FLUE-CURED TOBACCO DISEASE CONTROL

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Good disease control in flue-cured tobacco results from accurate diagnosis of disease problems, careful consideration of disease severity in each field, and prudent use of disease control practices. *Consistent disease control depends on the use of several control practices together. Crop rotation, early root and stalk destruction, and resistant varieties should always be used in conjunction with disease control chemicals.*

ACCURATE DIAGNOSES OF DISEASE PROBLEMS is the first step in controlling flue-cured tobacco diseases. Note any signs of disease during the growing season. Plant and soil samples can be taken and analyzed to identify the cause of the problem. Don't forget to record what the problem was determined to be, where and when it occurred, and how bad it eventually became, so that you can plan appropriate control practices for the future.

DISEASE-RESISTANT VARIETIES for black shank, Granville wilt, mosaic, as well as cyst and root-knot nematodes, are available to flue-cured tobacco growers in Virginia.

CROP ROTATION is particularly effective in helping to control black shank, Granville wilt, most nematodes, and tobacco mosaic. Crop rotation also provides many agronomic benefits. Length of rotation (the longer the better) and types of alternate crops are among the most important rotation considerations. Table 1 lists some possible rotation crops.

EARLY DESTRUCTION OF ROOTS AND STALKS reduces overwintering populations of nematodes and disease-causing organisms by destroying the tobacco debris that pathogens rely on for food and shelter during the fall and winter. *The earlier and more complete the destruction of tobacco debris, the better the disease control.* The objective of early root and stalk destruction is to pull the roots out of the ground, dry them out, break them up, and rot them away as soon as possible. Table 2 lists the steps involved.

DISEASE CONTROL IN TOBACCO GREENHOUSES

Avoid seeding tobacco greenhouses any earlier than necessary. Eliminate any volunteer tobacco plants. Plants closely related to tobacco (tomatoes, peppers, etc.) should not be grown in greenhouses used for transplant production.

Disease-causing organisms can enter a greenhouse in soil or plant debris, so 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 should be free of soil and plant debris.

Table 1. Usefulness of various rotation crops for tobacco disease control[1].

			Nematodes			
Rotation Crop	**Black Shank**	**Granville Wilt**	**Root-Knot**	**Tobacco Cyst**	**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[3]	H	H	L
Corn	H	M	L	H	H	H
Sweet potato	H	M	L[4]	-	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[2]	L	N	H
Potato, Irish	H	N	L	L	H	H
Tomato	H	N	N[3]	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, and assume excellent weed control in each rotation crop; H = highly valuable, M = moderately valuable, L = Little value, N = no value – may be worse than continuous tobacco, - = unknown.

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

[3]However, root-knot resistant cultivars can be highly effective rotation crops for tobacco.

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

Table 2. Steps in early stalk and root destruction.

1. Cut stalks into small pieces with a bush-hog or similar equipment *immediately after final harvest*.
2. Plow or disc-out stubble the same day that stalks are cut, pulling roots completely out of the soil.
3. Re-disc the field *2 weeks after the first operation*.
4. Plant a cover crop when root systems are completely dried-out and dead.

If tobacco mosaic (TMV) may have occurred in the previous year, greenhouse surfaces such as side-curtains, center walkways, and the 2x6 boards that support the float bays should be disinfected. A 10% solution of household bleach in water is sufficient for these purposes, as are most

disinfectants. There is no need to spray the purline supports or the plastic covers over the greenhouse. Float trays used when TMV may have been present should be washed and cleaned thoroughly before being steamed or treated. Mosaic has a number of weed hosts (horsenettle, ground cherry) which should all be removed from the vicinity of tobacco greenhouses.

Float trays should be cleaned and disinfected to minimize diseases that reduce seed emergence and kill or damage seedlings (*Rhizoctonia* and *Pythium*). As methyl bromide is no longer available, trays can be treated with aerated steam, maintained at 160^0F to 175^0F for at least 30 minutes, to minimize damping-off and sore shin diseases.

Never use water from streams or ponds in a tobacco greenhouse, as water from these sources may be contaminated. Avoid introducing disinfestants into water intended for plant uptake. Moving water from one bay to another can increase spread of water-borne pathogens. Filling bays with water long before floating the trays can make *Pythium* disease problems worse.

Condensation in the greenhouse favors disease. Temporarily lowering the side-curtains near dusk and ventilating the greenhouse with horizontal airflow fans will help reduce 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.

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

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

SPECIFIC DISEASES IMPORTANT IN VIRGINIA

Diseases like **black shank** and **Granville wilt** are caused by microscopic organisms that live in the soil. Any activity that moves soil from one place to another can spread these diseases. *Crop rotation, early root and stalk destruction, and a resistant variety should all be used before considering use of a pesticide to control black shank or Granville wilt.*

Table 3. DISEASES OF TOBACCO SEEDLINGS

Disease	Material	Rate
Pythium Root Rot (*Pythium* spp.)	Terramaster 4EC	Preventative: 1.4 fl oz/100 gal may be applied twice, as long as applications are 3 weeks apart. 1.0 fl oz/100 gal may be used as a third application as long as it is made no later than eight weeks after seeding. Curative: 1.4 fl oz/100 gal 2nd Curative: 1-1.4 fl oz/100 gal.
Remarks: 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 3.8 fl.oz./100 gallons 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 emulsion*, then distribute diluted emulsion evenly and thoroughly in float bed water.		
Target Spot *(Thanatephorus cucumeris);* **Blue Mold** *(Peronospora tabacina)*; **Anthracnose** *(Colletotrichum gloeosporioides)*	Penncozeb 75DF	0.5 lb/100 gal (1 level tsp/gal)
Remarks: Apply as a fine foliar spray to the point of run-off to ensure thorough coverage. 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 /1000 sq. ft. when the canopy has closed and plants are close to ready for transplanting. Repeat applications on a 5-7 day interval to protect new growth. *Some tobacco companies may prohibit use of mancozeb products like Penncozeb in 2020.*		
Target Spot (*Thanatephorus cucumeris*)	Quadris	0.14 fl oz (4 ml)/1,000 sq.ft. (6.0 fl oz/A)
Remarks: Apply in enough water for thorough coverage (5 gal/1,000 sq. ft.). The Special Local Need (24[c]) label allows only 1 application before transplanting, and requires the label be in the possession of the user at the time of application. Follow-up sprays are allowed in the field according to the Quadris federal label.		
Blue mold *(Peronospora tabacina)*	Aliette	0.5 lb (8 oz)/50 gal
Remarks: 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.		
Angular Leaf Spot or Wildfire (*Pseudomonas syringae*)	Agri-mycin 17, Fire-wall 17WP, Harbour, etc.	100-200 ppm (2-4 tsp/3gal)
Remarks: Foliar Spray- 100 ppm = 4 oz/50 gal or ½ lb/100 gal; preventative use. 200 ppm = ½ lb/50 gal or 1 lb/ 100 gal; curative use.		

Black shank is caused by a fungus-like pathogen that lives in soil and attacks tobacco roots and stalks. Tables 4, 5 and 9 present black shank resistance ratings for flue-cured tobacco varieties. *Virginia tobacco producers should assume that most of their fields contain race 1 of the black shank pathogen. In addition to planting a variety with high resistance to race 1, growers planting black shank problem fields in 2021 should apply a black shank fungicide at first cultivation and/or at layby in addition to use in the transplant water* (Table 10). Remember that while soil fumigants provide good to excellent control of Granville wilt and nematodes, they are generally not effective for black shank control.

Table 4. Reactions to Race 1 Black Shank by Flue-Cured Tobacco Varieties possessing the *Ph$_p$* gene.

		Relative Yield Index[3]	
Varieties with the *Ph* gene[1]	Percent Survival[2]	With Black Shank	Without Black Shank
NC 1226[4]	99	106	108
NC 196	73	74	102
PVH 1452	66	67	101
CC 700	67	66	98
PVH 1600	64	64	100
NC 72	57	57	100
CC 67	69	55	92
NC 299	47	47	100
CC 27	39	41	105
NC 297	37	38	103
CC 37	39	37	94
PVH 2310	30	30	100

[1] Varieties with the *Ph$_p$* gene possess very high resistance to race 0 of the black shank pathogen. Resistance to race 0 in varieties without the *Ph$_p$* gene is similar to or higher than that to race 1.

[2] Average % Survival without a soil fungicide from 3 years of field testing by North Carolina State University. Source: 2020 Tobacco Production Guide, Managing Diseases, Table 8.3.

[3] Relative Yield Index = yield of each cultivar relative to the yield of all other cultivars in the experiment(s). Yield indexes for "No Black Shank" = average relative yield from the 2015-2020 Virginia OVT tests conducted at the Southern Piedmont AREC, Blackstone. Yield indexes for "Black Shank (race 1)" = yield index without black shank multiplied by 2019-2020 NCSU Black Shank-% Survival ratings.

[4] Tentative ratings based on the limited data available in December 2020.

Table 5. Reactions to Race 1 Black Shank by Flue-Cured Tobacco Varieties that don't possess the *Ph_p* gene.

Varieties without the *Ph_p* gene[1]	Percent Survival[2]	Relative Yield Index[3] With Black Shank	Relative Yield Index[3] Without Black Shank
GL 386[4]	94	96	102
CC 35	82	95	116
NC 925	92	92	99
CC 1063	92	89	97
NC 938	87	87	100
CC 145[4]	91	82	90
K 346	85	80	93
NC 606	77	74	96
CC 33	71	68	95
GL 395	67	63	94
CC 143	56	58	105
GL 26H	53	57	108
CC 13	57	57	100
PVH 2254	50	50	101
PVH 2110	50	53	107
K 326	37	39	105

[1] Varieties with the *Ph_p* gene possess very high resistance to race 0 of the black shank pathogen. Resistance to race 0 in varieties without the *Ph_p* gene is similar to or higher than that to race 1.
[2] Average % Survival without a soil fungicide from 3 years of field testing by North Carolina State University. Source: 2020 Tobacco Production Guide, Managing Diseases, Table 8.3.
[3] Relative Yield Index = yield of each cultivar relative to the yield of all other cultivars in the experiment(s). Yield indexes for "No Black Shank" = average relative yield from the 2015-2020 Virginia OVT tests conducted at the Southern Piedmont AREC, Blackstone. Yield indexes for "Black Shank (race 1)" = yield index without black shank multiplied by 2019-2020 NCSU Black Shank-% Survival ratings.
[4] Tentative ratings based on the limited data available in December 2020.

Granville (Bacterial) wilt is caused by a soil-inhabiting bacterium that invades tobacco plants through one or more roots, and often kills the entire plant. The pathogen can also invade tobacco plants through wounds, so early and shallow cultivation and hand-topping can help reduce spread in infested fields. Although symptoms are somewhat similar to those for black shank, intermediate symptoms of Granville wilt involve wilting on only one side, and wilted leaves may retain their normal green color rather than yellowing. *Crop rotation and use of resistant varieties is ESSENTIAL for Granville wilt control.* Including soybeans as a rotation crop helps reduce losses to this disease (Table 1). Disease reduction and yield increases are generally much larger from use of resistant varieties compared to soil

fumigation (Tables 6, 7, 9, and 10). *Wilt-resistant varieties reduce infection through roots, but not stalks (infections that occur via mechanical toppers and/or tobacco harvesters)*. See Table 6. Topping and harvesting equipment should be adjusted and sanitized carefully before and after use in fields infested with the Granville wilt pathogen.

Table 6. Performance of selected flue-cured tobacco varieties in 2020 on-farm test for resistance to Granville Wilt, Dolphin, VA.

	Final % Healthy Plants						
Variety	8 Jun	2 Jul	16 Jul	30 Jul	14 Aug	26 Aug	1 Sep
PVH 1452	100	98	98	99	95	88	37
CC 145	100	97	95	96	94	80	50
PVH 1920	100	97	95	96	88	74	29
NC 196	100	96	95	93	90	65	29
CC 143	98	95	94	91	90	62	30
CC 27	99	97	94	94	94	59	27
NC 1226	100	97	94	94	93	55	17
CC 35	98	94	91	91	77	26	3

Tobacco Cyst (TCN), Root-Knot, and Lesion Nematodes are microscopic worms that live in the soil and feed on tobacco roots. *Fields continuously planted with tobacco will develop significant nematode problems*. In addition to stunting tobacco and reducing yield and quality on their own, tobacco nematodes also significantly increase levels of black shank, Fusarium wilt, and Granville wilt. Destruction of tobacco roots as soon as possible after harvest is a critical first step toward reliably acceptable nematode control in the future. Production practices such as early root and stalk destruction, crop rotation, and resistant varieties reduce nematode populations over much longer periods of time than nematicides, and should therefore always be used in addition to nematicides.

Frequent use of varieties with the Ph_p gene over the last 20 years has dramatically reduced TCN populations in many fields. Nematicide use should no longer be necessary for TCN control when resistant varieties have been planted in rotated fields, but may be necessary when the number of TCN juveniles and eggs exceeds 1,000 per 500 cc of soil (Tables 4, 7 and 9). *Planting a variety without the Ph_p gene for 1-2 consecutive years may allow TCN to increase to damaging levels.* Field histories and nematode assay results can be used to decide if nematicide use would be prudent for the 2021 crop.

Table 7. Reactions of flue-cured tobacco varieties to Granville Wilt.

		Relative Yield Index[3]	
Varieties with the Php gene[1]:	% Survival[2]	With Disease	Without Disease
PVH 1452	53	67	101
CC 37	67	63	94
NC 297	55	57	103
CC 27	49	51	105
CC 67	53	49	92
NC 299	46	46	100
NC 196	40	41	102
CC 700	36	35	98
NC 1226[4]	12	13	108
Varieties without the Php gene[1]			
GL 386[4]	78	80	102
NC 606	67	65	96
CC 1063	53	52	97
NC 938	51	51	100
CC 143	46	48	105
K 346	85	46	93
GL 26H	42	45	108
GL 395	45	42	94
GF 318	41	42	101
CC 13	42	42	100
NC 925	42	42	99
CC 33	41	39	95
CC 145[4]	35	32	90
K 326	24	25	105
CC 35	12	14	116

[1] Varieties with the *Php* gene possess very high resistance to race 0 of the black shank pathogen. Resistance to race 0 in varieties without the *Php* gene is similar to or higher than that to race 1.

[2] Average % Survival without a soil fungicide from 3 years of field testing by North Carolina State University. Source: 2020 Tobacco Production Guide, Managing Diseases, Table 8.3.

[3] Relative Yield Index = yield of each cultivar relative to the yield of all other cultivars in the experiment(s). Yield indexes for "No Granville Wilt" = average relative yield from the 2015-2020 Virginia OVT tests at the Southern Piedmont AREC, Blackstone. Yield indexes for "with Granville Wilt" = yield index without Granville wilt multiplied by average % Survival.

[4] *Ratings based on limited data available.*

Except for the new cultivar CC 145, all flue-cured tobacco cultivars currently being grown are resistant to races 1 and 3 of the southern root-knot nematode (*Meloidogyne incognita*). However, the peanut root-knot nematode (*M. arenaria*), races 2 and 4 of the southern root-knot nematode, and the Javanese root-knot nematode (*M. javanica*) are also now common in Virginia. The Guava root-knot nematode (*M. enterolobii*) is also currently spreading in a number of nearby states, including North Carolina. *Any galling on a "root-knot resistant" flue-cured tobacco cultivar indicates the presence of at least one of these other types of root-knot.* Flue-cured tobacco cultivars CC 13, CC 33, CC 35, and CC 37 are resistant to *M. arenaria* and *M. javanica* in addition to races 1 and 3 of *M. incognita*, and should significantly improve control of these species of root-knot nematodes (Table 9). However, no currently-grown tobacco cultivars possess resistance to *M. enterolobii*. Rotating tobacco with "non-host" crops will also reduce root-knot nematode populations (see Table 1), but forage legumes, such as clover, are often good hosts for root-knot. Sweet potato is a good host for *M. enterolobii*, so rotating flue-cured tobacco with sweet potato significantly increases the risk of that new nematode gaining a foothold or increasing in Virginia. Rotation intervals should be increased for as long as possible. Virginia growers should also be particularly careful when purchasing farm equipment and sweet potato planting stock from the Carolinas to avoid introducing this new and very damaging nematode into Virginia. Using an effective soil nematicide is advisable when crop rotation and resistant varieties aren't practical and preplant root-knot populations are high (Table 13). At this time, a maximum rate of Telone II is the only recommended nematicide treatment for fields where *M. enterolobii* has been detected.

Table 8. Interpreting Root-Knot Nematode infestation levels

Risk of Crop Loss	% Roots Galled	Nematodes/500 cc of soil: Fall Sample	Nematodes/500 cc of soil: Spring Sample	Control Options
Very Low	1 to 10	1 to 200	1 to 20	Practice crop rotation and/or plant a resistant variety
Low	11 to 25	201 to 1,000	21 to 100	Use crop rotation in combination with a resistant variety and/or a nematicide
Moderate	26 to 50	1,001 to 3,000	101 to 300	Increase rotation interval. Also use 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 with a nematicide rated 'E'

Significant crop stunting and relatively high populations of lesion or meadow nematodes (*Pratylenchus* species) seem increasingly common in flue-cured tobacco fields in Virginia. However, not all lesion nematode species damage tobacco, and nematode assay results aren't currently able to differentiate those species from others that don't parasitize tobacco. Rotation crops that reduce root-knot and tobacco cyst nematodes aren't necessarily effective for lesion nematodes, although a single year of forage or grain pearl millet can be highly effective. No resistance to lesion nematodes is available in tobacco varieties. Applying a tobacco nematicide for lesion nematode control may be profitable when: 1- significant stunting or crop weakness has already been observed, and 2- a soil nematode assay detects as few as 50-100 lesion nematodes/500 cc of soil.

Tomato spotted wilt virus (TSWV) is spread by various species of thrips usually within the first few weeks after transplanting. Greenhouse application of an appropriate systemic insecticide can significantly reduce damage caused by TSWV.

Tobacco mosaic virus (TMV) can be spread by contaminated clipping mowers in the greenhouse, from tobacco roots and stalks remaining in soil from previous crops, from weed hosts such as horsenettle and ground cherry, from contaminated objects and surfaces (trays, sheets, etc.), and from manufactured tobacco products. Workers should wash their hands regularly during planting. Rogueing infected plants before layby will reduce virus spread within a field. However, tobacco mosaic can't be eliminated from

infested fields without crop rotation and early destruction of roots and stalks. Mosaic resistant varieties can reduce damage and may help eliminate residual virus in infested fields. *Varieties such as CC 27, CC 37, CC 67, GL 26H, NC 297, PVH 2254, PVH 2275 or PVH 2310 may be appropriate for fields with a history of 30 to 50 percent of the plants infected with mosaic before topping. If a TMV-resistant variety is planted, the entire field should be planted to the resistant variety* to avoid significant plant injury.

Target Spot, Frogeye, and Blue Mold can be significant problems for tobacco producers in Virginia. Quadris is registered for target spot control in both the greenhouse and field (Tables 3 and 10), but only one spray is allowed in the greenhouse. If applied shortly after the 1st clipping, this spray should provide good disease control for at least 3 to 4 weeks. Target spot can also reach damaging levels in the field as topping time nears. Timely harvest of lower leaves often reduces leaf diseases by increasing air flow in fields, allowing upper leaves to dry-out, but in wet weather leaf diseases can continue to get worse through the harvest period. Fungicide sprays can help minimize leaf spots through these conditions, but continued sequential use of

Table 9. Tobacco disease resistance in selected flue-cured tobacco varieties available in 2021.

	Resistance Rating						
				Nematodes			
	Black Shank[1]			Root-Knot			
Variety	*Ph*$_p$ gene (race 0 only)[2]	Race 1	Granville Wilt[1]	*M. incognita*	Other species[3]	Tobacco Cyst	Tobacco Mosaic Virus
CC 13	-	57	42	+	+	-	-
CC 27	+	39	49	+	-	+	+
CC 33	-	71	41	+	+	-	-
CC 35	-	82	12	+	+	-	-
CC 37	+	39	67	+	+	+	+
CC 67	+	60	53	+	-	+	+
CC 143	-	56	46	+	-	-	-
CC 145[4]	-	91	35	-	-	-	-
CC 700	+	67	36	+	-	+	-
CC 1063	-	92	53	+	-	-	-
GF 318	+	60	41	+	-	+	-
GL 26H	-	53	42	+	-	-	+
GL 386[4]		94	78	+	-	-	-
GL 395	-	67	45	+	-	-	-
K 326	-	37	24	+	-	-	-
K 346	-	85	49	+	-	-	-
NC 196	+	73	40	+	-	+	-
NC 297	+	37	55	+	-	+	+
NC 299	+	47	46	+	-	+	-
NC 606	-	77	67	+	-	-	-
NC 925	-	92	42	+	-	-	-
NC 938	-	87	51	+	-	-	-
NC 1226[4]	+	99	12	+	-	+	-
PVH 1452	+	66	53	+	-	+	-
PVH 2310	+	30	37	+	-	+	-

[1] Resistance rating = "% Survival", the average % plants still alive near 2nd or 3rd harvest, without a soil fungicide or fumigant. See Tables 4-7 for more detailed information.
[2] Varieties with the *Ph*$_p$ gene are almost immune to race 0 of the black shank pathogen; resistance to race 0 without the *Ph*$_p$ gene is at least as high as resistance to race 1.
[3] "Other species" include *Meloidogyne arenaria* or *M. javanica*, which are now common in Virginia. All flue-cured tobacco varieties are thought to be susceptible to the guava root-knot nematode (*M. enterolobii)*, but this nematode has not been detected in Virginia.

[4] *Ratings based on limited data available.*

similar fungicide chemistries (FRAC groups) can lead to fungicide insensitivity within the target pathogens. Unfortunately, ***insensitivity to azoxystrobin (the active ingredient in Quadris) has been detected in tobacco leaf spot pathogens in both Kentucky and North Carolina every year since 2017. Similar fungicide insensitivity in Virginia populations of these pathogens is likely.*** Tobacco producers have no similarly effective fungicide alternative to Quadris for target spot and frogeye leaf spot control. Because these pathogens may develop increased insensitivity if Quadris is applied "back-to-back**", *growers are strongly encouraged to alternate application of Quadris with other foliar fungicides registered for use on tobacco*** in order to slow the spread of Quadris-resistant populations of the target spot and frogeye pathogens. Multiple fungicides are available for blue mold control and are listed in Tables 3, 11 and 12 of this chapter.

APPLICATION METHODS

Pesticide performance and safety is dependent on use of proper application methods. Proper pesticide use depends upon correct diagnosis of the problem, a clear understanding of the pesticide label, proper calibration of application equipment, and strict adherence to label directions and all federal, state and local pesticide laws and regulations.

Preplant Incorporated (Preplant) - Refer to section under weed control.

Foliar Spray (FS) – **Greenhouse applications** should not begin until seedlings are at least the size of a dime, but if repeated, should be applied at 5-7 day intervals up to transplanting. Use flat-fan, extended range tips at approximately 40 psi to maximize results. **Field sprays targeting the soil surface** should be applied using spray tips that evenly distribute the spray solution at spray volumes between 25 and 40 gallons per acre. **Field sprays for leaf diseases** should generally be applied using tips that apply a fine spray in 20-100 gallons per acre at 40-100 psi to maximize coverage as plants increase in size. Use of drop nozzles should significantly improve disease control after layby by improving spray coverage on bottom leaves, where foliar diseases are usually concentrated.

Fumigation: - Fumigant Management Plans (FMPs) are required for use of soil fumigants containing chloropicrin or metam sodium. Tobacco producers who plan to fumigate soil need to familiarize themselves with all requirements involved with use of the specific product they plan to use. These requirements are detailed in the extensive labels for all soil fumigants.**Precautionary and Restriction Statements** - Read and follow all directions, cautions, precautions, restrictions, and special precautions on

each product label. Take labels seriously. This publication must not be used as the only source of precautionary and restriction statements.

Table 10. FIELD DISEASES OF TOBACCO: ROOT AND STEM DISEASES

			Disease[2]	
Product	Rate/A	Application Method[1]	Black Shank	Granville wilt
Orondis Gold 200[3] + Ridomil Gold SL	4.8 fl oz + 6-8 fl oz	TPW	E	---
Orondis Gold Premix[3]	24-28 fl oz	TPW	E	---
Presidio[4]	4.0 fl oz	1st cultivation or layby	VG	---
Ridomil Gold SL	1 pt + 1 pt	PPI + layby	VG	---
Ultra Flourish	2 pt + 2 pt	PPI + layby	VG	---
MetaStar 2E AG	4 pt + 4 pt	PPI + layby	VG	---
Ridomil Gold SL	4-8 fl oz + 1.0 pt	TPW[5] + 1st cultivation and/or layby	VG	---
Ridomil Gold SL	1 pt + 1 pt	1st cultivation + layby	VG	---
Ultra Flourish	2 pt + 2 pt	1st cultivation + layby	VG	---
MetaStar 2E AG	4 pt + 4 pt	1st cultivation + layby	VG	---
Ridomil Gold SL	1 pt + 1 pt + 1 pt	PPI + 1st cultivation + layby	VG	---
Ultra Flourish	2 pt + 2 pt + 2 pt	PPI + 1st cultivation + layby	VG	---
MetaStar 2E AG	4 pt + 4 pt + 4 pt	PPI + 1st cultivation + layby	VG	---
Ridomil Gold SL	1-3 pt	PPI	F	---
Ultra Flourish	2-6 pt	PPI	F	---
MetaStar 2E AG	4-12 pt	PPI	F	---
Telone C-17	10.5 gal	F-Row	P-F[5]	G
Chlor-O-Pic	3 gal	F-Row	P-F[5]	G
Chloropicrin 100	3 gal	F-Row	P-F[5]	G
Pic Plus	4 gal	F-Row	P-F[5]	G

[1]PPI – broadcast, preplant-incorporated spray; TPW – addition of fungicide to water applied to furrow during transplanting; 1st cultivation – broadcast spray just *before* 1st cultivation; layby – broadcast spray just *before* layby; F-Row – inject 8 inches deep in row with single shank in center of row. Do not apply more than 3 pt of Ridomil Gold or Orondis Gold B; 6 pt of Ultra Flourish; 12 pt of Meta Star 2E AG; 9.6 fl oz Orondis Gold 200 or 27.8 fl oz Orondis Gold Premix; or 8 fl oz Presidio per acre per season.

[2]Control rating – F=fair; G=good; VG=very good; E = Excellent. (-) – No disease control or not labeled for this disease.

[3]Apply in at least 100-200 gallons of transplant water (TPW) per acre, followed by at least 1 subsequent fungicide application for black shank control using a non-FRAC 49 product. There is a risk of temporary plant injury from TPW application at lower rates of water per acre; pre-mixing the soil fungicide in a TPW nurse or source tank helps reduce risk of plant injury. Use higher rate for heavier soils or more susceptible varieties. Do not follow soil use with foliar sprays of any FRAC 49-containing product.

[4]Apply Presidio as a field spray after use of a different fungicide at or near transplanting. Presidio may be applied at 1st cultivation or layby, but not both.

[5]Apply in at least 100-200 gallons of transplant water (TPW) per acre, followed by at least 1 subsequent fungicide application for black shank control using a non-FRAC 4 product. . Use higher rates for heavier soils or more susceptible varieties.

[5]Fumigants will not control black shank without use of a soil fungicide, but may further improve control from application(s) of a black shank fungicide.

Table 11. FIELD DISEASES OF TOBACCO: TARGET SPOT, FROGEYE, etc

Disease	Material	Rate	Application Method[1]
Target Spot (*Thanatephorus cucumeris*); **Frogeye** (*Cercospora nicotianae*); **Blue mold** (*Peronospora tabacina*).	Quadris	6-12 fl. oz.	Foliar Spray
Remarks: First application for blue mold should be made at first indication of disease in the area; for target spot, spray at or soon after layby. Spray in sufficient water volume for complete coverage and canopy penetration. Research indicates 8-9 fl. oz/ Quadris/A usually provides optimal target spot control. Don't spray Quadris "back-to-back" but alternate with another fungicide from a different FRAC group. *Quadris now has a 21-day pre-harvest interval (PHI).* These restrictions will limit the maximum number of Quadris sprays to 2-3/field growing season. May enhance weather flecking; tank-mixing with EC pesticides or those containing high amounts of solvents may increase that effect.			
Target Spot (*Thanatephorus cucumeris*); **Blue mold** *Peronospora tabacina*); **Anthracnose** (*Colletotrichum gloeosporioides*)	Penncozeb 75 DF	1.5-2.0 lb/100 gal water	Foliar Spray
Remarks: Begin sprays when conditions favor disease and continue on a 5-7 day interval until the threat of disease subsides. Penncozeb shouldn't be applied within 6 weeks of first harvest to avoid excessive leaf residues. *Some tobacco companies may not purchase leaf treated with mancozeb fungicides like Penncozeb*.			

[1]Apply at 40-100 psi in 20 gal of water up to layby and up to 100 gal of water near topping. Higher spray volumes are important in maximizing coverage, which is important in achieving desired disease control. Use hollow-cone nozzles (TX12, etc.) Use of drop nozzles after layby stage should increase coverage on lower leaves where disease starts and is often concentrated.

Table 12. FIELD DISEASES OF TOBACCO: BLUE MOLD

Disease	Material	Rate	Application Method[2]
Blue mold *(Peronospora tabacina)*	Revus	8.0 fl.oz/A[1]	
Remarks: Foliar spray; begin application before disease develops and continue on a 7-10 day interval. Switch a non-FRAC Group 40 fungicide after 2 consecutive sprays. May be tank-mixed with an effective blue mold fungicide with a different mode of action. Use sufficient spray volume to provide thorough coverage. Adding a spreading/penetrating surfactant (non-ionic) may improve results.			
Blue mold *Peronospora tabacina*)	Forum + Penncozeb 75 DF	7.0 fl oz + 2.0 lb/100 gal water[1]	Foliar Spray
Remarks: Begin sprays when conditions favor disease and continue on a 5-7 day interval until the threat of disease subsides. Do not exceed 8 fl.oz./A of Forum per application or 30 fl.oz./A per season. Penncozeb shouldn't be applied within 6 weeks of first harvest to avoid excessive leaf residues. *Some tobacco companies may not purchase leaf treated with mancozeb fungicides like Penncozeb.*			
Blue mold *Peronospora tabacina*)	Orondis Ultra A + Orondis Ultra B	2.0 - 4.8 fl oz + 2.0 - 4.8 fl oz/100 gal water[1]	Foliar Spray
Remarks: Begin sprays when conditions favor disease and continue on a 7-10 day interval until the threat of disease subsides. Do not exceed 19.2 fl.oz./A per season. Do not follow soil use of Orondis with foliar sprays. Make no more than 2 sequential applications before rotating to a different fungicide to avoid fungicide resistance.			
Blue mold *Peronospora tabacina*)	Ridomil Gold EC Ultra Flourish MetaStar 2E AG	0.5-1 pt + 0.5 pt/A[1] 1-2 pt + 1 pt/A[1] 2-4 pt + 2pt[1]	Preplant + Layby
Remarks: Strains of the blue mold pathogen are often insensitive to mefenoxam, but mefenoxam may control sensitive strains early in the season, as well as *Pythium* damping-off. Read precautionary and rotation crop restrictions.			
Blue mold *Peronospora tabacina*)	Aliette	2.5-4.0 lb/A[1]	Foliar
Remarks: No more than 5 sprays allowed, 3 day pre-harvest interval; don't tank-mix.			
Blue mold *Peronospora tabacina*);**Tomato Spotted Wilt Virus** (TSWV)	Actigard 50WP	0.5 oz/20 gal/A	Foliar
Remarks: Begin applications when blue mold disease threatens and plants are at least 12 inches tall. Up to 3 sprays may be applied on a 10-day schedule. Treated plants require 3-5 days to fully respond to each application. TSWV sprays beginning within 7 days of transplanting or whenever plants have recovered from transplant shock may also be used to follow-up on greenhouse application of Actigard for TSWV control.			

[1]Use higher rates when disease is already present, for longer application intervals, or for more susceptible varieties. Mix 20-30 gal/A of spray solution for sprays during the first several weeks after transplanting; gradually increase spray volume to 40 gal/A by layby and 80-100 gal/A on tobacco ready to be topped.

[2]Foliar spray - apply at 40-100 psi in 20 to 100 gal of water. The amount of water depends on size of plant. Use hollow-cone nozzles (TX12, etc.) Use drop nozzles to apply fungicide to both the top and bottom leaves. Preplant + layby - first application preplant followed by a second spray just before last cultivation.

Table 13. TOBACCO NEMATICIDES

		Nematodes[1]			
		Root Knot			
Product	Rate/A, Application Method[3]	Meloidogyne incognita, arenaria, javanica	M. enterolobii[2]	Tobacco Cyst	Lesion Nematodes
Fumigants					
Chlor-O-Pic	3-4 gal	E	P-F	G	E
42% Metam products	25 gal	?	?	G	?
Pic Plus	4.2 gal	E	P-F	G	E
Telone II	6 gal	E	P-F	F	E
Telone II	9-10 gal	E	G	VG	E
Non-Fumigants					
Nimitz[4]	3.5-7.0 pt/, PPI	F-G	P-F	F-G	F
Velum Prime	6.5-6.87 fl oz, TPW	F-G	P-F	F-G	F

[1] Control ratings: E=Excellent; VG=Very Good; G=Good; F=Fair; P=Poor; ? = insufficient data available to provide reliable evaluation; (---) =no control or not labeled. Use higher rates for higher nematode populations or for heavier soils.

[2] Tentative ratings based on North Carolina State University ratings for *M. enterolobii* control.

[3] Soil fumigant rates assume injection 8 inches deep through a single shank in each row - 21-day waiting period before planting. PPI= before planting, apply broadcast in 40 gal/A, use at least 20 gal/A if applied in an 18-24 inch-wide band; incorporate 4-6 inches deep as soon as possible; TPW= transplant water application.

[4]Nimitz should be applied in a band over the center of preformed beds and incorporated at least 7 days before transplanting. Product label rates are expressed per ***treated acre*** (not planted acre).

[5]Do not apply more than 13.7 fl oz of Velum Prime (0.446 lbs fluopyram) per acre per year, regardless of formulation or method of application. Pre-harvest interval = 30 days. To limit potential development of pest resistance to fluopyram, the first foliar fungicide spray after use of Velum Prime should involve a product from a FRAC Group other than FRAC 7.

DISEASES OF TOBACCO

There Are No Chemical Controls For the Following Diseases

Disease	Remarks
Botrytis Blight (*Botrytis cinerea*)	A wet rot is often first observed on stems or leaves. A gray, downy material may be present on the surface of diseased areas. In the greenhouse, reducing surface moisture on leaves and stems by correct watering and improved ventilation, and collecting and removing loose-leaf material from clipping, will help reduce damage. "Greenhouse management practices effective for collar rot and target spot also help reduce incidence and severity of Botrytis blight. Occurrence of this disease is extremely rare in the field, but when observed, was associated with topping plants very late in very wet weather."
Brown Spot (*Alternaria alternata*)	Can be severe on mature tobacco, especially during periods of high humidity. Avoid leaving mature leaves in the field. Good sucker control also helps reduce disease incidence.
Collar Rot (*Sclerotinia sclerotiorum*)	Symptoms 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. Improving ventilation, reducing excess moisture, proper clipping procedures, and controlling target spot may help reduce disease.
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 drainage and fertilization can be beneficial. Do not plant in alkaline soils and avoid heavy applications 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/or air pollution. Hot humid days followed by heavy rains increase severity of problem.