aircraft.

²Read labels and observe all precautions and restrictions on application, pre-harvest interval, and restrictions on feeding treated hay, vines, or hulls to livestock.

Table 3.24 - Fungicide Sprays (cont.)

Disease	Product and Formulation	Rate of Formulation/Acre	Method and Timing of Application¹	Precautions and Remarks²
	Endura 70 WG (boscalid)	8.0-10.0 oz	Make no more than two sequential applications, then apply a fungicide having a different mode of action for fungicide resistance management.	Also suppresses leaf spot, and controls web blotch and Sclerotinia blight.
	Fontelis 1.67SC (penth iopyrad)	12-24 fl oz	Apply prior to disease onset and continue on 14- to 21-day interval or according to leaf spot advisory. Do not apply more than three consecutive sprays before rotation to a different mode of action fungicide.	Also controls Sclerotinia blight and leafspot, and suppresses CBR. Do not apply more than 72 fl oz/A per season.
	Priaxor 4.17SC (pyraclostrobin + fluxapyroxad)	8 fl oz	Apply prior to disease onset and continue at 14- to 28- day interval. Do not apply more than two consecutive sprays before rotation to a different mode of action fungicide	Also controls leaf spot, and suppresses CBR and Sclerotinia blight. Do not apply more than 24 fl oz/A per season.
	Proline 480SC (prothioconazole)	5.7 fl oz	Apply up to four consecutive sprays at 14-day interval or according to leaf spot advisory program from pegging to full seed.	Also controls leaf spot and suppresses CBR. Apply chiorothalonil as final season spray for managing resistance. Do not apply more than 22.8 fl oz per season.
	Provost 433 SC (prothioconazole + tebuconazole)	7.0-8.0 fl oz	Same as above.	Label also allows use at 10.7 fl oz/A for suppression of <i>Cylindrocladium</i> black rot.
Rhizoctonia limb rot	Stratego (trifloxystrobin + propiconazole)	14.0 oz	Apply two times spaced 30 days apart (early July and early August).	Sprays also control leaf spot and web blotch.

¹For best results, apply sprays according to leaf spot advisory program in a volume of 12.0 to 15.0 gal/A by ground sprayers or 5.0 gal/A with aircraft.

²Read labels and observe all precautions and restrictions on application, pre-harvest interval, and restrictions on feeding treated hay, vines, or hulls to livestock.

Table 3.24 - Fungicide Sprays (cont.)

Disease	Product and Formulation	Rate of Formulation/Acre	Method and Timing of Application¹	Precautions and Remarks²
Sclerotinia blight (<i>Sclerotinia minor</i> , <i>S. sclerotiorum</i>)	Omega 500 (fluazinam)	1.0-1.5 pt	Make first application according to disease scouting and the Sclerotinia advisory program. Up to two additional sprays may be applied depending upon disease pressure.	Provides good control of Sclerotinia blight and suppression of southern stem rot and Rhizoctonia pod rot.
	Endura 70 WG (boscalid)	8.0-10.0 oz	Make first application according to the Sclerotinia advisory program and disease scouting in problem fields. Up to three sprays are allowed, but do not make more than two sequential applications.	Provides partial control of Sclerotinia blight and suppression of stem rot. Also suppresses leaf spot and provides excellent control of web blotch.
Sclerotinia blight Sclerotinia minor) and Rhizoctonia pod and limb rot	Fontelis 1.67SC (penthiopyrad)	16-24fl oz (use higher rate if disease pressure in high)	Apply prior to disease onset and thereafter, according to 14- or 21day schedule and continue to scout fields and monitor Sclerotinia blight advisory.	Also controls leaf spot, southern stem rot, and suppresses CBR. Do not apply more than three sequential sprays or 72 fl oz/A per season.
	Propulse 3.34SC (prothioconazole + fluopyram)	13.6 fl oz	Apply the first spray when disease is initially detected, and if needed, a second application according to scouting for Sclerotinia blight advisory.	Also suppresses CBR. Do not apply more than 34.2 fl oz/A per season.

¹For best results, apply sprays according to leaf spot advisory program in a volume of 12.0 to 15.0 gal/A by ground sprayers or 5.0 gal/A with aircraft.

²Read labels and observe all precautions and restrictions on application, pre-harvest interval, and restrictions on feeding treated hay, vines, or hulls to livestock.

Table 3.25 - Soil Treatments

Disease	Product and Formulation	Rate of Formulation /acre	Method and Timing of Application	Precautions and Remarks ¹
Cylindrocladium black rot (CBR) (<i>Cylindrocladium parasiticum</i>) and nematodes	Vapam HL 42%	7.5-gal	Use with resistant varieties in cases of severe disease pressure; plant other varieties only in cases of light CBR pressure. Apply 8 inches deep at least 14 days preplant with one injector shank in front of a bed shaper to mark rows. Do not mix treated soil with untreated soil by tillage or other cultural practices after application.	Apply after soil temperatures exceed 60° F at 4-inch depth, and temperatures are likely to be above this level for 5 days. Do not apply when rainfall levels are likely to exceed 1 inch in the 72-hour period after treatment.
	Metam 42%	7.5-gal		
	Sectagon 42% (metam sodium)	7.5-gal		
Cylindrocladium black rot (CBR)	Proline 480SC (prothioconazole)	5.7 fl oz or 0.4 fl oz/1000 ft of row	Apply to the seed furrow at planting in a volume of 5 gal/A with either a spray nozzle or micro-tube	Use for suppression of CBR in conjunction with crop rotations of 3 years or longer. Proline may help to reduce seed transmission of CBR as well as root infection in naturally infested soil.
Nematodes	Telone II (1,3 dichloropropene)	3.0-6.0 gal	Apply 8-12 inches deep in row and bed soil. Wait 7-14 days before planting.	See label for precautions and restrictions.
	Velum Total (fluopyram + imidacloprid)	18 fl oz	Apply in-furrow during planting directed on or below seed. May also be applied by chemigation into the root-zone.	Also controls thrips and suppresses early and late leaf spot.

¹Read labels and observe all precautions and restrictions on application, pre-harvest interval, and restrictions on feeding treated hay, vines, or hulls to livestock.

Cotton

Hillary L. Mehl, Extension Plant Pathologist, Virginia Tech, Tidewater AREC

Seed and Seedling Diseases

Rapid emergence and strong early-season growth are recognized as being most important to success in cotton production. Seedling diseases occur more frequently under cool, wet conditions immediately after planting. Soil temperatures at the 4-inch depth should average above 60°F and the forecast should favor continuation of these conditions over the next 3 days. Daily soil temperatures and cotton degree days are available on the Web at <http://www.ipm.vt.edu/infonet/>. It is also advisable to check the 10-day forecast. Other factors, such as planting too deep, heavy soil crusting, sting and/or reniform nematodes, and misuse of herbicides may increase the problem. Seedling diseases do not usually kill an entire seedling population, but rather cause uneven, slow growing stands with skips in the row.

The first line of defense against seedling disease is to plant high quality seed that is coated with seed protectant fungicides and insecticides. Try to obtain seed with cool germination levels of 80 percent or higher. Avoid seed with cool germination levels below 70 percent. All commercial seed is routinely sold with protectant fungicide coatings which include Captan, Thiram, or Baytan plus PCNB, and metalaxyl. New treatments include Dynasty CST (azoxystrobin, fludioxonil, mefenoxam) and Trilex Advanced (Trilex, Baytan, Allegiance) for seedling diseases and Avicta Complete Pak (Dynasty CST, Cruiser, Avicta) and Aeris (thiodicarb, imidacloprid) for control of thrips and nematodes.

If additional protection is desired, an in-furrow fungicide treatment or hopper-box treatment can be used. Benefits would most likely be seen in fields with a history of seedling disease problems when planting early or when cold, wet weather is expected shortly after planting. Field trials at multiple locations in Virginia since 1990 have not shown an economic benefit from the use of in-furrow or hopper-box fungicide treatments.

Table 3.26 - In-furrow and Hopper-box Fungicides for Cotton

Disease	Fungicide Common Name	Fungicide Trade Name	Formulated Rate	Remarks
Seedling disease; Damping-off; seed rot.	PCNB +	Terraclor Super X 12.5G	8.0-12.0 lb/A	Apply to seed furrow at planting. Read and follow all label restrictions.
	etridiazole	Terraclor Super X 18.8G (Note: also available in liquid formulation)	6.0-9.0 lb/A	
	metalaxyl +	Ridomil PC (Note: Also available in liquid formulation.)	7.0-10.0 lb/A	Same as above.
	PCNB			
	azoxystrobin	Quadris	0.4-0.6 fl oz/1000 row ft	Same as above.
	carboxin +	Prevail	8.0-16.0 oz/cwt	Apply to seed in hopper at planting.
PCNB +				
metalaxyl				
pyraclostrobin	Headline 2.09SC	0.1-0.8 fl oz/1000 row ft	Apply in seed furrow. Do not apply more than 12 fl oz/A. See adjusted rates according to row spacing.	

Foliar Diseases and Boll Rots

Common leaf spot diseases of cotton in Virginia are caused by fungi that may include *Stemphylium*, *Cercospora*, *Colletotrichum*, and more recently *Corynespora*. Other diseases include boll rots caused by *Fusarium*, *Colletotrichum*, *Phoma*, and other fungi. Crop stress caused by drought, excesses of rainfall, and nutrient deficiencies are often associated with leaf and boll diseases and may be predisposing factors in cases with significant loss of yield. Rank growth favors development of *Corynespora* target spot which starts in the lower canopy and can potentially cause premature defoliation. Annual evaluations of foliar fungicides since 2000 in Virginia have provided little or no yield response to fungicide. In severe cases, target spot may cause yield loss and foliar fungicides may be warranted for control of this disease. The table below lists fungicides currently registered for control of foliar and boll pathogens of cotton in Virginia.

Table 3.27 - Foliar Fungicides for Control of Leaf Spots and Boll Rots

Disease	Fungicide Common Name	Fungicide Trade Name	Formulated Rate	Remarks
Alternaria leaf spot Anthracnose Ascochyta leaf spot Cercospora blight Diplodia boll rot Hard lock boll rot <i>Phoma</i> boll rot Rust <i>Stemphylium</i> leaf spot Target spot	pyraclostobin	Headline 2.09SC	6-12 fl oz/A	Apply 1st spray prior to disease development and continue on 7- to 14-day interval if conditions are conducive for disease. Apply no more than two consecutive sprays of Headline. Do not apply more than 36 fl oz/A per season including in-furrow and foliar applications. PHI= 30 days.
	pyraclostrobin + metconazole	TwinLine 1.75EC	7-8.5 fl oz/A	Same as above. Do not apply more than 26 fl oz/A per season. PHI = 30 days.
	azoxystrobin	Quadris	6.0-9.0 fl oz/A	Same as above. Do not apply more than 27 fl oz/A per year. PHI = 45 days.
	fluxapyroxad + pyraclostrobin	Priaxor	4 to 8 fl oz/A	Same as above. Do not apply more than 24 fl oz/A per season. PHI = 30 days. May also be applied in-furrow (0.1 to 0.6 fl oz/1000 row ft) for control or suppression of seedling diseases.

Nematodes

Nematodes cause significant damage to cotton in some fields in Southeastern Virginia. Sting nematode is recognized as highly destructive to cotton because of the crop's extreme sensitivity to this nematode but is generally only a problem in soils with >80% sand content. Root knot nematodes are generally not a problem when peanut and cotton are rotated in the same field since the two crops are hosts for different root knot nematode species. However, southern root knot nematodes have become an increasing problem where cotton is grown continuously for 5 or more years.

Diagnostic assays for nematodes in soil planted to cotton are conducted by the Nematode Diagnostic Laboratory at Virginia Tech. The Virginia Predictive Nematode Assay Program offers growers an opportunity to locate problem fields prior to planting. The best time to collect soil samples for assay is in the fall following harvest. Assay forms, sample bags, and instructions should be obtained from a local Virginia Cooperative Extension office before collecting samples. A service charge of \$11.00 for vermiform or \$19.00 for cyst nematodes is levied on each sample. Counts of vermiform species are all that is needed if cotton is the only crop to be grown. However, if soybean or possibly tobacco might be considered as possible alternative crops, then counts of cyst nematodes would be more important or even critical.

Nematode control is best accomplished by preventing the buildup of harmful numbers of nematodes in soil through crop rotation and good weed control. Some cotton varieties with resistance or tolerance to southern root knot nematode are available. If nematodes pose a threat to cotton production, chemical control can be used to minimize the risk of crop damage.

Table 3.28 - Nematicides for Use in Cotton

Nematode	Nematicide Common Name	Nematicide Trade Name	Formulated Rate	Remarks¹
Sting, Reniform, Lesion, Lance, Root knot, Stubby root	1,3 - D	Telone II	3.0 gal/A	Apply 8-12 inches deep in row and bed soil. Wait 7-14 days before planting.
	abamectin	Avicta Complete Pak (seed treatment)	Mixture of Dynasty CST + Cruiser + Avicta	Must be applied by commercial applicator equipment with rate adjusted for seed size. Mixture protects against seedling disease, early season thrips, and early season root damage by nematodes.
	thiodicarb	Aeris Seed-applied Insecticide/Nematicide	Mixture of thiodicarb + Gaucho	Same as above, except lacks a fungicide for additional seedling disease control, and must be applied as an overcoat on fungicide-treated seed.
	Velum Total (fluopyram + imidacloprid)	Velum Total	14-18 fl oz/A	Apply in-furrow during planting directed on or below seed. May also be applied by chemigation into the root-zone. Also controls thrips and suppresses Fusarium spp. and target spot.

¹Read product label carefully. Note application hazards, re-entry statements, restrictions on feeding livestock, rotation restrictions, and protective clothing required before treatment. Read and observe all requirements as defined on labels.

