Disease and Nematode Management in Field Crops

2016

Nathan Kleczewski, University of Delaware

Hillary Mehl, Virginia Tech

Adapted for the Mid-Atlantic Region

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

This report does not include data on Tobacco, Cotton or Peanuts. The full report may be found at: https://pubs.ext.vt.edu/456/456-016/Section03-Diseases-and-Nematodes-1-full.pdf.

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.

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. zeae-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. zeae-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)

Fungicide(s)				Anthracnose leaf blight	Common rust	Gray leaf spot	Northern leaf blight	Southern rust	Harvest Restriction[2]
Class	Active ingredient (%)	Product/Trade name	Rate/A (fl oz)						
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	Aproach 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
	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% Propiconazole 11.7%	Quilt Xcel 2.2 SE Aframe Plus 2.2 SE	10.5 - 14.0	VG	VG-E	E	VG	VG	30 days
	Cyproconazole 7.17% Picoxystrobin 17.94%	Aproach Prima 2.34 SC	3.4 – 6.8	U	U	E	VG	VG	30 days
	Flutriafol 19.3% Fluoxastrobin 14.84%	Fortix 3.22 SC	4.0 -6.0	U	U	E	VG	VG	R4 (dough)

[1]Additional 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.

[2]Harvest 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.)

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

[1]Additional 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.

[2]Harvest 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 + Propi-conazole	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	Aproach	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 + *Bacillus firmus*	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) (Fusarium virguliforme)	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.

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

Fungicide(s)				Arial 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 Restric-tion[5]
Class	**Active ingredient (%)**	**Product/Trade name**	**Rate/A (fl. oz)**									
QoI Strobilurins Group 11	Azoxystrobin 22.9%	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	Aproach 2.08SC	6.0-12.0	VG	G	G	F	P	U	G	G[8]	14 days
	Pyraclostrobin 23.6%	Headline 2.09 EC/SC	6.0-12.0	VG	VG	G	F	P	U	VG	NL	21 days
DMI Triazoles Group 3	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
	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)
MBC Thiopha-naties Group 1	Thiophanate-methyl	Topsin-M Multiple Generics	10.0–20.0	U	U	U	F	VG	U	G	F	21 days
SDHI Carbo-ximides Group 7	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.)

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 Restric-tion[5]
Class	Active ingredient (%)	Product/Trade name	Rate/A (fl. oz)									
Mixed mode of action	Azoxystrobin 18.2% Difenconazole 11.4%	Quadris Top 2.72 SC	8.0 – 14.0	U	U	U	U	VG	U	VG	NL	14 days
	Azoxystrobin 7.0% Propiconazole 11.7%	Avaris 1.66 SC Quilt 1.66 SC HM-0812 1.66 SC	14.0 – 20.5	U	U	G	U	F	U	VG	NL	21 days
	Azoxystrobin 13.5% Propiconazole 11.7%	Quilt Xcel 2.2 SE	10.5 - 21.0	E	VG	G	F	F	U	VG	NL	R6
	Fluoxastrobin 18.0% Tebuconazole 25.0%	Evito T 3.99 F	4.0 -6.0	U	F	VG	P-F	F	U	U	NL	30 days
	Pyraclostrobin 28.58% Fluxapyroxad 14.33%	Priaxor 4.17 SC	4.0 – 8.0	E	VG	E	F	F	U	VG	P	21 days
	Trifloxystrobin 32.3% Prothioconazole 10.8%	Stratego YLD 4.18 SC[8]	4.0 – 4.65	VG	VG	VG	F	F	U	VG	NL	21 days
	Cyproconazole 7.17% Picoxystrobin 17.94%	Aproach Prima 2.34 SC	5.0-6.8	U	U	U	U	G	U	U	NL	14 days
	Flutriafol 19.3% Fluoxastrobin 14.84%	Fortix	4.0-6.0	U	U	U	U	G	U	U	U	R5 (begin-ning seed)

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

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 Restric-tion[5]
Class	Active ingredient (%)	Product/Trade name	Rate/A (fl. oz)									
	Pyraclostrobin 28.58% Fluxapyroxad 14.33% Tetraconazole 20.50%	Priaxor D 4.17 SC 1.9 SC	4.0 (each compo-nent)	U	U	U	U	G	U	U	U	21 days R5 (begin-ning seed)
	Trifloxystrobin 32.3% Prothioconazole 10.8%	Stratego YLD 4.18 SC[8]	4.0 – 4.65	VG	VG	VG	F	F	U	VG	NL	21 days
	Tetraconazole 7.48% Azoxystrobin 9.35%	Affiance SC	10.0-14.0	U	U	U	U	U	U	U	U	14 days

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 efficacy.

[1]Multiple 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.

[2]Cercospora 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.

[3]In 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.

[4]White 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.

[5]Harvest 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.

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

[7]Proline 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.

[8]Stratego 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 cm^3 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	*Pasteuria*
Poncho/ VOTiVO	Root knot, soybean cyst	Biological nematicide	*Bacillus firmus*

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	-	-	-	-	-	-	-

[1]1 = highly effective; 2 = moderately effective; 3 = slightly effective; and - = no effect in reducing disease.

[2]Seed 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

[1]1 = highly effective; 2 = moderately effective; 3 = slightly effective; and - = no effect in reducing disease.

[2]Seed 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 suceptible to thie disease. An example of this occuring 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

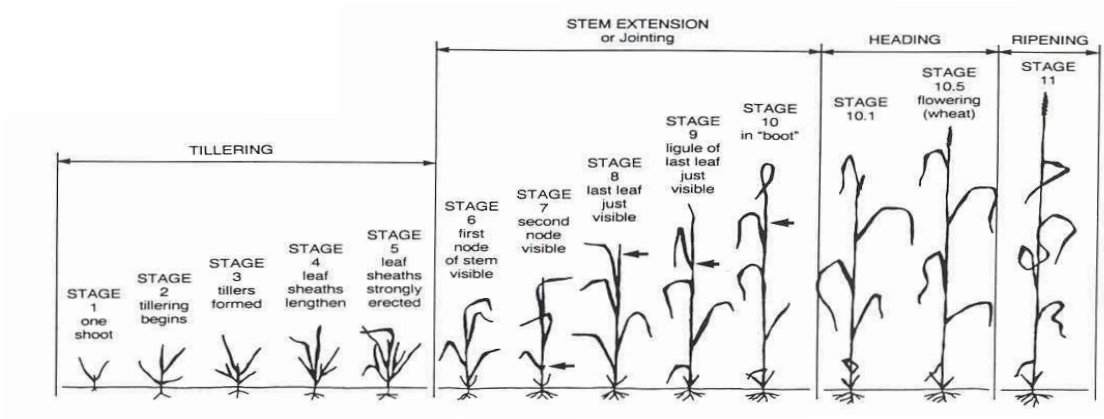
Fungicide(s)				Powdery mildew	Stagonospora leaf/glume blotch	Septoria leaf blotch	Tan spot	Stripe rust	Leaf rust	Stem rust	Head scab	Harvest Restriction
Class	Active ingredient	Product	Rate/A (fl. oz)									
Strobilurin	Picoxystrobin 22.5%	Aproach SC	6.0 - 12	G[1]	--	VG[2]	VG	E[3]	VG	VG	NL	Feekes 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
Triazole	Metconazole 8.6%	Caramba 0.75 SL	10.0 - 17.0	VG	VG	--	VG	E	E	E	G	30 days
	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
	Prothioconazole19% Tebuconazole 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% Pyraclostrobin 12%	TwinLine 1.75 EC	7.0 – 9.0	G	VG	VG	E	E	E	VG	NL	Feekes 10.5
	Fluxapyroxad 14.3% Pyraclostrobin 28.6%	Priaxor	4.0 - 8.0	G	VG	VG	E	VG	VG	G	NL	Feekes 10.5
	Propiconazole 11.7% Azoxystrobin 13.5%	Quilt Xcel 2.2 SE[4]	10.5 - 14.0	VG	VG	VG	VG	E	E	VG	NL	Feekes 10.5
	Prothioconazole 10.8% Trifloxystrobin 32.3%	Stratego YLD	4.0	G	VG	VG	VG	VG	VG	VG	NL	Feekes 10.5 35 days
	Cyproconazole 7.17% Picoxystrobin 17.94%	Aproach Prima SC	3.4-6.8	VG	--	VG	VG	E	VG	--	NR	45 days

[1]Efficacy 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.
[2] Product efficacy may be reduced in areas with fungal populations that are resistant to strobilurin fungicides.
[3]Efficacy may be significantly reduced if solo strobilurin products are applied after stripe rust infection has occurred.
[4]Multiple 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, Tebuzol 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.
[5]Products 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.

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

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.

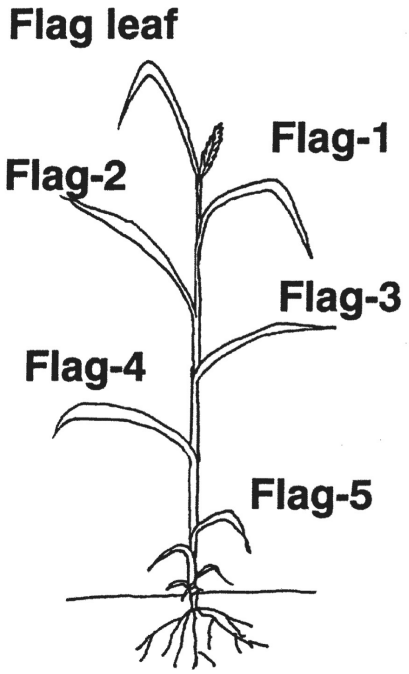


Fig 3.1 Determination of treatment threshold for septoria leaf and glume blotch in wheat.

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.

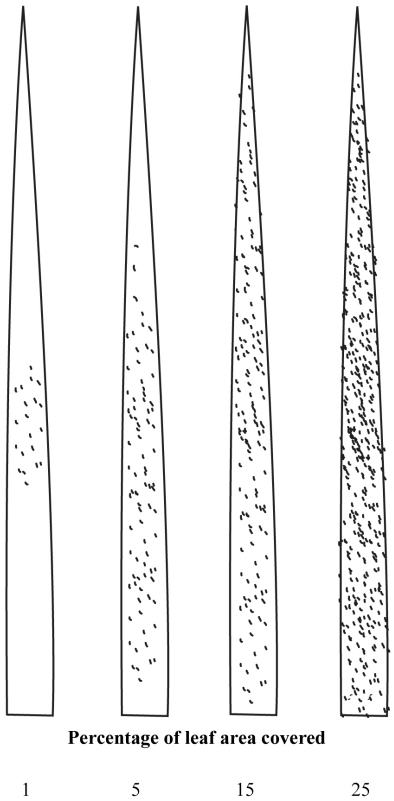


Fig 3.2
Percentage of leaf area affected by lef rust. (James, C. 1971. A Manual of Assessment Keys for Plant Diseases. Publication 1458. Canada Department of Agriculture.)

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).

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 Prosaro®, 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 infected 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	Anthrac-nose	Phyto-phthora root rot	Root-knot nematode	Aphano-myces 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
Recom-mended minimum resistance[1]	MR	MR	MR	R	R	Soil test[2]	MR	NA	NA

[1]Always 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.

[2]Nematode 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.

[3]Aphanomyces 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
Seed treatment fungicides				
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.
Soil treatment fungicides				
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.