TOBACCO DISEASE MANAGEMENT

Bruce Fortnum

Tobacco diseases accounted for an estimated loss of $2 million in 2005 to South Carolina farmers (see chart below)! Disease losses were lower in 2005 than the previous year. Bacterial wilt continues to be our major disease in South Carolina. The widespread losses and disease patterns within affected fields strongly suggest the bacterium was moved during mechanical topping and/or leaf removal. The higher than normal rainfall in some areas resulted in plants that were more susceptible to bacterial wilt and more readily infected by contact with contaminated machinery!

The introduction of newer varieties with improved black shank resistance has reduced losses to black shank in spite of weather that was favorable for disease development in 2005. As farmers adopt new high yielding varieties such as NC 71, NC 72, Speight 168, and NC 297 with high black shank resistance reduced losses to black shank may continue. However, bacterial wilt, the new race 1 of black shank and root-knot nematodes, all soil borne diseases, can still cause significant losses and highlights the necessity of crop rotation and use of varieties with disease resistance.

Tomato spotted wilt (TSW) losses were greater in 2005 than 2004. Disease losses were especially severe in the southern portion of our tobacco production where some fields experienced stand reduction approaching 75%. These severe losses alert us to the potential of TSW to cause severe crop loss. Losses to TSW will most likely be severe in the future if the weather is favorable for the thips vector, virus transmission and disease expression. Sporadic epidemics of TSW have occurred in Georgia and will most likely occur in South Carolina's tobacco in the future.

TOBACCO DISEASE LOSSES 2000-2003

DISEASE	2002		2003		2004		2005	
	%	$(000)	%	$(000)	%	$(000)	%	$(000)
Bacterial wilt	1.38	1,805	0.93	1,215	3.5	3,850	1.47	932
Black Shank	0.72	941	0.37	484	0.79	869	0.8	508
Nematodes	0.06	81	0.19	248	0.34	374	0.11	70
Mosaic	0.005	7	0.001	1.3	0.001	1.1	0.05	31
Fusarium Wilt	0.0003	0.4	0.001	1.3	0.001	1.1	0	0
Brown Spot	0.0003	0.4	0.001	1.3	0.001	1.1	0.001	0.6
Angular Leaf Spot	0	0	0	0	0	0	0	0
PVY	0.001	1.9	0.15	196	0.01	11	0.001	0.6
Etch	---	---	0.15	196	0.01	11	0	0
Blue Mold	0	0	0	0	0	0	0	0
TSW	8.56	11,134	0.16	209	0.21	231	0.49	310
Target spot	0	0	0	0	0	0	0.33	209
All Others	0.006	8	0.06	78	1.54	1,694	.02	12
TOTALS	10.75	13,981	2.04	2,629	6.41	7,051	3.27	2,073

Endemic diseases such as black shank, bacterial wilt and root-knot nematodes always cause significant disease losses in South Carolina (2002-2005). These important and potentially devastating diseases of tobacco can best be managed through a combination of control methods. It is urged that **growers identify disease problems in their fields** and follow disease management suggestions based on **rotation, variety selection, sanitation and chemical treatments**. A sound disease management strategy cannot be developed without the proper identification of the disease problems in your fields. **Disease development is a dynamic process and can change over time. Low disease losses in your fields in the recent past does not assure disease losses will remain low!** New varieties with high resistance to black shank need to be monitored for the development of new strains of the pathogen. Your disease control program should be based on the assumption that changes in pathogen populations and disease pressures will occur. Changes in the tobacco program has made crop productivity and leaf quality essential for economic success. Good disease control will be the cornerstone of a successful farm operation.

Incidence of Disease (% of acres affected)

Disease	2002	2003	2004	2005
Bacterial wilt	22	15	31	13
Black Shank	12	9	12	13
Nematodes	12	14	9	6
Mosaic	0.5	0.5	0.5	2
Fusarium Wilt	0.1	.08	.01	0
Etch	16	9	6	0.4
PVY	7	6	7	0
Blue Mold	0	0	0	0
Target Spot	0	0	0	8
Tomato Spotted Wilt	69	6	22	51

DISEASE MANAGEMENT STRATEGY IN A POST-PROGRAM ERA

Disease losses affect tobacco yields, quality and profitability. Disease control options can be expensive to use and costly especially if the wrong control option is chosen. Great care needs to be exercised to assure a return on your control investment.

Rotation: The best defense against most diseases and the least expensive is a good, well-planned rotation. However, the diseases must be correctly identified within particular fields to develop a sound rotation plan. Any rotation is better than no rotation, but certain crops will do a better job of suppressing certain diseases. While some growers take a chance and do not rotate, sooner or later they will get caught with unexpected losses. Some diseases, such as bacterial wilt or black shank, may destroy entire fields! Also, some diseases such as mosaic and nematodes may be causing more damage than realized through observation because the plant may not completely die. Losses to these diseases are easily masked in a year in which rainfall was plentiful. Although difficult to see, these losses substantially reduce farm income! Losses to the three major diseases in South Carolina, that consistently reduce yields from year to year,

can be reduced through a planned rotation program. Study the results of on-farm rotation studies for particular diseases in the following pages.

Host Resistance: Selection of resistant varieties provides a highly effective and inexpensive method of reducing losses to disease. Varieties differ in resistance to black shank, bacterial wilt, tobacco mosaic, Fusarium wilt and root-knot nematodes, so any one variety will not be the best choice in all fields. Study the disease ratings (see tobacco variety test under the Tobacco Production Section) and agronomic characteristics of varieties and select varieties resistant to disease causing organisms found in your fields. Proper identification and record of disease pressure is the key to successful variety selection. Study the results of on-farm variety trials for diseases found on your farm.

Chemical Treatments: Selection of chemical treatments should be your **LAST CONSIDERATION** in a disease control strategy. Rotation, variety selection and proper sanitation reduce populations of pathogenic organisms to levels that can be controlled by chemical applications. Choose your chemicals to match the disease pressure in your fields. Study the results of on-farm chemical studies for particular diseases in the following pages.

BACTERIAL WILT CONTROL

Bacterial wilt is the most serious of the soil borne diseases of tobacco in South Carolina. It is very difficult to manage. The disease is concentrated in the eastern-most counties in the Pee Dee Region, but is present and increasing in severity in other important tobacco-producing counties.

Symptoms of bacterial wilt appear first as a wilt of leaves on one side of the plant. Eventually, the entire plant wilts, and infected plants usually die. Stalks appear dark brown or black at the ground level and look very much like black shank. However, bacterial wilt-infected plants have black streaks in the tissue just under the outer bark. Portions of lower stalk tissue will ooze milky strands of bacteria when placed in a clear container of water.

Bacterial wilt is a disease that is caused by a bacterium (*Ralstonia solanacearum*), which lives in the soil. These bacteria cause disease when they infect the roots through wounds. Any type of root wounding provides an entry point for infection. Therefore, shallow cultivation will help to avoid wounding roots, which provide points for infection. Natural wounds occur in the root system as a result of root growth through the soil; therefore, a certain amount of natural infection can take place, if the bacterial population is high enough in the soil around the root system.

The bacterium that causes bacterial wilt also infects a number of other crop plants, such as tomatoes, potatoes, peppers, eggplant and peanuts. Ragweed is a very common weed that is a host for the bacterium. Therefore, it is very important to recognize and control this weed thoroughly in areas planned for tobacco. The bacteria are very persistent in soil, and long rotations (three years or longer) may be necessary in some fields to assist in managing the disease. ***Rotation is imperative for management***. Multipurpose chemicals (Telone C-17 and Chlor-O-Pic) also assist in control. Several new varieties with high resistance are available, which also assist in control. New and older varieties with fairly high resistance include K-149, Ox 207, K-346, GL 350, NC 810, and SP 168, SP 179, SP 210, SP 220 (see tobacco variety test). *Bacterial wilt **MUST** be managed by a combination of rotation, variety selection, and possible use of multipurpose chemicals.* Other helpful practices include root and stalk destruction, enhanced soil drainage (utilize a high wide bed) and early shallow cultivation to avoid root wounding. It is also VERY IMPORTANT to avoid spread of bacterial wilt by movement of infested soil on farm equipment or by other means. The following tables show results of recent on-farm tests utilizing rotation, varieties and multipurpose chemicals for control of bacterial wilt.

EFFECT OF ROTATION ON BACTERIAL WILT

VARIETY	ROTATION	% WILTED PLANTS
K 326	Tob-Tob	36
	Corn-Tob	20
	Soybean-Tob	25
K 149	Tob-Tob	19
	Corn-Tob	10
	Soybean-Tob	6

EFFECT OF VARIETIES AND NEMATICIDES ON BACTERIAL WILT

VARIETY	NEMATICIDE	YIELD (LB/A)	$/A	% DISEASED PLANTS
K-346	Nemacur (2 gpa)	2,000	3,240	16
	Telone C17 (10.5 gpa)	2,246	3,639	16
	C-O-P (3 gpa)	1,832	2,968	14
K-149	Nemacur (2 gpa)	2,144	3,473	15
	Telone C17 (10.5 gpa)	2,304	3,732	11
	C-O-P (3 gpa)	2,472	4,005	12
Sp-117	Nemacur (2 gpa)	1,680	2,722	24
	Telone C17 (10.5 gpa)	2,312	3,745	14
	C-O-P (3 gpa)	2,192	3,551	17
K-326	Nemacur (2 gpa)	1,768	2,864	29
	Telone C17 (10.5 gpa)	2,088	3,383	32
	C-O-P (3 gpa)	2,269	3,676	29
Average across varieties	Nemacur (2 gpa)	1,898	3,074	21
	Telone C17 (10.5 gpa)	2,237	3,624	18
	C-O-P (3 gpa)	2,191	3,550	18

Multipurpose fumigants require a waiting period of up to 3 weeks. Spring rains can frequently interfere with the application of multi-purpose fumigants. Late fall or early spring fumigation provides the producer with a greater period of time to apply fumigants and reduces the risk of crop injury. However, weed growth can occur on a formed bed with a standard in-row application applied in late fall or early spring. In addition, application of herbicides and soil-applied insecticides to a formed bed is difficult. Broadcast application of multipurpose fumigants allows the producer to apply soil applied insecticides and herbicides, following the waiting period, as a commonly applied preplant broadcast incorporated treatment. The following table is a comparison of in-row and broadcast application of a multipurpose fumigant for control of bacterial wilt.

BROADCAST AND IN-ROW FUMIGATION FOR BACTERIAL WILT CONTROL

TREATMENT	YIELD (LB/A)		$/A	
	K326	K149	K326	K149
Broadcast				
10 gpa Telone C 17	1,518	1,824	2460	2955
12 gpa Telone C 17	1,878	1986	3042	3217
14 gpa Telone C 17	1,878	1962	3042	3178
16 gpa Telone C 17	1,854	2058	3003	3334
20 gpa Telone C 17	2,160	2202	3499	3567
In-row				
10.5 gpa Telone C 17	1,374	1734	2225	2809
No Treatment	930	1182	1506	1915

Averages of four trials conducted at the Pee Dee REC.

Mechanical Spread of Bacterial Wilt

It is generally believed that infection of tobacco in the field occurs through the root system. The rapid spread of bacterial wilt within South Carolina suggests that the organism is being spread in a more rapid and efficient manner that would be expected solely by the movement of soil on equipment. County agents in South Carolina have observed an increase of hollow stalk. Hollow stalk is a disease normally caused by an Erwinia soft rot bacterium. The use of new diagnostic procedures at Clemson University have allowed use to identify bacteria to species and many of the cases of hollow stalk have been identified as *Ralstonia solanacearum*, the causal organism of bacterial wilt of tobacco. If inoculated onto a cut tobacco stalk, *Ralstonia solanacearum* will invade the plant and produce symptoms very similar to hollow stalk disease.

Field trials conducted at the Pee Dee REC and on farm have shown that the bacterium can be spread very easily during mechanical topping and harvesting. If the topper was driven through infected tobacco the mechanical topper transmitted the pathogen easily to health tobacco. **A 3-4 week delay was observed before symptoms appeared.** The only effective method of removing the bacterium from the cutter blades was steam or a 50% Clorox solution. Further work is underway to define the role of mechanical topping, harvesting and stalk destruction on disease spread and to develop sanitation procedures to limit the spread of this devastating pathogen on machinery.

SPREAD OF BACTERIAL WILT ON MECHANICAL TOPPERS

TREATMENT	PERCENT DISEASE			
	K 326		K 346	
	1999	2000	1999	2000
Hand topped	54	14	24	6
Machine topped	83	25	67	14

Mechanical topping was conducted on-farm by producer with no intentional contamination of the mechanical topper. Test conducted in Horry Co.

MODIFIED TOPPER BLADE DESIGNED TO REDUCE THE MECHANICAL TRANSMISSION OF BACTERIAL WILT

Treatment	Modified topper blade	Bacterial Wilt Stem Necrosis	
		K 326	K 346
Control	-	5	4.4
Disinfectant 50% strength	+	1.6	1.2
Disinfectant 100% strength	+	1.1	0.2
Hand topped	-	1.5	0.3

Necrosis rated on a 0 to 5 scale where: 5 = 100% dead
A label will be sought for use of the disinfectant on tobacco in 2006, a limited number of topper blades will be marketed in 2006.

SPREAD OF BACTERIAL WILT ON HARVESTING EQUIPMENT

TREATMENT	% DISEASE	STEM NECROSIS*
Hand harvested	48	4.6
Machine-mild stem bruising	65	7.8
Machine-severe stem bruising	83	7.0

*Necrosis rated on a 0-10 scale (Pee Dee REC)

The bacterium that causes bacterial wilt (*Ralstonia solanacearum*) was recovered on 60% of the mechanical harvesters surveyed in Horry County!

BEST MANAGEMENT SYSTEM FOR CONTROL OF BACTERIAL WILT

The following points should be considered to help control mechanical transmission of bacterial wilt:

The following points should be considered to help control mechanical transmission of bacterial wilt:

1. Crop rotation to include soybeans
2. Use of host resistance
3. Multipurpose soil fumigation
4. Hand topping or prioritize order of topping, and harvesting (**healthy tobacco first**).
5. Eliminate or reduce stalk wounding at harvest. Keep harvesters clean and properly adjusted to **avoid stem injury** and operate mechanical harvesters at the proper speed.
6. Use Roundup to kill stalks or immediate stalk destruction following last harvest
7. Maintain proper drainage in field
8. Use of a winter cover crop

USE OF BEST MANAGEMENT TO REDUCE BACTERIAL WILT OF TOBACCO

Management	C-17	Variety	% Disease	Yield 2004	Yield - 2005 tobacco following tobacco	Yield - 2005 following a soybean rotation
Standard Management	-	K 326	68	966	1126	2106
Standard Management	+	K 326	21	1647	1432	2408
Standard Management	-	Ox 207	26	1777	1618	2472
Standard Management	+	Ox 207	5	2377	1751	3118
Best Management	-	K 326	38	1841	918	2554
Best Management	+	K 326	6	2473	1482	3710
Best Management	-	Ox 207	10	2487	1288	2818
Best Management	+	Ox 207	2	2640	2276	3801

Standard Management = mechanical topping and leaf removal
Best Management = hand topping and reduced stem abrasion at harvest

BLACK SHANK CONTROL

Black shank can cause significant losses in South Carolina tobacco. Black shank is caused by a fungus (*Phytophthora parasitica* var. *nicotianae*), which lives in the soil and attacks the plant primarily through the roots. Wounds are not required for infection by the black shank fungus. **High soil moisture favors root colonization by the black shank fungus**, although effects of early season infections become most apparent when soil moisture becomes limited. Sustaining high disease losses from black shank is tragic, because we know that rotation is very effective in reducing levels of the fungus in the soil. Any rotation is effective to some degree, because tobacco is the only host of the black shank fungus. The longer the rotation, the more effective the control. Therefore, rotation is the backbone of a successful control strategy, which also should utilize resistant varieties, chemicals and cultural practices.

BLACK SHANK CONTROL OPTIONS

FIELD INFESTATION LEVEL	ROTATION	VARIETAL RESISTANCE OPTIONS	CHEMICAL CONTROL
High (More than 6% disease)	1) 4 year	Moderate to high	Nematicide
	2) 3 year	High only	Multipurpose or Ridomil + Nematicide
	3) 2 year	High only	Ridomil + Nematicide
Moderate (1% - 6% disease)	1) 3 year	Low to High	Nematicide
	2) 2 year	High only	Multipurpose or Ridomil + Nematicide
	3) None*	High only	Ridomil + Nematicide
Low (Less than 1% disease)	1) 2 year	Low to high	Nematicide
	2) None*	High only	Multipurpose or Ridomil + Nematicide

*NOTE: **Continuous culture (tobacco following tobacco) is not recommended**. However, if this cropping system is chosen, use only varieties with high resistance and a black shank control chemical. Do NOT consider continuous culture if the infestation level is greater than 6% of the plants having black shank. Continuous use of new varieties with high resistance (NC 71 and NC 72) without crop rotation may lead to the development of new strains of the pathogen reducing the effectiveness of the newer resistant cultivars. **Numerous fields have been observed with race 1 of black shank, which causes disease on NC 71 and NC 72.** In addition, continuous use of new varieties with high resistance to black shank (such as NC 71) without crop rotation may lead to losses from other diseases such as Fusarium wilt (see disease resistance ratings). **Tobacco following tobacco is not recommended regardless of the level of resistance in the newer tobacco varieties!** Ridomil Gold can be used at layby at the rate of 0.5 OR one pt/A if no more than one pint was applied preplant. Ridomil Gold can be applied up to 1.5 qt/A if applied 1 pt preplant plus 0.5-1 pt/A at first cultivation followed by 0.5-1 pt/A at layby.

Varieties with very high to high resistance to race 0 of black shank include: Coker 371-Gold, GL 350, NC 71, NC 72, NC 291, NC 810, Sp 168, SP 179, SP 220, NC299, NC102, RGH 51, K346, and SPH20 (see tobacco variety trial and disease resistance ratings).

Study the following guidelines and results of on-farm test for management of black shank.

RIDOMIL GOLD FOR BLACK SHANK CONTROL

ROTATION	RIDOMIL GOLD EC APPLICATION	REI
None (Continuous tobacco is **NOT recommended**)	1 qt/A preplant broadcast OR 1 pt/A preplant broadcast + 1 pt /A layby* OR 1 pt/A preplant + 1 pt/A first cultivation + 1 pt/A layby*	48 hr
2 year (Tobacco in alternate years)	1.5 pt /A preplant broadcast OR 1 pt/A preplant broadcast + 0.5 pt /A layby*	48 hr
3 year or more (Tobacco every third year or more)	1 pt /A preplant OR 1 pt/A preplant broadcast + 0.5 pt/A layby*	48 hr

*Apply Ridomil at layby cultivation using two drop nozzles per row directed to sides of bed.
***REI = reentry interval**

NOTE: Do **NOT** rely on Ridomil or multipurpose chemicals alone to control black shank. Rotation and varieties with strong resistance to black shank should be used in addition to chemical controls.

EFFECT OF VARIETY AND RIDOMIL GOLD ON BLACK SHANK CONTROL

VARIETY	CHEMICAL	YIELD 1999	YIELD 2000	% DISEASE 1999	% DISEASE 2000
K 326	Control	415	2180	88	96
	Ridomil G	2229	1972	13	46
K 346	Control	1833	2441	41	25
	Ridomil G	2244	2565	3	22
NC 71	Control	2627	3198	3	2
	Ridomil G	2492	3296	2	7
NC 72	Control	2406	3257	2	12
	Ridomil G	2583	3289	1	14
Sp 168	Control	2275	2976	3	3
	Ridomil G	2162	3076	2	8

Location:Florence County 1999, Williamsburg 2000
Ridomil G application = 1 pt/A preplant followed by 1 pt/A at layby

EFFECT OF ROTATION ON BLACK SHANK

TREATMENT	ROTATION (Tob-Corn-Corn-Tob)		NO ROTATION (Tob-Tob-Tob-Tob)	
	lb/A	% Diseased	lb/A	% Diseased
No fungicide	2,626	9	1,118	43
Ridomil 2E 1 gal/A	2,678	1	2,301	10

MULTI-PURPOSE CHEMICALS FOR BLACK SHANK, BACTERIAL WILT AND NEMATODE CONTROL.

MATERIAL	RATE/A	REMARKS	REI
Telone C17	10.5 gal	CAUTION: 3-week waiting period between Application and Transplanting.	5 days
Chlor-O-Pic	3.0 gal	Same as above.	48 hr and gas conc. Less than 0.1 ppm

EFFECT OF MULTI-PURPOSE CHEMICALS AND RIDOMIL GOLD ON BLACK SHANK

Chemical	Ridomil G Application Timing			K 326 Percent Disease
	PPI	PTP	Layby	
Telone II 6 gal/A In-row				100
Telone C17 10.5 gal/A In-row				100
Telone II 6 gal/A In-row	2pt			57
Telone C17 10.5 gal/A In-row	2pt			62
Telone II 6 gal/A In-row	1 pt		1 pt	31
Telone C17 10.5 gal/A In-row	1 pt		1 pt	52
Telone II 6 gal/A In-row		1 pt	1 pt	11
Telone C17 10.5 gal/A In-row		1 pt	1 pt	13

PPI = preplant incorporated - 2 weeks prior to transplanting
PTP = applied to bed and incorporated immediately prior to transplanting
Layby = Ridomil at layby cultivation using two drop nozzles per row directed to sides of bed.

EFFECT OF VARIETY AND MULTI-PURPOSE CHEMICALS ON BLACK SHANK

CHEMICAL	VARIETY			
	K346		C371	
	Yield	% Disease	Yield	% Disease
Nemacur 1.5 gal/A	2228	39	3034	1
Telone II 6 gal/A In-row	2341	26	3200	0
Telone C17 6 gal/A In-row	2581	27	3141	0
Telone C17 8 gal/A Brd	2304	27	3088	0

Ridomil Gold, 1.5 pt/A PPI, Location:Williamsburg County

NEMATODE CONTROL

Damage caused by nematodes are difficult to estimate because damage to roots may not be apparent in above ground symptions, yet significant reductions in yields can occur with moderate levels of nematodes. Nematodes may increase the incidence of other diseases such as black shank, bacterial wilt and Fusarium wilt. The reduced use of fumigants during wet springs always results in dramatic increases in nematode damage and demonstrates the importance of soil fumigation!

The most important nematodes on tobacco are the root-knot nematodes. The most prevalent is the southern root-knot nematode, *Meloidogyne incognita*. However, another species (*M. arenaria*) also infests some fields. *Meloidogyne arenaria* (sometimes called peanut root-knot) is important because it is very damaging to tobacco and there is presently no resistance to this pest. Varieties that are resistant to the southern root-knot (*M. incognita*) are not resistant to *M. arenaria*. However, rotation is effective for both root-knot species and again should provide the basis for management of nematodes. If you notice gall development on root-knot resistant varieties, you should have the nematode identified. Your Extension agent can assist you with the

details for this determination. Surveys indicate nearly 1/3 of sampled tobacco fields contain populations of root-knot nematodes (such as the peanut root-knot nematode) that will produce galls on resistant cultivars.

Nematicides may also be effective in reducing nematode numbers in soil. It is best to base the control strategy on rotation, with use of resistant varieties when appropriate and nematicide treatments to supplement the rotation strategy. If rotation cannot be practiced, or only short rotations (1 year) are utilized, the use of nematicides and resistance becomes essential. Combining rotation, resistant varieties, and nematicides or fumigants is the best control practice. The following table illustrates the effect of rotation on root-knot nematodes. The test was conducted to demonstrate the effect of rotation on relative populations of *M. incognita* and the more damaging *M. arenaria* nematodes in a field initially infested with 50% *M. incognita* and 50% *M. arenaria*. Note that cotton and corn favor shifts to the less virulent *M. incognita*, which can be managed with resistance and chemicals.

EFFECT OF ROTATION ON ROOT-KNOT NEMATODES

ROTATION	NEMATODE SPECIES		YIELD lb/A	
	% M. ARENARIA	% M. INCOGNITA	NO NEMATICIDE	TELONE II
Tob-Tob-Tob-Tob	71	29	1,197	2,738
Fallow-Tob-Fallow-Tob	80	20	2,738	2,995
Cotton-Tob-Cotton-Tob	16	84	1,882	2,995
Corn-Tob-Corn-Tob	22	78	2,139	3,251
Soybean-Tob-Soybean-Tob	95	5	941	2,995

Fumigant nematicides require waiting periods of up to 3 weeks before tobacco can be safely transplanted into fumigated soils. Interest has been expressed in fall fumigation as another option for growers. On-farm tests indicate that this is a viable option for producers. The following table represents a comparison of fall vs. spring fumigation with several materials for root-knot control. Growers should be aware that weeds may build up in fall-fumigated beds. Weeds would have to be managed by cultivation, which could recontaminate beds with nematodes. However, results by Clemson researchers indicate that good nematode control by fumigation is possible whenever soil moisture and soil temperature conditions (55^{o} F at 6 inches is best) are favorable. Cold, wet soils will not allow fumigants to work to the best of their capability.

FALL VS. SPRING FUMIGATION FOR ROOT-KNOT

TREATMENTS	YIELD (lb/A)	$/A	GALL INDEX*
Fall			
C-O-P (3 gal/A)	2,994	4,723	1.37
Telone II (6 gal/A)	2,857	4,766	1.60
----------	----	----	----
Average	2,925	4,745	1.5
Spring			
C-O-P (3 gal/A)	2,963	4,389	3.63
Telone II (6 gal/A)	2,676	4,305	1.03
----------	----	----	----
Average	2,829	4,347	2.3
Spring			
Nemacur-Dasanit	2,171	3,606	9.07
Check + Diazinon	2,197	3,875	9.47

*Gall index on a scale of 1 to 10 with 1 representing roots with 0 galls and 10 representing roots 100% galled

BROADCAST FUMIGATION TO CONTROL ROOT KNOT WITH POST FUMIGANT CULTIVATION TO SEAL THE CHISEL TRACE

PRODUCT	APPLICATION METHOD	INCORPORATION FOLLOWING FUMIGATION	YIELD	ROOT GALLING
Telone II (8 gal/A)	Brd Chisel Plow	none	2640	0
Telone II (12 gal/A)	Brd Chisel Plow	none	2437	0.1
Telone C17 (12 gpa)	Brd Chisel Plow	none	2384	0.1
Telone C17 (16 gpa)	Brd Chisel Plow	none	2714	0
Telone II (8 gal/A)	Brd Chisel Plow	Drag on chisel plow	2762	0.1
Telone II (12 gal/A)	Brd Chisel Plow	Drag on chisel plow	2602	0
Telone C17 (12 gpa)	Brd Chisel Plow	Drag on chisel plow	2709	0.5
Telone C17 (16 gpa)	Brd Chisel Plow	Drag on chisel plow	2768	0
Telone II (8 gal/A)	Brd Chisel Plow	Field cultivator	2330	0.2
Telone II (12 gal/A)	Brd Chisel Plow	Field cultivator	2432	0.1
Telone C17 (12 gpa)	Brd Chisel Plow	Field cultivator	2874	0.2
Telone C17 (16 gpa)	Brd Chisel Plow	Field cultivator	2976	0
Telone II (6 gal/A)	In-row	---	2597	0.3
Telone C17 (10.5 gpa)	In-row	---	2666	0.5
Control	---	---	1669	3.4

Georgetown county, 2001
Brd = broadcast application with a chisel plow

In-row fumigant nematicides should be applied during the subsoiling operation. Placement of fumigant nematicides below the clay subsoil should be avoided. Soil moisture should not be excessive **at the point of injection** or poor control will be achieved.

PLACEMENT DEPTH OF IN-ROW FUMIGANT NEMATICIDES.

PRODUCT	PLACEMENT	YIELD lb/A
Telone II (6 gal/A)	Bottom of subsoiler (16 inches deep)	2768
Telone II (6 gal/A)	Middle of subsoiler (10 inches below level soil line)	2720
C-O-P (3 gal/A)	Bottom of subsoiler (16 inches deep)	2720
C-O-P (3 gal/A)	Middle of subsoiler (10 inches below level soil line)	2672
Untreated control		1488

Location: Georgetown County
Sandy loam soil heavily infested with root-knot nematodes.

TOBACCO NEMATICIDES

NEMATICIDE	RATE/A	ROOT KNOT CONTROL		REMARKS*
		Southern (M. incognita)	Peanut (M. arenaria)	
FUMIGANTS:				
Telone II	6 gal	Excellent	Excellent	FR REI = 5 days
MULTIPURPOSE CHEMICALS:**				
Telone C17	10.5 gal	Excellent	Excellent	FR REI = 5 days
Chlor-O-Pic	3 gal	Excellent	Very Good[1] Very Good[1]	FR REI = 48 hr and gas conc. less than 0.1 ppm
NONFUMIGANTS:				
Nemacur 3	1.3-2 gal	Good	Fair	B & I REI = 48 hr
Mocap 6EC	1-2 gal	Good	***	B & I REI = 48 hr
Lorsban 4E	5 qt	Poor	***	B & I REI = 24 hr
Furadan 4F	1.5 gal	Poor	Poor	B & I REI = 48 hr
TANK MIXES:				
Nemacur 3 + Lorsban 4E	1-2 gal + 2 qt	Good	Fair	B & I REI = 48 hr
Nemacur 3 + Mocap 6E	1 gal + 2-4 qt	Good	Fair	B & I REI = 48 hr

* FR - Fumigant row; B & I - Broadcast and incorporate.
** Multipurpose chemicals have effectiveness for nematodes, black shank and Bacterial wilt.
*** Not registered for this nematode species.
[1] Although some root galling may occur at the end of the growing season, yield responses are similar among the multipurpose fumigants. **REI = reentry interval.**

Broadcast application of fumigant nematicides allows the producer to apply soil applied insecticides and herbicides, following the waiting period, as a commonly applied preplant broadcast incorporated treatment. The following table is a comparison of in-row and broadcast application of fumigant nematicides for control of nematodes.

BROADCAST FUMIGATION FOR CONTROL OF ROOT-KNOT NEMATODES

PRODUCT	PLACEMENT	YIELD lb/A
Telone C17	10 gal/A Chisel Plow	3100
Telone C17	14 gal/A Chisel Plow	3095
Telone C17	16 gal/A Chisel Plow	2895
Telone C17	10.5 gal/A In-row	3267
Telone II	6 gal/A Chisel Plow	2480
Telone II	8 gal/A Chisel Plow	2943
Telone II	10 gal/A Chisel Plow	2938
Telone II	6 gal/A In-row	3086
Untreated control	---	2337

Trial conducted at the Pee Dee REC

TOMATO SPOTTED WILT

Widespread occurrence of Tomato Spotted Wilt (TSW) in South Carolina during 2002 has caused considerable concern among our tobacco producers. Numerous producers in South Carolina have seen losses in early season plantings approaching 30-70% of their tobacco crop. County agent surveys estimate up to 20% of the tobacco plants in South Carolina were killed or severely stunted by TSW in 2002.

***Scope*:** TSW occurs worldwide and has caused serious losses in Central Europe, Greece, Brazil and Argentina. More recently losses in the USA have increased dramatically in the southern production areas such as Georgia with sporadic occurrences in production sites further north. Recently (2001, 2002), the incidence and severity of TSW has increased in South Carolina. The incidence of TSW causing noticeable stand loss reached 25% of the production fields in 2001. Damage appears to be more severe when the winter and spring weather is dryer than normal. TSW has a wide host range (166 species in 34 plant families) and can be found in winter weeds. Symptoms of TSW will depend on the age of the plant and the environmental conditions during plant growth. Early infection immediately after planting can kill the plant rapidly, appearing like damping off. As the plant ages new growth contains typical centric necrotic rings and zonate necrotic spots on the young leaves. The bud will frequently be twisted. As the plant matures black necrotic streaks can be seen on the stem. Severe stunting occurs after infection. Infected plants typically do not increase in height after symptom expression. Early infected plants rarely produce harvestable leaves. Plants can be infected at any stage of development. However, in South Carolina infections typically occur early in the season with losses climaxing in mid to late May.

***Control*:** TSW infections occur through wounds in epidermal cells caused by tobacco thrips. Generally insecticides have been ineffective in reducing virus transmission because very little time is required to transmit the virus. The insecticide may kill the insect but only after the plant

has already acquired the virus. Thrips population's peak in April and May and then decline in June. This approximates the timing of TSW seen in South Carolina. Imidacloprid (Admire 2F) applied as a greenhouse tray drench and to a much lesser extend as a transplant water treatment has been shown to reduce TSW in field plantings in Georgia and in South Carolina. The reduction in TSW may not be directly related to control of the thrips. Newer aphid control materials such as Platinum also reduce TSW. In trials in 2002, Platinum appears to give similar suppression of TSW when compared to Admire. TSW control following Admire or Platinum treatment can range from 25% to 50% reductions in plant loss. Due to the random nature of infection across the field (no edge effects) stand losses as great as 10% generally do not result in yield reductions! As the number of plants killed increases above 10%, dramatic yield and quality losses can be expected. Plants that are bordered by missing plants pick up nitrogen normally used by competing plants. This results in uneven ripening across the field. Although the effect is not readily apparent from observing the field, there is a pronounced lack of uniformity in leaf ripening and is reflected in leaf quality.

Actigard is a new pesticide labeled for the control of blue mold on tobacco. Actigard works through stimulating the plants own defense mechanisms, commonly refereed to as systemic acquired resistance (SAR). Excellent blue mold control has been observed following Actigard application. Data suggests that Actigard will also reduce TSW. Use of Actigard in combination with Admire or Platinum is additive providing a better alternative to producers than Admire or Platinum alone. Both products used together can reduce losses 50-60% on a regular basis. However, the potential of plant injury exists with the use of Actigard . Formerly, actigard was labeled through a special third party label due to the potential for plant injury. The present blue mold label specifies application when the plants reach 18 inches tall, generally to late for TSW control. It is not known if a third party label will be available for the 2006 growing season to allow Actigard + (Admire or Platinum) treatments. Check with your county agent for details on use of Actigard for 2006.

***Expectations*:** Losses to TSW are generally most severe during the first month after planting in the USA. Although damage can sometimes be seen throughout the season our experiences in South Carolina suggests reductions in new occurrences after the middle of May. The potential losses to TSW in 2006 cannot be predicted, however, based on the historical losses in Georgia severe losses in South Carolina could occur in 2006. Farmers should carefully weigh the cost of control and expectations for disease reduction when choosing their disease control system.

***Host Resistance*:** Although promising breeding material exists, no released variety is resistant to TSW. Host resistance will play a vital role in suppression of TSW in the future.

The following points should be considered to help control Tomato Spotted Wilt:

1. **Avoid early planting**
2. **Apply Admire or Platinum as a tray drench**
3. **Use healthy disease free seedlings to reduce stand loss to other pathogens**
4. **Follow fertility recommendations - avoid excessive nitrogen application**
5. **Irrigate if possible to assure sustained crop growth**
6. **Consider use of Actigard (see information on labeling above) if expectation of disease loss is high or if severe losses to TSW were experienced in previous years.**

MOSAIC CONTROL

Losses to tobacco mosaic virus (TMV) hit an all time record in 2000 with an estimated loss of $1,527,000! The early development of the disease suggests that initial infection of the seedlings occurred in the greenhouse. It is unclear how and why mosaic was observed in so many greenhouses in 2000. TMV to date has not been shown to be seed borne. The change to greenhouse production of seedlings many have magnified a minor problem into a major one. Just one plant within a large greenhouse that is TMV positive can have a devastating effect on the quality of seedlings grown within that greenhouse. Although losses were low in 2005, careful sanitation is needed in all years to prevent TMV.

Growers should not reuse trays from any greenhouse that had TMV the previous year. Plant roots grow through the tray and it would be impossible to remove all root fragments and sterilize the trays to assure they were TMV free. I would expect that the transmission of TMV to new seedlings would be very low, however you only need one infected plant per greenhouse to spread the virus during mowing. If trays are to be reused consider the use of TMV resistant cultivars such as CC27, NC 297, RGH4 or SpH20.

Remember, tobacco mosaic is caused by a virus that is very easily spread by hand or machinery. If workers do not wash their hands with abrasive soap or dip them in milk every 30 minutes while handling transplants, the virus can be introduced into the field and very efficiently spread within the field. Mosaic can be spread at any time in the growing season; it is commonly spread by hand topping. Mosaic does not kill the plant but produces symptoms which range from a mild mottling on the leaves to distortion and "mosaic burn" on the leaves. Mosaic infection early in the season results in stunted, low yielding plants. If mosaic burn (dead areas in the leaves) occurs, both yield and quality are reduced. Even without severe symptoms, losses to mosaic are expensive, thus making tobacco mosaic one of the most important diseases.

The following points should be considered to help control mosaic:

1. Rotate tobacco fields.
2. Do NOT use tobacco products when working in the plant beds or in greenhouses, during transplanting, or during topping.
3. Do NOT cover or carry tobacco transplants on old or possibly contaminated tobacco sheets.
4. When clipping transplants in beds or greenhouses, disinfect the underside of the mower with chlorine bleach mixed 1:1 with water immediately after each clipping.
5. Wash hands with abrasive hand soap (such as "Lava") or dip them in milk before handling plants. Repeat every 30 minutes.
6. Before first cultivation, remove plants showing mosaic symptoms.
7. Avoid unnecessary cultivations.
8. Complete layby cultivation before plants are tall enough to touch equipment under tractor.
9. Follow root and stalk destruction recommendations as soon after harvest as possible. Most mosaic infections begin in fields from previous crop residues!
10. Use resistant varieties, such as CC27, NC 297, RGH 4, or SpH20 where mosaic is severe or rotation is not practiced.

TARGET SPOT CONTROL

Target spot is endemic to South Carolina tobacco fields and is caused by a fungus (*Thanatephorus cucumeris*). Disease development is more severe during wet weather. An epidemic of target spot occurred in South Carolina during 2005 with losses estimated at $209,000. Excessive rainfall and high relative humidity resulted in increased losses to target spot. The symptoms appear similar to brown spot and are easy to confuse. Necrotic tissue can become brittle, fall out, and leave a shot hole appearance. Under high relative humidity lesions can increase rapidly blighting large portions of the leaf. A section 18 crisis exemption was requested and received for the use of Quadris fungicide for control of target spot in 2005. Please check with your county agent on the status of the Quadris label prior to use.

BROWN SPOT CONTROL

Brown spot is a disease of the maturing leaves of tobacco and is most serious during periods of high humidity. The best measures to reduce losses to brown spot are to plant varieties tolerant to the disease, avoid excess nitrogen fertilization which delays maturity, and alter spacing of plants in the row to increase air circulation and reduce humidity.

Be aware of conditions favorable for infection by the brown spot fungus. If such conditions occur during harvest, increasing the priming rate should help to stay ahead of the disease. Fungicide control is not successful and is therefore not recommended.

BLUE MOLD CONTROL

Blue mold was not observed in South Carolina during 2005. Blue mold occurs in Florida and Georgia almost every year and has the potential to cause severe losses in South Carolina. Ridomil resistant strains have been observed in other states and pose a possible threat to the tobacco crop in South Carolina. Blue mold is potentially one of the most destructive diseases of tobacco. It is caused by a fungus (*Peronospora tabacina*) that is airborne, and disease can spread very quickly, leading to epidemics, if not properly managed. This occurred in 1979 and 1980 in all tobacco-producing states, leading to tremendous losses. Ridomil has generally given good control of blue mold when used as a preplant soil incorporation treatment. However, **if a Ridomil G insensitive strain occurs in South Carolina other control options should be considered.** Acrobat MZ has received a section 24 state label for blue mold control. Actigard 50 WG received a label for blue mold control in 2000.

Ridomil Gold.

Rates of 0.5-1 pt/A Ridomil Gold per acre should be used at or before transplanting.
If necessary, an additional 0.5 pt can be used at layby, if no more than 1 pt/A was used at planting. Growers should be reminded that the Ridomil label does <u>not</u> allow foliar applications. Soil-applied Ridomil gives better control for longer periods of time and reduces the threat of resistant spores building up. The amount of Ridomil Gold used will depend on control necessary for black shank.

FIELD BLUE MOLD CONTROL

SOIL TREATMENTS	RATE	REMARKS
Ridomil Gold	0.5-1 pt/A	Broadcast and incorporate 2-4 inches at or before transplanting. An additional 0.5 pt/A may be used at layby if no more than 1 pt/A was applied at planting. REI = 48 hr.
FOLIAR TREATMENTS*	**RATE**	**REMARKS**
Mancozeb (Dithane DF)	1.5 - 2.0 lb/ 100 gal	Use only in the field if there is a threat of Ridomil-insensitive blue mold. Mix 1.5 -2.0 lb per 100 gallons of water, spray foliage weekly for complete coverage up to a maximum of 100 gallons per acre. **Do not spray after appearance of first button or within 21 days of harvest, whichever is earlier.** REI = 24 hr
Acrobat MZ	2.5 lb/100 gal	Use only in the field if there is a threat of Ridomil-insensitive blue mold. Mix 2.5 lb per 100 gallons of water, spray foliage every 5-7 days for complete coverage. Do not exceed 10 lb/acre of Acrobat MZ per season. Begin application when the Blue Mold advisory states that conditions favor development of blue mold, and before the onset of disease. Consult the label for specific application information. LABEL MUST BE IN THE POSSESSION OF THE USER AT THE TIME OF FUNGICIDE APPLICATION. **Do not spray after appearance of first button or within 21 days of harvest, whichever is earlier.** REI = 24 hr.
Actigard 50 WG	0.5 oz/A	Begin application after plants reach a height of 18 inches. Apply on a preventative schedule when blue mold threatens. Another registered blue mold product should be used prior to 18 inches for early season control and after the final application if conditions are conducive for disease. Make up to 2 applications on a 10-day schedule. Apply in a minimum of 20 gals./A. Application of Actigard may result in leaf yellowing. This cosmetic yellowing normally disappears after final application. REI = 12 hr.

REI = reentry interval.

DISEASE MANAGEMENT IN GREENHOUSE TRANSPLANT PRODUCTION

There are several potentially important disease problems that may occur in greenhouse transplant production systems. These include target spot (*Rhizoctonia solani*), white mold or stem rot (*Sclerotinia spp*.), damping-off caused by *Pythium* spp. or *Rhizoctonia* spp., blue mold (*Peronospora tabacina*), gray mold (*Botrytis cinerea*), soft rot (*Erwinia* spp.) and tobacco mosaic virus. The potential also exists for diseases most often associated with field-grown tobacco to occur, and include bacterial wilt (*Ralstonia solanacearum*) and black shank (*Phytophthora parasitica* var. *nicotianae*).

There are few fungicides labeled for greenhouse tobacco transplant production. A label for Dithane DF has been obtained for greenhouse and plant bed use but the potential for phytotoxicity exists (see chart below). It is imperative that producers take extra precautions to prevent pathogens from entering the greenhouse and to minimize environmental conditions within the greenhouse that might encourage disease development. Thus, ventilation, sanitation, monitoring, and use of good production practices are important disease management factors.

TOBACCO GREENHOUSE DISEASE CONTROL

DISEASE	CHEMICAL	RATE/50 GAL WATER	REMARKS*
Blue Mold Damping off, Stem rot and Target spot	Mancozeb (Dithane DF)	0.25 lb/50 gal water	For greenhouse and floatbed systems, use 1/2 lb per 100 gal water (one level teaspoon per gallon). Spray every 5 to 7 days to the point of run-off. Apply 3 gallons of the fungicide spray mixture on small plants (dime size),gradually increasing the spray volume to 6 to 12 gallons per 1000 sq. ft. as plants enlarge until transplanting to the field. For stem rot, use enough volume to wet the base of plant stems. REI = 24 hr.

Continued on next page.

TOBACCO GREENHOUSE DISEASE CONTROL (Continued)

DISEASE	CHEMICAL	RATE/50 GAL WATER	REMARKS*
Pythium seedling blight	Terramaster 35WP	1 oz per 100 gallons of water	Do not apply as a drench or in irrigation water. Apply this product only to tobacco float-bed water. Consult the label for mixing directions. Crop injury can occur with improper mixing. REI = 12 hr. Terramaster 35WP used as a **preventative treatment** before symptoms occur, mix 1 oz of Terramaster /100 gal of water no sooner than two weeks after seeding. A sequential preventative application of 1 oz/100 gal of water can be made in 3 week intervals for a maximum of three applications per season. Do not apply Terramaster 35 WP later than 8 weeks after seeding. REI = 12 hr.
	Terramaster 35WP	2 oz per 100 gallons of water	Terramaster 35WP used as a **curative treatment** when disease symptions first appear, mix 2 oz of Terramaster 35 WP /100 gal of water no sooner than three weeks after seeding and when leaves are at least 1 inch in diameter. If pythium disease symptoms recur after the first application, a second application of 1-2 oz. per 100 gallons of water can be made. Allow at least a 3-week interval between the first and second application. Do not apply Terramaster 35 WP later than 8 weeks after seeding. REI = 12 hr.
	Terramaster 4EC	1.4 oz/100 gal water	Do not apply as a drench or in irrigation water. Apply this product only to tobacco float-bed water. Consult the label for mixing directions. Crop injury can occur with improper mixing. Terramaster 4EC used as a **preventative treatment** before symptoms occur, mix 1.4 fl. oz of Terramaster /100 gal of water no sooner than three weeks after seeding. A sequential preventative application of 1.4 fl oz/100 gal of water can be made 3 weeks after the first application. Do not apply Terramaster 4EC later than 8 weeks after seeding. REI = 12 hr.
	Terramaster 4EC	1.4 oz/100 gal water	Terramaster 4EC used as a **curative treatment** when symptoms first appear, mix 1.4 fl oz of Terramaster /100 gal of water no sooner than three weeks after seeding and when leaves are at least 1 in. in diameter. If Pythium symptoms recur after the first application, a second application of 1-1.4 fl oz/100 gal of water can be made. Allow at least a 3-week interval between the first and second application. Do not apply Terramaster 4EC later than 8 weeks after seeding. No more than 2.8 fl. oz. of Terramaster 4EC /100 gal of water may be applied to each crop of transplants. REI = 12 hr.

- The potential for phytotoxicity exists when Dithane DF is used on tobacco seedlings. To minimize potential for damage, 72 hours prior to large scale application, the user should test for potential phytotoxicity by applying the fungicide to a small sample area growing under similar conditions. In general, injury is greater in greenhouse systems.

Ridomil Gold, Ridomil 2E or Acrobat MZ are not labeled for use in greenhouses, or float-bed plant production systems. REI = reentry interval.

VENTILATION

Ventilation using side curtains and promoting horizontal air flow with fans is very important to remove stagnant air pockets and lower humidity within the house. Good ventilation and air movement reduces the potential for leaf diseases such as target spot, blue mold, and gray mold. This also promotes evaporative cooling of the transplants and should reduce the potential for warm-weather diseases such as soft rot. Systems such as horizontal air flow using fans suspended from the ceiling or use of a polytube for ventilation are recommended.

SANITATION

Sanitation practices are also very important, both during actual production of the transplants as well as before and after a production run. Sanitation practices are those that strive to prevent introduction of pathogens into the production area and to prevent their spread. The use of sterile peat-vermiculite soil mixes, sanitizing clipping mowers with bleach solutions, washing used trays with bleach solutions, promoting good drainage and dry walkways, etc. are examples of sanitation practices. It is suggested that mowers be thoroughly cleaned with a 50% solution of household bleach after each clipping. This is very important for Mosaic control. **Remove plant clippings from the vicinity of the greenhouse structure.** Do not allow tobacco products to be used in the greenhouse. Workers should wash their hands with abrasive soap or dip them in milk prior to handling of transplants and trays. Do not use surface water (ponds, streams) for irrigation or filling of float trays. These waters may contain pathogens. After trays are used, they should be thoroughly washed to remove old soil mix and stored in a clean, dry location. Before they are used again, they should be washed or drenched in a 10% bleach solution, and rinsed with clean water. Producers should keep all aspects of tray filling and transport of filled, seeded trays to the greenhouse as sanitary as possible. Contamination of trays can occur anywhere in the path.

Walkways should be constructed so that they are as clean and dry as possible. Using gravel or even cement walkways promotes drainage and helps prevent pathogen-laden soil from being introduced into the production area. Make sure any equipment, including rubber boots used to work in float baths, are cleaned and sanitized before they are used in production houses. **Do not use any tobacco products within or near the greenhouse. Do not bring fruit into the greenhouse structure.**

MONITORING

Growers should constantly monitor the crop from seeding to setting of transplants for signs and symptoms of disease. Frequently, wilted or yellow plants indicate disease is becoming established. Trays with diseased plants should be removed promptly from the vicinity and destroyed. Clippings should be collected in bag attachments and removed from the vicinity of the houses, as some pathogens (e.g. white mold) may continue to produce spores on dead plant material.

USE GOOD PRODUCTION PRACTICES

Finally, strive to produce the transplants using good production practices. Make sure your water source is a good one and the pH and bicarbonate levels are acceptable. Allow adequate fertility for production, but do not over-fertilize, as this causes succulent plants to develop that are more susceptible to diseases. Make sure temperatures in the house do not become extreme (hot

or cold) as these stresses may cause the plants to become weakened and more readily attacked by pathogens. **Do not heat the float water**. Tobacco seedlings can grow in float systems with very cold float water. Low float water temperatures reduce the spread of *Pythium* spp. in the float water. Heating the float water may increase Pythium seedling disease.