Disease and Nematode Management in Corn and Sorghum

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General Considerations

The yield and quality of field crops are reduced to some degree by diseases and nematodes each year. Management strategies for disease and nematode control vary by crop, field, and year. An ***integrated*** approach is necessary to minimize unnecessary inputs and maximize profits to the grower. Integrated disease and nematode management combines multiple approaches including cultivar selection, cultural practices such as crop rotation, and judicious use of pesticides based on disease advisories, economic thresholds, and/or scouting. The following points should be considered when making disease and nematode management decisions:

- **Susceptibility of crop variety to disease and/or nematodes.** 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. Be aware of the specific diseases and nematodes 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 pesticide 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 pathogens require a living plant host and must move in from warmer regions each year (e.g. some rusts). Crop parasitic nematodes need a plant host to reproduce, so nematodes with a narrow host range can be controlled by rotating to a non-host.
- **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) and fungicide applications should be timed accordingly to maximize efficacy.
- **Proper pathogen and nematode identification.** Field crops can be affected by a variety of fungi, bacteria, viruses, and nematodes. Each type of pathogen requires a different approach for disease management. Many abiotic issues including compaction, drought, nutrient deficiencies, and chemical damage can appear similar to some diseases. Proper identification of biotic and abiotic problems impacting the crop are key to avoiding ineffective or unnecessary chemical applications.
- **Disease and nematode pressure.** Are diseases present at amounts that require intervention? Scout fields regularly to maximize profits. Future nematode management decisions can be based on economic damage thresholds if crop parasitic nematode populations are quantified at harvest.
- **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 for pathogen growth and reproduction. Warm, humid conditions favor 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 and nematode management decisions, especially before applying a fungicide or nematicide that may or may not be needed. **Plant pathogens and nematodes are most effectively managed by integrating several of the following practices:**

1. **Adapted, disease and nematode resistant cultivars** - produce plants able to resist pathogen and nematode attack. Every variety has a resistance "package" that provides levels of resistance or tolerance to specific pests. 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 and nematodes cannot be managed with resistance, and not every variety has adequate resistance to all potential pests. However, growers who do not consider resistance when selecting varieties are taking a considerable and likely a costly, risk.
2. **Rotation** - avoid build up of pathogens and nematode populations by not continually planting the same crop 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 when possible and manage weeds. 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 pathogens 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 and damage from parasitic nematodes.
6. **Good quality, disease-free seed** - promote healthy, vigorous seedling development. In addition, some pathogens can move in or on seed. Using clean, certified seed can help reduce the development of these and maximize stands.
7. **Chemical control** - judicious use of fungicides and nematicides is necessary is some cropping situations. If pathogen or nematode pressure is high, chemical control may be needed to protect crop yields.

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 for preventing the development of certain seedborne smut diseases, the systemic form of downy mildew and for 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, Southern Corn Leaf Blight, and Northern Corn Leaf Blight

Three economically important blighting diseases of corn in Virginia and the mid-Atlantic region are gray leaf spot (*Cercospora zeae-maydis*), southern corn leaf blight (*Bipolaris maydis*), and northern corn leaf blight (*Setosphaeria turcica*). Gray leaf spot 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). Northern corn leaf blight lesions are long (2 - 6 inches), wide (1 - 1.5 inches), and elliptical or boat-shaped. Lesions are tan to gray-green and may show faint concentric rings of spores on the lesion surface. Southern corn leaf blight lesions are elongated between veins, tan, and up to 1 inch long with parallel margins. Southern leaf blight is favored by warmer weather compared to northern leaf blight and gray leaf spot.

Yield Loss
Foliar diseases are most damaging when leaves are blighted at or just after silking stage. At this critical time disease 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 the R5 (dent) growth stage 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 these foliar fungal pathogens is helpful in understanding why disease has increased in intensity, severity, and distribution over the past 25 years. *C. zeae-maydis* and other fungal pathogens overwinter 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 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. No till or minimal till production systems serve as overwintering sources for the fungus and provide the primary inoculum to produce severe levels of foliar disease in the next season.

Management of Gray Leaf Spot, Southern Corn Leaf Blight, and Northern Corn Leaf Blight
In conventional tillage systems, burying residue through tillage will significantly reduce disease pressure for the subsequent corn crop. Growers utilizing a minimal tillage system should promote residue decomposition by sizing residue, turbo tilling, or lightly discing fields. Avoid planting into unworked corn residue. Growers should continue to use conservation tillage methods wherever practical, but consider planting different crops in rotation with corn in their farming system. A one- or two-year rotation away from corn will help reduce inoculum levels of these fungal pathogens. However, infested (diseased) corn debris on adjacent fields may be plentiful enough to initiate significant disease losses on moderately- to highly-susceptible hybrids. Growers with a history of gray leaf spot in their fields are encouraged to select one or more of the newer gray leaf spot resistant hybrids. Selection should be based on yield potential and standability under gray leaf spot pressure.

Common and Southern Rust
Common and Southern rusts can occasionally cause yield loss in the mid-Atlantic region. The fungi causing rusts require a living host to survive and reproduce and as a result do not survive the winter months. Each growing season these pathogens must blow into the mid-Atlantic from central America and parts of the deep south. Damage is dependent on when these diseases arrive relative to the growth stage of corn. Arrival of either disease before the R3 (milk) growth stage could result in significant yield loss under the appropriate conditions. Rusts are characterized by orange pustules that occur on foliage. When these pustules are rubbed against hands or clothing they will leave an orange to brown, rusty color (hence the name rust). Common rust pustules are often ellipsoid, cinnamon brown, and can be found on both the upper and lower surfaces of the leaf. In contrast, Southern rust forms round, brown to orange pustules that are found predominantly on the upper leaf surface. Pustules may also be found on husks and stalks. Disease development of common rust is favored by moderate temperatures (42-77°F) whereas Southern rust prefers warmer weather (77-82°F). Hot temperatures limit the development of common rust and causes pustules to become inactive. As a result, Southern rust typically arrives later in the growing season (July-August) compared to common rust.

Yield Loss
Rusts are most damaging when they reach the ear leaf or above by R3. Estimates for yield losses vary, but range from 3-8% for each 10% of total leaf area infected by the R5 (dent) growth stage.

Management of Rusts
Selection of hybrids with good resistance is the primary means of managing both rusts. In 2008, a race of Southern rust was identified that was able to overcome a Southern rust resistance gene. Fungicides applied preventatively can help to manage rusts; however, optimal timings likely differ for the two diseases. Movement of Southern rust can be monitored on the ipmPIPE website (https://corn.ipmpipe.org/southerncornrust/).

Stalk Rots

Stalk rots are the most common and devastating diseases/disorders affecting corn. These diseases are insidious, and often growers are unaware of their effects until harvest. Low levels of stalk rot occur in nearly every corn field in the mid-Atlantic, and severity and incidence varies from year to year. Losses of over 50% can occur in severe cases.

Stalk rot pathogens decay the central pith, which weakens the stalk. One can envision a healthy stalk being a solid rod of plant tissue. A rotted stalk is no more than a tube with decaying pith loosely packed inside. Thus, corn suffering from stalk rot may easily lodge when exposed to windy conditions. Initial symptoms of stalk rots include premature wilting and ear drop. As the disease progresses stalks senesce rapidly and turn brown to grey.

Factors that Favor Stalk Rots

Carbohydrate Stress

Carbohydrate stress in corn can be caused by either limits to photosynthesis or over-commitment of carbohydrate resources to the ear. The following are generalizations. For more detailed information refer to agronomy texts or primary literature.

Limitation to photosynthesis can be caused by numerous factors. The most important factors impacting stalk rots in corn are foliar diseases, insect damage, cloud cover, high plant density, and nutrient and water deficiencies. Disease and insect damage reduce the amount of photosynthetic area, thereby reducing the overall carbon budget. As levels of damage to foliage by pathogens and pests increase, so too does the amount of stalk rot. Cloud cover and high planting density reduce the amount of light accessible to foliage and therefore photosynthetic rate. High planting densities also can limit access to water and nutrients, which reduce photosynthetic rate through other mechanisms.

Hybrid characteristics such as a large cob size and high kernel numbers may predispose plants to stalk rots. This is because the aforementioned factors increase the amount of “pull” the cob has on the plant carbon budget. After flowering, the carbohydrates, produced through photosynthesis in the ear leaf, are preferentially diverted to the ear. However, if the ear leaf cannot meet the demands of grain fill, carbohydrates are mobilized from the root and stalk. Without a sufficient carbohydrate supply, the production of chemicals for defense of plant tissues is reduced, resulting in increased levels of infection by stalk rotting pathogens. For this reason, many of the stalk-rotting pathogens are opportunistic, and disease is caused by whatever organism happens to be in the vicinity when carbohydrate stress occurs

Fertility

Limited access to nutrients critical to photosynthesis can cause carbohydrate stress and increase stalk rots. Although there is variability in terms of specific nutrients and diseases, in general, stalk rots increase when nutrients are lost during the growing season. Conversely, over fertilization can cause excessively lush growth. Lush growth is often structurally weak and easily invaded by fungi.

Water

Limitations to water impact the amount of gaseous carbon that moves to the foliage from the atmosphere. Plants contain tiny openings in the foliage and stems that allow gas exchange. When water is plentiful, these openings open. When water is deficient, these openings close, which limits the amount of carbon that enters the plant leaf and therefore the amount of carbohydrates available for grain fill, plant defense, etc. Therefore, any factor that limits the ability of the plant to access water may ultimately predispose the plant to stalk rot. Excessively wet conditions can leach nitrogen from the soil and stress roots, facilitating fungal infection.

Hybrid Genetics

Hybrids differ in their susceptibility to stalk rots. In general, hybrids with low ratings of stalk strength or those that produce exceptionally large ears tend to be more prone to stalk rots than those with strong stalks and smaller ears. Hybrids also can differ in their water and nutrient use profiles, which as mentioned previously, impact the carbon budget of the plant.

Management

Management of stalk rots should include the use of: 1) hybrids with resistance to stalk rot pathogens and/or high ratings of stalk strength and stay green characteristics; 2) a balanced fertility program based on the environment, population, and hybrid; 3) programs to control foliar diseases and insects; 4) irrigation to avoid drought stress.

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 for Management of Foliar Diseases in Corn

Class	Active ingredient (%)	Product/Trade name	Rate/A (fl oz)	Anthracnose leaf blight	Common rust	Gray leaf spot	Northern leaf blight	Southern rust	Harvest Restriction [2]
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	VG	7 days
	picoxystrobin 22.5%	Aproach 2.08 SC	3.0 – 12.0	VG	VG-E	F-VG	VG	G	7 days
DMI Triazoles Group 3	propiconazole 41.8%	Tilt 3.6 EC, Multiple Generics	2.0 – 4.0	NL	VG	G	G	F-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	F-G	36 days
	tetraconazole 20.5%	Domark 230 ME, Multiple Generics	4.0 – 6.0	U	U	E	U	G	R3 (milk)
	flutriafol 20.9%	Xyway LFR 1.92 SC LFR	7.6 – 15.2	NL	U	NL	G	VG	N/A
Mixed mode of action	azoxystrobin 13.5% propiconazole 11.7%	Quilt Xcel 2.2 SE, Multiple Generics	10.5 – 14.0	VG	VG-E	E	VG	VG	30 days
	benzovindiflupyr 2.9% azoxytrobin 10.5% propiconazole 11.9%	Trivapro 2.21SE	13.7	U	U	E	VG	E	30 days
	cyproconazole 7.17% picoxystrobin 17.94%	Aproach Prima 2.34 SC	3.4 – 6.8	U	U	E	VG	G-VG	30 days
	flutriafol 19.3% fluoxastrobin 14.84%	Fortix 3.22 SC, Preemptor 3.22 SC	4.0 – 6.0	U	U	E	VG-E	VG	R4 (dough)

Table 3.1 - Fungicides for Management of Foliar Diseases in Corn (cont.)

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)						
Mixed mode of action	pyraclostrobin 13.6% metconazole 5.1%	Headline AMP 1.68 SC	10.0 – 14.4	U	E	E	VG	G-VG	20 days
	prothioconazole 16.0% trifloxystrobin 13.7%	Delaro 325SC	8.0 – 12.0	VG	E	E	VG	VG	14 days
	prothioconazole 14.9% trifloxystrobin 13.1% fluopyram 10.9%	Delaro Complete	4.0 – 12.0 fl oz	U	U	E	VG-E	G-VG	14 days
	pydiflumetofen 7.0% azoxystrobin 9.3% propiconazole 11.6%	Miravis Neo 2.5SE	13.7	U	U	E	VG-E	VG	30 days
	mefentrifluconazole 17.56% pyraclostrobin 17.56%	Veltyma	7.0 – 10.0	U	U	U	U	U	21 days
	bixafen 15.55% flutriafol 26.47%	Lucento	3.0 – 5.5	U	U	U	U	U	30 days
	pyraclostrobin 28.58% fluxapyroxad 14.33%	Priaxor 4.17 SC	4.0 – 8.0	U	VG	VG	VG-E	G	21 days
	trifloxystrobin 32.3% prothioconazole 10.8%	Stratego YLD 4.18 SC	4.0 – 5.0	VG	E	E	VG	G-VG	14 days
	azoxystrobin 9.35% tetraconazole 7.48%	Affiance 1.5 SC	10.0 – 17.0	U	U	U	G-VG	G	7 days
	flutriafol 18.63% azoxystrobin 25.30%	TopGuard EQ	5.0 – 7.0	U	F	VG	G	U	45 days
	flutriafol 15.7% azoxystrobin 15.7% fluindapyr 10.5%	Adastrio 4.0 SC	7.0 – 9.0	U	U	U	U	U	30 days

Table 3.1 - Fungicides for Management of Foliar Diseases in Corn (cont.)

[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.

Nematodes Affecting 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 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 parasitic 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 3.2 - Corn Nematicides

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.
	Burkholderia rinojensis	BioST Nematicide 100	8 oz/100 lb seed	-	Also provides protection against soil dwelling insects.
	fluopyram	Velum	3.0 - 6.84 fl oz/acre	PHI = 30	Apply specified dosage using any of the following methods: • In-furrow spray during planting directed on or below seed. • Chemigation into root-zone through low-pressure drip or trickle irrigation.
	abamectin	Averland	4.0 - 6.0 fl oz/ acre		Apply in-furrow in a minimum of 5 gallons per acre of final volume as a spray or dribble directed on the seed during planting. rates are based on a 30” row spacing.

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 3.3 - Foliar Applied Fungicides for Sorghum

Active ingredient	Fungicide trade name	Application rate per acre	PHI (days)	Remarks
azoxystrobin	Quadris, Multiple Generics	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.
azoxystrobin + propiconazole	Quilt, Xcel, Multiple Generics	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.
pyraclostrobin	Headline SC	6.0-12.0	Apply no later than 25% flowering.	Group 11 fungicide. Do not make more than one application per year.
flutriafol	Xyway LFR	7.6 - 15.2	–	May be applied to corn in-furrow at planting or post-emergence directed to the soil at the base of the plant. For control of late-season infestations, heavy disease pressure situations, or foliar diseases not listed above, a supplemental foliar application may be needed. * Please refer to row space conversion chart in application instructions for application rates on row spacings other than 30”. May be applied in a 2x2 band at the full use rate with starter fertilizer.
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.
fluxapyroxad + pyraclostrobin + propiconazole	Nexicor	7.0-13.0	21	Group 11 fungicide. Do not make more than one application per year.

Table 3.3 - Foliar Applied Fungicides for Sorghum (cont.)

Active ingredient	Fungicide trade name	Application rate per acre	PHI (days)	Remarks
fluoxastrobin	Evito 480 SC	2.0-4.0	21	Group 11 fungicide. Do not make more than two applications per season with a minimum interval of 14 days between applications. Do not apply more than 8 fl oz/A per season.
mefentrifluconazole + pyraclostrobin	Veltyma	7.0-10.0	21	Do not make more than one application. Do not apply more than 10 fl oz/A per season.

Soybeans

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Managing Seed and Seedling Diseases of Soybeans

There are several pathogens that can kill seedlings and reduce soybean stands. Seedling pathogens 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.

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 3.4 - Fungicide Efficacy for Control of Soybean Seedling Diseases

Fungicide active ingredient	Pythium sp.[1]	Phytophthora root rot	Rhizoctonia sp.	Fusarium sp.[1,3]	Sudden death syndrome (SDS) (Fusarium virguliforme)	Phomopsis sp.
azoxystrobin	P-G	NS	VG	G	NR	P
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-VG	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[2]	E	NR	NR	NR	NR
metalaxyl	E[2]	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
pydiflumetofen	NR	NR	NR	NR	VG	NR
pyraclostrobin	P-G	NR	F	F	NR	G
sedaxane	NR	NR	E	NS	NR	G
thiabendazole	NR	NR	NS	NS	P	U
trifloxystrobin	P	P	F-E	F-G	NR	P-F

1. Products may vary in efficacy against different *Fusarium* and *Pythium* species.
2. Areas with mefenoxam or metalaxy insensitive populations may see less efficacy with these products.
3. Listed seed treatments do not have efficacy against *Fusarium virguliforme*, causal agent of sudden death syndrome.

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

Table 3.5 - Seed Treatment Products Containing Seedling Disease Fungicides (cont.)

Product/Trade name	Active ingredient
CruiserMaxx Advanced or Cruiser Maxx Plus	fludioxonil mefenoxam
CruiserMaxx Advanced Vibrance	fludioxonil mefenoxam sedaxane
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
Saltro	pydiflumetofen
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 (NCERA-137) has 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. Efficacy categories: NR = Not Recommended; P = Poor; F = Fair; G = Good; VG = Very Good; E = Excellent; NL = Not labelled for use against this disease; U = Unknown efficacy or insufficient data to rank product efficacy.

Table 3.6 - Foliar Fungicide Efficacy for Control of Foliar Soybean Diseases

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 Restriction[5]
Class	**Active ingredient (%)**	**Product/Trade name**	**Rate/A (fl. oz)**									
QoI Strobilurins Group 11	azoxystrobin 22.9%	Quadris 2.08 SC[6], Multiple Generics	6.0-15.5	VG	VG	G	P	P	U	G-VG	P	14 days
	fluoxastrobin 40.3%	Aftershock 480 SC Evito 480 SC	2.0-5.7	VG	G	G	P	P	U	U	NL	R5 (beginning seed) 30 days
	picoxystrobin	Aproach 2.08SC	6.0-12.0	VG	G	G	P	P	U	G	G[8]	14 days
	pyraclostrobin 23.6%	Headline 2.09 EC/SC	6.0-12.0	VG	VG	G	P	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	P-G	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]	2.5-5.0	NL	NL	NL	NL	G-VG	NL	VG	F	21 days
	tetraconazole 20.5%	Domark 230ME Multiple Generics	4.0–5.0	NL	VG	VG	P-G	G-VG	U	VG-E	F	R5 (beginning seed)
MBC Thiophanaties Group 1	thiophanate-methyl	Topsin-M Multiple Generics	10.0–20.0	U	U	U	F	VG	U	G	F	21 days
SDHI Carboximides Group 7	boscalid 70%	Endura 0.7 DF	3.5 – 11.0	U	NL	VG	U	P	NL	NL	VG	21 days

Table 3.6 - Foliar Fungicide Efficacy for Control of Foliar Soybean Diseases (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 Restriction[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	G-VG	P-G	VG	U	VG	NL	14 days
	azoxystrobin 19.8% defenoconazole 19.8%	Quadris Top SBX 3.76 SC	7.0 – 7.5	U	U	U	U	G-VG	U	U	U	14 days
	azoxystrobin 7.0% propiconazole 11.7%	Quilt 1.66 SC Multiple Generics[6]	14.0 – 20.5	U	U	G	F	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
	pyraclostrobin 28.58% fluxapyroxad 14.33%	Priaxor 4.17 SC	4.0 – 8.0	E	VG	E	P-G	P-F	U	VG	P	21 days
	pyraclostrobin 28.58% fluxapyroxad 14.33% tetraconazole 20.50%	Priaxor D 4.17 SC 1.9 SC	4.0 (each component)	U	U	VG	U	G-VG	U	U	P	21 days R5 (beginning 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
	cyproconazole 7.17% picoxystrobin 17.94%	Aproach Prima 2.34 SC	5.0-6.8	U	U	VG	P-G	G	U	U	NL	14 days

Table 3.6 - Foliar Fungicide Efficacy for Control of Foliar Soybean Diseases (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 Restriction[5]
Class	Active ingredient (%)	Product/Trade name	Rate/A (fl. oz)									
	flutriafol 19.3% fluoxastrobin 14.84%	Fortix SC Preemptor SC	4.0-6.0	U	U	G	P-G	VG	U	U	U	R5 (beginning 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 1.5 SC	10.0-14.0	U	VG	VG	F	G	U	U	U	14 days R5
	benzovindiflupyr 2.9% propiconazole 11.9% azoxystrobin 10.5%	Trivapro	13.7-20.7	E	U	VG	P-G	F-G	G	VG-E	NL	14 days R6
	azoxystrobin 25.3% flutriafol 18.63%	Topguard EQ 4.29SC	5.0-7.0	U	U	VG	U	G-VG	U	U	P	21 days
	flutriafol 26.47% bixafen 15.5%	Lucento 4.17SC	3.0-5.5	U	U	VG	U	VG	U	U	U	21 days
	prothioconazole 16.0% trifloxystrobin 13.7	Delaro 325SC	8.0-11.0	U	U	VG	U	G-VG	U	U	NL	21 days
	prothioconazole 14.9% trifloxystrobin 13.1% fluopyram 10.9%	Delaro Complete	8.0-11.0 fl oz	U	U	VG	U	U	U	U	U	21 days

Table 3.6 - Foliar Fungicide Efficacy for Control of Foliar Soybean Diseases (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 Restriction[5]
Class	Active ingredient (%)	Product/Trade name	Rate/A (fl. oz)									
	pydiflumetofen 6.9% difenoconazole 11.5%	Miravis Top 1.67SC	13.7	U	U	VG	P-G	VG	G	U	U	14 days
	pydiflumetofen 7.0% azoxystrobin 9.3% propiconazole 11.6%	Miravis Neo 2.5 SC	13.7	U	U	U	U	U	U	U	P	
	tetraconazole 17.76% fluoxastrobin 17.76	Zolera FX 3.34SC	4.4-6.8	U	U	U	U	G-VG	U	U	U	30 days R5
	thiophanate-methyl 21.3% tetraconazole 4.2%	Acropolis	20.0-23.0	NL	U	U	U	VG	U	VG-E	U	30 days R5
	mefentrifluconazole 11.61% pyraclostrobin 15.49% fluxapyroxad 7.74%	Revytek	8.0-15.0	U	U	U	U	U	U	U	U	21 days
	pyraclostrobin 17.56% mefentrifluconazole 17.56%	Veltyma	7.0-10.0	U	U	U	G-VG	U	U	U	NL	

[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.

[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. 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 Economic Damage Thresholds for Soybeans (per 500 cm^3 soil)

	LOW	MODERATE	HIGH
Soybean cyst juveniles	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 are unlikely to 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: Sanitation measures should be implemented 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

Nematode	Corn	Cotton	Peanut	Soybean	Perennial grass forage
Soybean Cyst	Yes	Yes	Yes	No	Yes
Dagger	Yes	Yes	No	No	Yes
Lance	No	No	Yes	No	No
Lesion	No	No	No	No	Yes
Ring	No	Yes	No	No	No
Northern Root- Knot	Yes	Yes	No	No	Yes
Southern Root-Knot	No	No	Yes	No	Yes
Spiral	Yes	Yes	Yes	No	Yes
Sting	No	No	No	No	Yes
Stubby Root	No	No	No	No	No
Stunt	Yes	Yes	Yes	No	Yes

*Note that no indicates that the crop is not a good rotational crop and “yes” indicates the crop is a poor or non-host for the indicated nematode and therefore a good choice for a rotational crop.

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 economic 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
Saltro	Root-knot, soybean cyst, others	Fungicide Nematicide	Pydiflumetofen
Clariva	Soybean cyst	Biological nematicide	*Pasteuria*
Poncho/VOTiVO	Root knot, soybean cyst	Biological nematicide	*Bacillus firmus*
BioST Nematicide 100	Root knot, soybean cyst, sting, others	Biological nematicide/ insecticide	*Burkholderia rinojenses*
Velum		Fungicide Nematicide	Fluopyram

Small Grains

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Small Grain Diseases

Disease management is critical for those interested in maximizing small grain yields and grain quality. Many pathogens cause disease in mid-Atlantic small grains, and several significantly impact yields during years that favor disease. This section discusses how to manage diseases that 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 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 3.12 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(s)	Product	Rate/A (fl. oz)									
Strobilurin	picoxystrobin 22.5%	Aproach SC	6.0 - 12	G[1]	VG	VG[2]	VG	E[3]	VG	VG	NL[4]	Feekes 10.5
Strobilurin	pyraclostrobin 23.6%	Headline SC	6.0 - 9.0	G	VG[2]	VG[2]	E	E[3]	E	G	NL[4]	Feekes 10.5
Triazole	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[5]	4.0	VG	VG	VG	VG	VG	VG	VG	P	Feekes 10.5.4
Triazole	prothioconazole 41%	Proline 480 SC	5.0 - 5.7	--	VG	VG	VG	VG	VG	VG	G	30 days
Triazole	tebuconazole 38.7%	Folicur 3.6 F[5]	4.0	NL	NL	NL	NL	E	E	E	F	30 days
Triazole	prothioconazole19% tebuconazole 19%	Prosaro 421 SC	6.5 - 8.2	G	VG	VG	VG	E	E	E	G	30 days
Triazole	metconazole 10.91% prothioconazole 18.19%	Sphaerex	4.0 - 7.3	VG	VG	VG	VG	E	E	E	G	30 days
Mixed modes of action[6]	metconazole 7.4% pyraclostrobin 12%	TwinLine 1.75 EC	7.0 - 9.0	G	VG	VG	E	E	E	VG	NL[4]	Feekes 10.5
Mixed modes of action[6]	fluxapyroxad 14.3% pyraclostrobin 28.6%	Priaxor	4.0 - 8.0	G	VG	VG	E	VG	VG	G	NL[4]	Feekes 10.5
Mixed modes of action[6]	fluoxastrobin 14.8% pyraclostrobin 18.7% propiconazole 11.7%	Nexicor EC	7.0 - 13.0	G	VG	VG	E	E	E	VG	NL[4]	Feekes 10.5
Mixed modes of action[6]	propiconazole 11.7% azoxystrobin 13.5%	Quilt Xcel 2.2 SE[5]	10.5 - 14.0	VG	VG	VG	VG	E	E	VG	NL[4]	Feekes 10.5
Mixed modes of action[6]	prothioconazole 10.8% trifloxystrobin 32.3%	Stratego YLD	4.0	G	VG	VG	VG	VG	VG	VG	NL[4]	Feekes 10.5 35 days
Mixed modes of action[6]	cyproconazole 7.17% picoxystrobin 17.94%	Aproach Prima SC	3.4 - 6.8	VG	VG	VG	VG	E	VG	--	NR[4]	45 days
Mixed modes of action[6]	tebuconazole 22.6% trifloxystrobin 22.6%	Absolute Maxx SC	5.0	G	VG	VG	VG	VG	E	VG	NL[4]	35 days
Mixed modes of action[6]	fluoxastrobin 14.8% flutriafol 19.3%	Fortix	4.0 - 6.0	--	--	VG	VG	E	VG	--	NL[4]	Feekes 10.5 and 40 days
Mixed modes of action[6]	benzovindiflupyr 2.9% propiconazole 11.9% azoxystrobin 10.5%	Trivapro SE	9.4 - 13.7	VG	VG	VG	VG	E	E	VG	NL[4]	Feekes 10.5.4 and 14 days
Mixed modes of action[6]	prothioconazole 16.0% trifloxystrobin13.7%	Delaro 325 SC	8.0	G	VG	VG	VG	VG	VG	VG	NL	Feekes 10.5 35 days

Table 3.12 - Efficacy of Fungicides for Wheat Disease Control Based on Appropriate Application Timing (cont.)

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(s)	Product	Rate/A (fl. oz)									
Mixed modes of action[6]	prothioconazole 14.9% trifloxystrobin 13.1% fluopyram 10.9%	Delaro Complete	8.0	VG	VG	VG	VG	VG	VG	VG	NL	35 days
	fluoxastrobin 14.8% flutriafol 19.3%	Preemptor SC	4.0 - 6.0	G	VG	VG	VG	E	VG	VG	NL	Feekes 10.5 40 days
	pydiflumetofen 13.7% propiconazole 11.4%	Miravis Ace	13.7	VG	VG	VG	VG	VG	VG	VG	G	Feekes 10.5.4
	prothioconazole 17.39% tebuconazole 8.70% fluopyram 8.70%	Prosaro Pro 400 SC	10.3 - 13.6	G	VG	VG	VG	E	E	E	G	30 days
	azoxystrobin 25.30% flutriafol 18.63%	Topguard EQ	4.0 - 7.0	G	VG	VG	VG	VG	VG	VG	NL	Feekes 10.5.4

[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]Application of strobilurin products after heading may result in elevated levels of the mycotoxin deoxynivalenol (DON) in grain damaged by head scab.

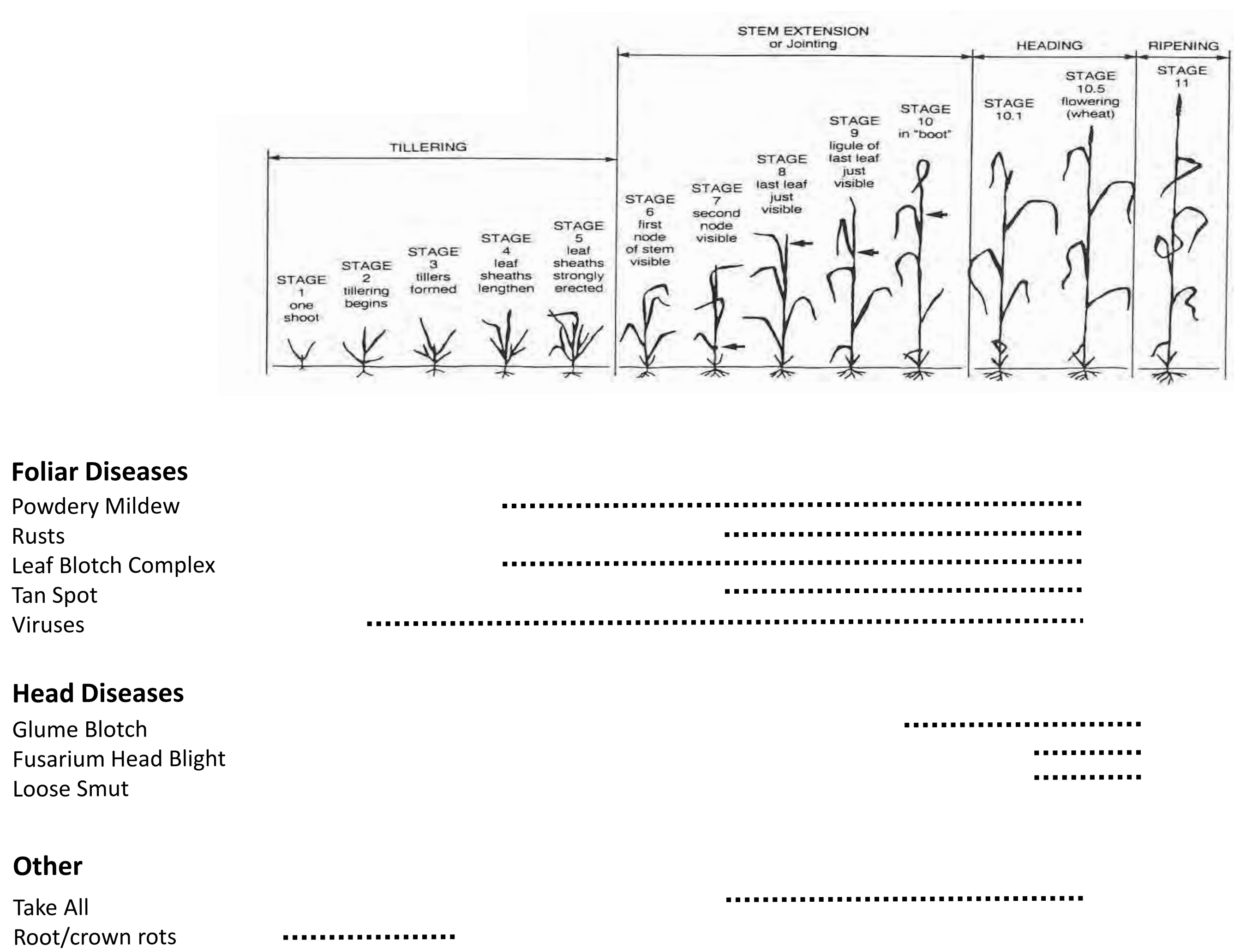
[5]Multiple generic products containing the same active ingredients also may be labeled in some states.

[6]Products with mixed modes of action generally combine triazole and strobilurin active ingredients. Priaxor, Nexicor, and the Trivapro copack include carboxamide 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 is not 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 4) 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 who scout their fields will benefit by 1) being able to 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. Specific diseases occur at certain times of the year when the environment is conducive or he plant growth stage is susceptible to disease.



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- to 10-foot radius.

General Symptoms: Stunted, deformed plants. Foliage may be streaked or mottled. Leaf discoloration (red/orange). Entire fields are rarely affected. Instead look for single or small groups of plants in patches.

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

Barley Yellow Dwarf

Barley yellow dwarf virus (BYDV) is the most widely distributed and destructive of the viral diseases that affect wheat. Symptoms of BYDV 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 have the greatest impact on yield. Plants infected in the fall 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 aphid vectors in the fall and early spring. Grain yields from such plants have been 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 BYDV epidemics are cool temperatures (50˚ to 65˚F) with rainfall that supports 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 in early spring.

Wheat Spindle Streak Mosaic Virus (Wheat Yellow Mosaic)

Wheat spindle streak mosaic virus (WSSMV) 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 WSSMV. However, the field pattern of WSMV 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. WSMV 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- to 10-foot radius.

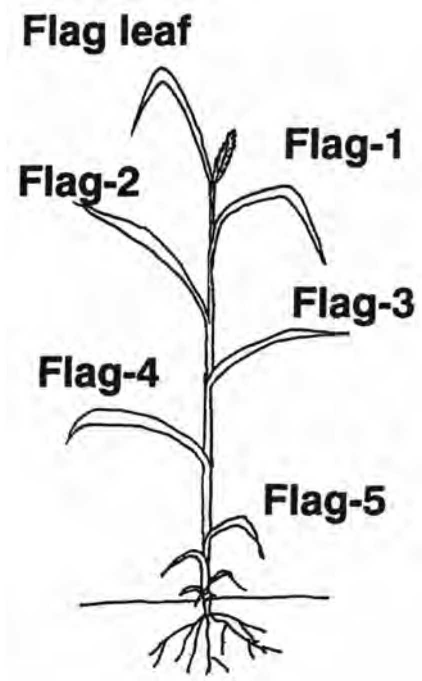


Fig 3.1 Determination of treatment threshold for septoria leaf and glume blotch in wheat.

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 *Parastagonospora nodorum* (Syn. *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: *Parastagonospora 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. *P. 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 *P. 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 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- to 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 *P. 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- to 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:
Blumeria graminis is 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- to 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.

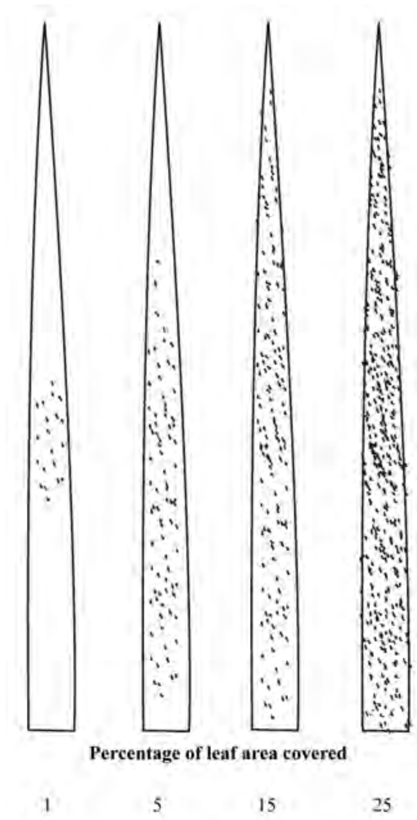


Fig 3.2
Percentage of leaf area affected by lef rust. (James, C. 1971. A Manual of Assessment Keys for Plant Diseases. Publication 1458. Canada Department of Agriculture.)

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- to 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 *Parastagonospora nodorum*, a component of Leaf Blotch Complex, which is described in the previous section.

Management: Plant resistant varieties. Varieties with resistance to 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- to 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. The FHB fungus 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 10-20 gallons per acre with fine to medium-size droplets (approximately 300-350 microns). If the ground rig is traveling less than 6 mph use forward and backward facing nozzles angled 30° to 45° down from horizontal to achieve optimal coverage; if traveling above 6 mph use a single forward-facing nozzle 30° down from horizontal. 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 most effective fungicides for disease and DON suppression are Miravis Ace, Prosaro, Prosaro Pro, Sphaerex, 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- to 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 uninfected 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- to 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

David Langston, 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.

[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, NA = resistance varieties not available.

Table 3.15 - Fungicide Treatment

Crop	Disease	Active ingredient	Trade name	Remarks
Seed treatment fungicides				
Alfalfa and other forage legumes	Damping-off and early season Phytophthora root rot	metalaxyl	Allegiance FL Acquire Belmont 2.7 FS Dyna-Shield Metalaxyl Metalaxyl 265 ST MetaStar ST Sebring 318 FS	Registered for application by commercial seed treaters only. Excellent control of Pythium damping-off.
Alfalfa, clover, and vetch	Seed decay and damping-off	thiram	Protector-D	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 Ultra Flourish	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

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Effective management of tobacco diseases and nematodes **depends** on accurate identification of the problems and the implementation of multiple disease management approaches (crop rotation, resistant varieties, early removal and destruction of stalk and root, etc.).

Disease Management Practices

Crop Rotation

Crop rotation is a valuable cultural method to reduce losses caused by plant pathogens and nematodes. Tobacco following tobacco should be avoided because this practice will build up pathogen population densities.

Table 3.16 - Value of Rotation Crops for Tobacco Disease Control[1]

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
Sweet potato	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	-	N	L	L	H	H
Tomato	-	N	N[2]	N	N	M

[1]Adapted 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 with the assumption of excellent weed control in each rotation crop; H = high value, M = moderate value, L = Little value, N = no value – may be worse than continuous tobacco, - = unknown.

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

[3]Root-knot resistant sweet potato cultivars are moderately effective rotation crops for tobacco.

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

Early Removal and Destruction of Stalk and Root

This practice helps reduce disease, insect, and weed population densities 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 maximize benefit: 1) **flue-cured** - cut stalks into small pieces with bushhog or similar equipment the day that harvest is completed; 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 residue; 4) plant a cover crop when root systems are killed and plant debris is buried.

Disease-resistant Varieties

Planting disease-resistant varieties offers excellent control over most of tobacco diseases. However, growers should consider the major disease problem and the level of pathogen population density when selecting a resistant variety. In severe disease situations, chemical control 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 varieties.

Disease Control in Tobacco Greenhouses

Disease causing organisms can be introduced into a greenhouse through contaminated 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 be sanitized periodically. A 1:10 solution of household bleach and water is sufficient for these purposes.

Float trays should always be thoroughly cleaned and disinfected before fumigation. If float trays are to be sanitized by steaming, they should remain in aerated steam at 160º F to 175ºF for at least 30 minutes in order to minimize *Rhizoctonia* damping-off and sore shin, as well as *Pythium* damping-off.

If tobacco mosaic virus (TMV) occurred in the previous year, greenhouse surfaces 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 were used when TMV were present should be sanitized.* Older trays should be discarded and replaced. TMV has a number of weed hosts (horsenettle, ground cherry), and they should be removed from the vicinity of tobacco greenhouses.

Do not fill float bays with water from streams or ponds as these sources may be contaminated. Filling bays with water long before floating the trays can make *Pythium* problems worse. Be careful to avoid introducing disinfectants into water intended for plant uptake. Avoid moving water from one greenhouse bay to another because it increases the chance of spreading water-borne pathogens like *Pythium*.

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. 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 creates favorable conditions for plant pathogens. 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 that 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.

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. Most tobacco cultivars currently being planted are not resistant to tobacco blue mold. Dark-fired tobacco is generally less susceptible than flue-cured tobacco, which is generally less susceptible than burley tobacco, although burley cultivar KT 206LC has low-to-moderate resistance to blue mold. Burley tobacco cultivar TN 90LC is somewhat less resistant to blue mold than KT 206LC. KT 204LC is less resistant than TN 90LC, but is less susceptible to blue mold compared to most other burley tobacco cultivars. A number of effective fungicides are available for controlling tobacco blue mold when it occurs, and several are relatively new, including Revus, Orondis Ultra, and Presidio.

Fusarium wilt

Caused by Fusarium *oxysporum* f. sp. *nicotianae*. Recent studies at Virginia Tech's Southern Piedmont AREC showed that other *Fusarium* species are also associated with the disease. Fusairum wilt can become a serious problem when tobacco plants are stressed by abiotic (e.g., drought, warm) and other biotic factors (e.g., nematode). Infected plants are often wilted on one-side, and leaves or parts of leaves are significantly yellowed or chlorotic. 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 containing chloropicrin may be required where significant stand loss has occurred.

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 fungal-like pathogen (*Phytophthora nicotianae*) 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. This doesn't mean that black shank cannot occur in fields that don't have a recent history of tobacco production. The pathogen can be introduced or moved from other fields (on field equipment, for example), and severe disease can develop if weather conditions during the growing season favor its spread. 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. **Tobacco cultivars possessing the *Php* or *Phl genes* are highly resistant to RACE 0 of the black shank pathogen, but vary in resistance to RACE 1. Determining physiological races of *P. nicotianae* (race 0 or 1) and their population densities in a tobacco field can aid in selection of tobacco cultivars. 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, <u>always know the resistance to race 1 before selecting a variety</u>.** Several highly effective black shank fungicides are also 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 and Orondis Gold 200 are labeled for application at or near transplanting, and while these fungicides are highly effective, <u>a transplant water fungicide application alone is unlikely to provide season-long black shank control</u>. 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. Pre-plant soil fumigation with a product containing chloropicrin may assist results from a black shank fungicide, but fumigation alone 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 (*Ralstonia solanacearum*) that invades tobacco plants through natural openings and wounds of roots and subsequently kills the entire plant. The pathogen can also invade tobacco plants through wounds caused by cultivation, mechanical topping, and mechanical harvest. For this reason, **early, shallow cultivation and topping by hand** can help reduce disease spread 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 and take longer to yellow during curing 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 soil fumigation, but sometimes fields should be fumigated with a resistant variety planted when disease pressure is severe. However, mechanical toppers and tobacco harvesters can spread bacterial wilt widely, late in the season, and infection through wounded stems, rather than roots, bypasses the protection available in wilt resistant tobacco cultivars. Hand-topping and adjusting harvesters as precisely as possible are the only measures available to minimize late season spread of bacterial wilt via field equipment. **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. However, plant-parasitic nematodes can *significantly* increase problems with root diseases such as bacterial wilt, black shank, and Fusarium wilt, even when nematode populations are very low. 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 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 to not 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. Be aware that grass cover or rotation crops may not reduce lesion nematode populations to the same extent as for root-knot or tobacco cyst nematodes. Fall soil samples should be collected from soybean fields when tobacco is the intended crop in the following spring to ensure that damaging lesion nematode populations are not present.

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*), and other types or species are now common. *Any root galling on a currently grown flue-cured tobacco 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, 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

		Nematodes/500 cc of soil		
Risk of Crop Loss	**% Roots Galled**	**Fall Sample**	**Spring Sample**	**Control Options[1]**
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'.

[1]Be 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 at the end of the growing season is greater than 20%**. Rotation intervals should be increased as long as possible and a soil nematicide or fumigant should be applied when this level of galling has been observed.

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.

Viruses

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. Rogueing infected plants before layby will reduce spread of the virus within a field. TMV can be eliminated by using of resistant varieties along with crop rotation and early root and stalk destruction. All burley varieties are resistant to TMV except HB 3307PLC, N 777LC, TN 86LC, and KT 215LC. Flue-cured tobacco cultivars CC 27, CC 37, CC 67, GL 26H, NC 297, PVH 2254, PVH 2275, and PVH 2310 are TMV-resistant. Traditional Virginia-type dark-fired tobacco cultivars (Shirey, for example) are susceptible to TMV, but some newer varieties (KT D6LC, KT D14LC, PD 7305LC, KY 171, DF 911) are TMV-resistant. *TMV-resistant varieties should be planted in tobacco fields when 30 to 50 percent of the plants are infected with TMV by topping. If a TMV-resistant variety is planted 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 insecticides containing 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 before transplanting, in addition to imidacloprid or thiamethoxam, 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 chapters on tobacco insect control in the production guides for burley, dark, and flue-cured tobacco 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 regional *Burley and Dark Tobacco Production Guide* (Virginia Cooperative Extension publication 436-050) for information on resistance to these viruses in currently-grown burley varieties.

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 fungicide sprays should not begin until seedlings are at least the size of a dime. 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 80-100 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 to improve coverage of leaves. Spray pressures should generally range between 40 and 100 psi. Improving spray coverage on bottom leaves, where fungal leaf spot diseases usually start and are concentrated, should significantly improve control. Fungicides applied using airblast 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 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; completed “post-application summaries” within 30 days of application; and official notification requirements. Fumigant applicators must complete an EPA-approved training program within the previous 3 years in order to purchase and apply these products. This training isn’t required for those who use products without chloropicrin or metam sodium, such as Telone II (containing only 1,3-dichloropropene). Further information on certified fumigant applicator training is available at https://www.epa.gov/soil-fumigants/soil-fumigant-training-certified-applicators.

Field Procedures - Performance of all or most field procedures must be documented in the GAP section of the FMP for chloropicrin 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 are usually applied in tobacco fields by injecting 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.

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 2-3 weeks of application, depending upon the specific soil fumigant used. *When rains or cold temperatures slow aeration during the exposure period, aeration can be improved by using a chisel implement to "open up" the bed, as long as soil is only disturbed above the original depth of injection. Do not rehill rows or turn soil if doing so risks contaminating beds with untreated soil. Do not use tools, equipment, and/or residues that may be 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
Pythium root rot *(Pythium spp.)* **Blackleg** *(Pectobacterium carotovorum)*	Terramaster 4EC	**Preventative:** 1.0 fl oz/100 gal **Sequential:** 1.0 fl oz/100 gal **Curative:** 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. FRAC Code 14.
	Oxidate 2.0	**Preventive:** 6-24 fl oz/1000 gal **Curative:** 1.25-2.5 fl oz/10 gal	**Preventive:** treat or maintain a residual 12.8 fl oz/1,000 gal of float bed water **Curative:** initial treatment of float bed water
	Oxidate 5.0	**Preventive:** 1.0 fl oz/100 gal H2O	
Anthracnose *(Colletotrichum gloeosporioides)* **Blue mold** *(Peronospora tabacina)* **Target spot** *(Thanatephorus cucumeris)* **Damping off** *(Rhizoctonia solani)*	Penncozeb 75DF mancozeb	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. FRAC Code M3.

Table 3.18 - Diseases of Tobacco Seedlings (cont.)

Disease	Material	Rate	Remarks
Target spot *(Thanatephorus cucumeris)*	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.FRAC Code 11.
Gray mold *(Botrytis cinerea)*		0.14 oz (4c)/1,000 sq ft	Only one application prior to transplanting.
Angular leaf spot or Wildfire *(Pseudomonas syringae p.v. tabaci)*	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. FRAC Code 25.
Blue mold (*Peronospora tabacina*)	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-penetator, such as a non-ionic surfactant, may increase activity. Thorough coverage is needed for maximum activity. FRAC Code 33.

Table 3.19 - Foliar Diseases in the Field

Disease	Material	Rate	Remarks
Blue mold *(Peronospora tabacina);* **Frogeye** *(Cercospora nicotianae):* **Target spot** *(Thanatephorus cucumeris-sexual; Rhizoctonia solani-asexual stage)*	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; in sufficient water volume for complete coverage and canopy penetration, but apply no more than twice before switching to a different fungicide from a FRAC Group other than 11; may enhance weather flecking, but this does not affect yield or quality; up to 4 applications/year allowed; pre-harvest interval (PHI) is now 21 days. Tank mixing with insecticides formulated as ECs or containing high amounts of solvents may cause some crop injury. FRAC Code 11.
Blue mold *(Peronospora tabacina)*	Orondis Ultra Premix	5.5 – 8.0 fl oz	FRAC Groups U15 and 40. Do not use if Orondis Gold 200 has already 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 on more susceptible varieties. Make no more than 2 sequential applications before rotating to a fungicide with a mode of action other than 40. See label for additional use restrictions. Thorough spray coverage is important in maximizing disease control; adding a spreader-penetrating adjuvant may improve activity. No more than 4 applications (32 fl oz) allowed, with a 7-day PHI. If 3 or more fungicides are applied for blue mold control, Orondis Gold can be used for only 1/3 of the total sprays made.

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

Disease	Material	Rate	Remarks
Blue mold *(Peronospora tabacina)* (cont.)	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 is not in FRAC Group 40. Thorough spray coverage is important in maximizing disease control; adding a spreader-penetrating adjuvant may improve activity. FRAC Group 40.
	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. FRAC Code U15.
	Forum + Penncozeb 75DF	7.0 fl oz/100 gal 2.0 lb/100 gal	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 is FRAC Group 40; mancozeb fungicides are FRAC Group M3.
	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. FRAC Code 43.
	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. FRAC Code M3.

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

Disease	Material	Rate	Remarks
Blue mold *(Peronospora tabacina)* (cont.)	Ridomil Gold SL Ultra Flourish 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. **Do not apply if mefenoxam or metalaxyl-insensitive pathogen strains have been reported to be present.** FRAC Code 4.
	Ridomil Gold SL Ultra Flourish 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 mefenoxam or metalaxyl-insensitive pathogen strains have been reported to be present.** FRAC Code 4.
	Aliette	2.5-4.0 lb/A	Foliar spray; no more than 5 sprays allowed, 3-day preharvest interval; don't tank mix. FRAC Code 33.
	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. FRAC Code P01.

Table 3.20 - Root and Stem Diseases in the Field

Disease	Material	Rate/Acre	Remarks
Black shank (*Phytophthora nicotianae*)	**<u>Transplant Water Use</u>** Orondis Gold Premix	24.0–27.8 fl oz	FRAC Groups 49 and 40. For transplant water (TPW) or in-furrow (IF) at planting application only. Risk of injury from TPW use drops with increasing TPW volume (100-200 gal/A. Premix in a tank separate from the TPW source tank to avoid negative interactions with fertilizers ot other pesticides in the TPW solution. IF spray solutions should use a sufficient water volume to move into the root zone. Use the high labeled rate if disease pressure is expected to be severe. **Follow-up with additional after planting sprays at 1st cultivation and/or layby using a fungicide outside of FRAC-49**. See label for additional use restrictions. No more than 1 application allowed.
	Ridomil Gold SL Orondis Gold 200	4.0-8.0 fl oz (0.25-0.5 pt) 4.8-19.2 fl oz (0.30-1.2 pt)	Apply Ridomil Gold (FRAC Code 4) and/or Orondis Gold 200 (FRAC Code 49) in at least 100 gal (200 gal for burley and dark tobacco) transplant water/A. Orondis Gold 200 must not be applied sequentially (back-to-back). 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, using a fungicide product with a different FRAC Code.**

Table 3.20 - Root and Stem Diseases in the Field (cont.)

Disease	Material	Rate/Acre	Remarks
Black shank (*Phytophthora nicotianae*) (cont.)	**Pre-Plant Spray** **Flue-Cured** Ridomil Gold SL Ultra Flourish MetaStar 2E AG	 1.0-2.0 pt 2.0-4.0 pt 8.0-12.0 pt	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. FRAC Code 4.
	Burley and Dark Ridomil Gold SL Ultra Flourish MetaStar 2E AG	 1.0-2.0 pt 2.0-6.0 pt 8.0-12.0 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 either Presidio or 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 (FRAC Code 4), 6.0 pt of Ultra Flourish (FRAC Code 4), 12.0 pt of MetaStar (FRAC Code 4), 8.0 fl oz of Presidio (FRAC Code 43), or 38.6 fl oz Orondis Gold 200 (FRAC Code 49) per acre.
	Post-Plant Spray(s) Ridomil Gold SL Ultra Flourish MetaStar 2E AG Presidio Orondis Gold 200	 1.0-2.0 pt 2.0-4.0 pt 4.0-8.0 pt 4.0 fl oz 4.8-19.2 fl oz	
	No-Till Sprays **Ridomil Gold SL** Ultra Flourish MetaStar 2E AG	 0.5-1.0 pt 3.0 pt 6.0 pt	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. FRAC Code 4.
	Soil Fumigants 100% Chloropicrin products Pic+	 3.0 gal 4.2 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. A soil fungicide should also always be used in addition to a soil fumigant when the fumigant is applied for black shank control.
Fusarium wilt (*Fusarium oxysporum* f. sp. *nicotianae*)	100% Chloropicrin products Pic+	3.0 gal 4.2 gal	In severe cases, apply a soil fumigant containing 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.
Bacterial or Granville wilt (*Ralstonia solanacearum*)	100% Chloropicrin products Pic+	3.0 gal 4.0 gal	Fumigants should always be used in conjunction with host resistance and crop rotation.

Table 3.21 - Nematodes[1,2]

Material	Rate/A	Application Method	Root-Knot And Others	Tobacco Cyst	Remarks
Non-Fumigants					
Nimitz	3 -7 pt (56-112 fl oz)/ treated acre	Banded PPI	F	F	With spray volume at least 40 gal/A; apply at least 7 days before transplanting. Use higher rates in fields with higher nematode populations and for tobacco cyst.
Velum Prime	6.5-6.84 fl oz	Transplant water drench	F	F	Suppression only. Do not apply more than 13.7 fl oz per acre per year, regardless of formulation or application method.
Majestene	8-16 pt	Soil incorporated Preplant, 1st cultivation, & Layby	P-F	P-F	OMRI-listed product for nematode suppression in organic tobacco. Multiple applications are needed: in the transplant water, then again at 1st cultivation, and again at layby, for example. Use sufficient water to soak the root zone around plants at each application. Use the high labeled rate if nematode pressure is expected to be severe. See label for additional use restrictions. 4 hr REI.
Fumigants					
100% Chloropicrin products	3.0 gal	Row	E	G	TriPic 100, etc.
42% metam sodium	20.0-25.0 gal	Row	nd	G	Metam CLR, Vapam, Sectagon, etc.
Pic+	4.0 gal	Row	E	G	
Telone II	9.0-10.0 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] **BANDED-PPI** - Research results indicate product performance is best when applied in a 12-24 inch band centered over where the transplanting furrow will be. **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
Collar rot *(Sclerotinia sclerotiorum)*	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 *(Bacillus cereus)* 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

David Langston, Extension Plant Pathologist, Virginia Tech, Tidewater AREC

Weather-Based Crop Advisories

The Peanut/Cotton Infonet 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.
- The Virginia Peanut Hotline (1-800-795-0700) provide the last effective fungicide spray dates for leaf spot and Sclerotinia blight daily Monday-Friday.
- Contact your local Extension agent or call (757) 807-6536 and ask for David Langston 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.

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 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):** Currently grown Virginia-type peanuts have good resistance to CBR.
- **Sclerotinia blight:** Bailey II has some tolerance to Sclerotinia blight.
- **Early and late leaf spot:** Currently planted peanut varieties have moderate susceptibility to leaf spots.
- **Tomato spotted wilt virus:** Compared to older Virginia-type varieties, current varieties are moderately susceptible to TSWV.

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.

Fungicides

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 some of the approved chemicals for control of specific disease problems. Other products may be available, but these are the most common fungicides for control of peanut diseases in Virginia. **Read the label instructions attached to the pesticide containers before application.**

Though it primarily applies to exports, it should be noted that due to recent pesticide residue restrictions made by the European Union, certain peanut shellers will not accept ANY peanuts that have had the restricted chemicals applied. The new restrictions are NOT based on increased safety concerns, and they may still be labelled for use in the U.S. However, under the current circumstances peanut growers should NOT use them, and many chemical suppliers are voluntarily ceasing sales of these products for use in peanut. The chemicals fall into two major categories:

1) propiconazole-containing products and
2) mono/dipotassium salts or phosphorous acid based products.

Products in category 1 are used for leaf spot management and include Tilt (propiconazole), Tilt Bravo (propiconazole + chlorothalonil), Stratego (propiconazole + trifloxystrobin), and Artisan (propiconazole + flutolanil). There are several generic products with propiconazole as well, so be sure to check labels for propiconazole as an active ingredient. Some good alternatives to propiconazole in leaf spot fungicide programs include Alto (cyproconazole) + Bravo Weather Stik (chlorothalonil), Absolute (tebuconazole + trifoxystrobin), and Priaxor (fluxapyroxad + pyraclostrobin).

Fungicides in the second category are applied for management of Pythium pod rot, and there is not widespread use of these fungicides in Virginia. However, growers still need to be aware and be sure they are not using these. Typically, a different type of fungicide for Pythium control is included in seed treatments such as Dynasty, and these products are still okay to use.

Due to these restrictions, fungicide products containing these active ingredients are no longer recommended and are not included in the fungicide tables below.

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 Cylindrocladium 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 *Rhizoctonia sp.*
	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 *Cylindrocladium* black rot.
	Rancona V PD (ipconazole + carboxin + metalaxyl)	4.0 oz	Same as above.	Controls seed rot, damping off, and seedling blight.

[1]Do 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(s) controlled	Active ingredient	Product and formulation	Rate per Acre	Method and Timing of Application[1]	Precautions and Remarks[2]
Foliar diseases only (early and late leaf spot, web blotch)	chlorothalonil	Bravo 720 Bravo Ultrex Echo 720 Various others	1.5 pt 1.4 lb 1.5 pt	Apply according to leaf-spot advisory program or a calendar-based program using 14-21 day intervals.	**Caution:** Sclerotinia blight will be more difficult to control when these products are applied at intervals of less than 21 days.
	tebuconazole + trifloxystrobin	Absolute 500SC	3.7-7.0 fl oz	Same as above.	Do not apply more than 4 sprays and apply chlorothalonil as the final spray for fungicide resistance management. Also controls limb rot.
	mancozeb	Koverall	1.0-2.0 lb	Same as above.	Only effective against early leaf spot.
	cyproconazole	Alto 100SL	5.5 fl oz	Same as above.	Mix or alternate with another fungicide to improve foliar disease control and reduce risk of fungicide resistance.
	picoxystrobin + cyproconazole	Aproach Prima	5.0 - 6.8 fl oz	Same as above.	Begin applications at early vegetative growth and prior to disease development. Use higher rate under high disease pressure.
	flutriafol	Topguard 1.04 SC	7-14 fl oz	Same as above.	Same as above.
	tetraconazole	Eminent 125SL	6-13 fl oz	Same as above.	Same as above.
Early and late leaf spot, web blotch, Rhizoctonia limb rot, Southern stem rot	tetraconazole	Domark 230ME	5.25 to 6.9 fl oz	Same as above.	Do not make more than 2 applications or 13.8 fl oz per acre per year. PHI = 14 days.
	pydiflumetofen	Miravis	3.4 fl oz	Begin applications prior to disease development. For early and late leaf spot control, apply on a 21 to 28-day interval.	Do not make more than three applications of Miravis or other Group 7 fungicides before alternating with another fungicide mode of action. Also suppresses Sclerotinia blight.

[1]For 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.

[2]Read 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(s) controlled	Active ingredient	Product and formulation	Rate per Acre	Method and Timing of Application[1]	Precautions and Remarks[2]
Early and late leaf spot, web blotch, Rhizoctonia limb rot, Southern stem rot (con't)	tebuconazole + prothioconazole	Provost Silver	13.0 fl 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.
	metconazole	Quash 50 WDG	2.5-4 oz	Same as above.	Apply up to 4 sprays then use a fungicide with a different mode of action.
	tebuconazole	Folicur 3.6F Multiple generics	7.2 fl oz	Same as above.	Many populations of leaf spot fungicide are not controlled by tebuconazole alone. Mix with chlorothalo-nil or another fungi-cide with a different mode of action.
	penthiopyrad	Fontelis 1.67SC	16-24 fl oz	Same as above.	Apply up to 3 sprays, then use a fungicide with a different mode of action. Also suppresses Sclerotinia blight.
	azoxystrobin	Abound 2.08F	9.0-12.3 fl oz	Apply according to leaf spot advisory program, but do not make more than two applications.	Do not apply within 50 days of harvest. Not recommended for the last spray.
	azoxystrobin + tebuconazole	Custodia SC	15.5 fl oz	Apply according to leaf spot advisory.	Make up to 2 to 4 applications in mid-season as part of an advisory program.
	fluoxastrobin	Evito 480SC Aftershock	3.8-5.7 fl oz	Same as above.	Make up to 2 appli-cations per season and rotate or mix with another fungi-cide with a different mode of action.
	fluoxastrobin + tetraconazole	Evito T	6-11.2 fl oz	Same as above.	Make up to 2 to 4 applications in mid-season as part of an advisory program.

[1]For 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.

[2]Read 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(s) controlled	Active ingredient	Product and formulation	Rate per Acre	Method and Timing of Application[1]	Precautions and Remarks[2]
Early and late leaf spot, web blotch, Rhizoctonia limb rot, Southern stem rot (con't)	pyraclostrobin	Headline 2.09EC, 2.08SC	6-15 fl oz	Same as above.	Make up to 2 applications per season and rotate or mix with another fungicide with a different mode of action.
	fluxapyroxad + pyraclostrobin	Priaxor	4-8 fl oz	Same as above.	Use 1 to 3 times per season. Use higher rates for limb rot and stem rot control.
	azoxystrobin + benzovindiflupyr	Elatus	7.3-9.5 fl oz	Same as above.	Make no more than 3 applications before alternating with a fungicide with a different mode of action. May also be applied as an early season banded application for suppression of soilborne diseases. Excellent stem rot control.
	bixafen + flutriafol	Lucento	3-5.5 fl oz	Apply according to leaf-spot advisory program or a calendar-based program using 14-21 day intervals.	Do not apply more than 11 fl oz of product/A per year. PHI = 14 days.
	mefentrifluconazole	Provysol	2.5-7.0 fl oz	For leaf spot, apply at 14 to 21 day intervals; for soilborne diseases apply at 14 to 28 day intervals. Use the higher rate for soilborne diseases.	Do not apply more than 21 fl oz/A per year. PHI = 14 days.
	mefentrifluconazole + pyraclostrobin + fluxapyroxad	Revytek	8.0-15.0	For leaf spot, apply at 14 to 21 day intervals; for soilborne diseases apply at 14 to 28 day intervals. Use the higher rate for soilborne diseases.	Do not apply more than 15 fl oz/A per year. PHI = 14 days.
	inpyrfluxam	Excalia	2.0-4.0 fl oz	Apply prior to disease development. Do not apply earlier than 30 days after planting.	Do not apply more than 8 fl oz/A per year. PHI = 40 days.

[1]For 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.

[2]Read 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(s) controlled	Active ingredient	Product and formulation	Rate per Acre	Method and Timing of Application[1]	Precautions and Remarks[2]
Sclerotinia blight	fluazinam	Omega 500F Vantana	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.
	boscalid	Endura 70 WG	8-10 fl 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.
	penthiopyrad	Fontelis 1.67SC	12-24 fl oz	Apply prior to disease onset and thereafter according to scouting or Sclerotinia blight advisory.	Suppression only. 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.
	prothioconazole + fluopyram	Propulse 3.34SC	13.6 fl oz	Apply the first spray when disease is initially detected, and if needed, a second application according to scouting or Sclerotinia blight advisory.	Suppression only. Also suppresses CBR and limb rot. Do not apply more than 34.2 fl oz/A per season. May also be applied to the seed furrow at planting for suppression of soil-borne diseases.
	pydiflumetofen tank-mixed with azoxystrobin + benzovindiflupyr	Miravis + Elatus	3.4 fl oz, Miravis 9.5 oz, Elatus	See above for both fungicides.	

[1]For 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.

[2]Read 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) (*Cylindrocladium parasiticum*) and nematodes	Vapam HL 42% Metam 42% Sectagon 42% (metam sodium)	7.5-gal 7.5-gal 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.
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	6.5 - 6.84 fl oz	Apply in-furrow during planting directed on or below seed. May also be applied by chemigation into the root-zone.	May suppress early season early and late leaf spot.
	Propulse (fluopyram + prothioconazole)	13.6 fl oz	May be applied by chemigation or foliar spray.	For maximum nematode suppression, Propulse should be applied 45 days after planting following an at-plant nematicide (e.g. Velum Total). Also controls early and late leaf spot.
	AgLogic 15G, AgLogic 15GG (aldicarb)	7 lb	In furrow at planting.	See label for precautions and restrictions. Also controls thrips.

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

Cotton

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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.

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

Disease	Fungicide Common Name	FungicideTrade Name	Formulated Rate	Remarks
Seedling disease; damping-off; seed rot.	PCNB + etridiazole	Terraclor Super X 12.5G Terraclor Super X 18.8G (Note: also available in liquid formulation)	8.0-12.0 lb/A 6.0-9.0 lb/A	Apply to seed furrow at planting. Read and follow all label restrictions.
	metalaxyl + PCNB	Ridomil PC (Note: Also available in liquid formulation.)	7.0-10.0 lb/A	Same as above.
	azoxystrobin	Quadris	0.4-0.6 fl oz/1000 row ft	Same as above.
	carboxin + PCNB + metalaxyl	Prevail	8.0-16.0 oz/cwt	Apply to seed in hopper at planting.

Foliar Diseases and Boll Rots

Rarely are fungicides needed in Virginia cotton. However they may arise on rare occasions. 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 leaf spot Areolate mildew Ascochyta leaf spot Cercospora blight Diplodia boll rot Hard lock boll rot *Phoma* boll rot Rust *Stemphylium* 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. Counts of veriform 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	Active ingredient(s)	Trade Name	Formulated Rate	Remarks[1]
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 500FS	0.10 - 0.15 mg/seed	Must be applied by commercial applicator equipment with rate adjusted for seed size. For early season insect and disease control, Avicta should be combined with Cruiser 5FS (insecticide) and Dynasty CST (fungicide) seed treatments. In high nematode pressure situations, it may be necessary to combine a seed treatment with an in-furrow nematicide. Apply in-furrow in a minimum of 5 gallons per acre of final volume as a spray or dribble directed on the seed during planting. • Linear application rate is based on 36” rows. For different row spacing consult the Linear Application Rate Conversion Chart in the Instructions for At-Plant Applications section. In all cases do not exceed the maximum per acre use restriction.
	fluopyram	COPeO PRIME	0.2 - 0.3 mg ai/seed or 1.127 - 1.69 fl oz/100,000 cotton seeds	Currently available on Stoneville (all seed) and FiberMax (premium seed treatment) varieties. In high nematode pressure situations, it may be necessary to combine a seed treatment with an in-furrow nematicide.
	thiodicarb (nematicide/ insecticide) + imidaclo-prid (insecticide)	Aeris Seed-applied Insecticide/Nematicide	25.6 fl oz/100 cwt seed	Same as above, except lacks a fungicide for additional seedling disease control, and must be applied as an overcoat on fungicide-treated seed.
	Burkholderia rinojenses	BioST Nematicide 100	8 oz/100 lb seed	Can be applied with fungicide and insecticide seed treatments.

Table 3.28 - Nematicides for Use in Cotton (cont.)

Nematode	Active ingredient(s)	Trade Name	Formulated Rate	Remarks[1]
Sting, Reniform, Lesion, Lance, Root knot, Stubby root	fluopyram (nematicide) + imidacloprid (insecticide)	Velum	5.0 - 6.84 fl oz/A	Apply in-furrow during planting directed on or below seed. May also be applied by chemigation into the root-zone. Also suppresses *Fusarium* spp.
	aldicarb	AgLogic 15G	3.5 - 7.0 lb/A	This is a restricted use pesticide, so be sure to follow the precautions on the label. Also controls thrips and some other insect pests.

[1]Read 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.