Contents

Prepared at North Carolina State University.
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Extension Personnel Working with Tobacco

Tobacco growers in North Carolina are fortunate to have an Extension agent with tobacco responsibilities in each tobacco-producing county. These agents are supported by research and extension faculty in the College of Agriculture and Life Sciences at North Carolina State University. The following are the county Cooperative Extension Service personnel with tobacco responsibilities as of December 5, 2013.

County	*Name*	*Telephone*
Alamance	Will Strader	336-570-6740
Alexander	Allison Brown	828-632-4451
Anson	Jessica Rankin	828-694-2915
Beaufort	Jacob Searcy	252-946-0111
Bertie	Richard Rhodes	252-794-5317
Bladen	Ryan Harrelson	910-862-4591
Brunswick	Mark Blevins	910-253-2610
Caldwell	Seth Nagy	828-757-1290
Carteret	Mike Carroll	252-728-8421
Caswell	Will Strader	336-694-4158
Chatham	Sam Groce	919-542-8202
Chowan	Tim Smith	252-482-6585
Columbus	Michael Shaw	910-640-6605
Craven	Mike Carroll	252-633-1477
Cumberland	Colby Lambert	910-321-6875
Davidson	Troy Coggins	336-242-2081
Davie	Tim Hambrick	336-751-6297
Duplin	Curtis Fountain	910-296-2143
Durham	Delphine Sellars	919-560-0526
Edgecombe	Art Bradley	252-641-7815
Forsyth	Tim Hambrick	336-703-2850
Franklin	Charles Mitchell	919-496-3344
Gates	Paul Smith	252-357-1400
Granville	Paul Westfall	919-603-1350
Greene	Roy Thagard	252-747-5831
Guilford	Wick Wickliffe	336-375-5876
Halifax	Arthur Whitehead	252-583-5161
Harnett	Brian Parrish	910-893-7530
Hertford	Wendy Burgess	252-358-7822
Hoke	Keith Walters	910-875-3461

County	Name	Telephone
Iredell	Teresa Herman	704-878-3153
Johnston	Bryant Spivey	919-989-5380
Jones	Jacob Morgan	252-448-9621
Lee	Kim Tungate	919-775-5624
Lenoir	Tammy Kelly	252-527-2191
Martin	Al Cochran	252-792-1621
Montgomery	Molly Alexi	910-576-6011
Moore	Taylor Williams	910-947-3188
Nash	Charlie Tyson	252-459-9810
Northampton	Craig Ellison	252-534-2711
Onslow	Melissa Huffman	910-455-5873
Orange	Carl Matyac	919-245-2050
Pamlico	Daniel Simpson	252-745-4121
Pender	Mark Seitz	910-259-1235
Person	Kim Woods	336-599-1195
Pitt	Mitch Smith	252-902-1702
Randolph	Jonathan Black	336-318-6000
Richmond	Susan Kelly	910-997-8255
Robeson	Mac Malloy	910-671-3276
Rockingham	Will Strader	336-342-8230
Sampson	Della King	910-592-7161
Scotland	Randy Wood	910-277-2422
Stokes	Tim Hambrick	336-593-8179
Surry	James Boggs	336-401-8025
Vance	Paul McKenzie	252-438-8188
Wake	Katherine Williams	919-250-1096
Warren	Paul McKenzie	252-257-3640
Washington	Lance Grimes	252-793-2163
Wayne	Tyler Whaley	919-731-1520
Wilkes	John Cothren	336-651-7331
Wilson	Norman Harrell	252-237-0111
Yadkin	James Boggs	336-679-2061

1. U.S. Tobacco Situation and Outlook

Blake Brown
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Cigarette Market

The cigarette market, particularly in developed countries, is characterized by increased regulation. In the United States the Food and Drug Administration (FDA) Center for Tobacco Products (CTP) slowly moves forward with implementation of the 2009 Family Smoking and Protection Act. All characterizing flavors have been banned except menthol. Study of the menthol issue continues with new funding for research studies despite a Tobacco Products Scientific Advisory Committee study recommending that menthol be banned. More than 100 harmful constituents have been identified in cigarettes by FDA, with 20 being flagged for testing. Proposed graphic labels have been ditched after courts ruled in favor of the industry in a suit that cited the graphic labels as a violation of the free speech amendment. FDA will develop new proposed labeling requirements. Draft guidance has been produced for approval of modified-risk tobacco products. With an annual budget of more than $450 million, the CTP has proceeded with inspections of tobacco manufacturing facilities and will devote $53 million in research funding to fourteen Tobacco Centers of Regulatory Science. With much study and few conclusions for implementation, a primary effect of the CTP on the market for cigarettes has been increased uncertainty about when future regulatory actions may be implemented. One impact of this uncertainty at the farm level is that manufacturers are more reluctant to hold inventories of tobacco due to the uncertainty of what levels of identified constituents may be allowed in the future. Lower inventories may be a factor in the increased volatility of farm-level tobacco prices.

U.S. cigarette consumption continues its steady decline. Total consumption was 286 billion cigarettes in 2012, down from 299 billion in 2011 and down from the peak of 633 billion in 1981. Per capita consumption was 920 cigarettes, down from 969 in 2011 and from the peak of 2,905 in 1976. According to *Tax Burden on Tobacco* (vol. 47, 2012) the average retail price for cigarettes in the United States was

$5.64 per pack in November 2012. Federal taxes are $1.01 per pack, and the weighted average state excise tax was $1.21 per pack in 2012. In FY 2012, federal tax collections on cigarettes were $14.5 billion, and state tax collections were $17 billion. After large increases in state and federal excise tax rates on tobacco products last decade, the increase in tax rates has slowed in recent years. As of this year, only 10 states have not adopted statewide bans on smoking. Of those adopting statewide bans, 28 have enacted bans on smoking in all inside public places.

The emerging e-cigarette market has potential to dramatically reshape the U.S. cigarette market. Some analysts think e-cigarette consumption could surpass consumption of traditional cigarettes in the United States within a decade. The stance taken by FDA (currently uncertain) on e-cigarettes will be a critical factor in the outcome of this market. Traditional cigarette manufacturers are now investing heavily in this sector. Currently, some in industry have indicated that extracting nicotine for e-cigarettes may require more tobacco than is required for comparable smoking quantities of traditional cigarettes. However, should this sector continue to grow, incentives will encourage creation of tobacco varieties specifically for nicotine extraction. Thus, optimism that growth in e-cigarettes will increase demand for traditional tobacco production is not warranted. Just the opposite could occur.

In the European Union, the Tobacco Products Directive (TPD) that regulates tobacco products is being revised. The EU Parliament voted on the revisions October 8, 2013. Revisions include banning all characterizing flavors in cigarettes, requiring health warnings that cover 65% of the cigarette package, stricter controls on Internet sales, and increased tracking and traceability. Flavorings will be phased out over five years, except for menthol, which will be phased out over eight years. The revisions passed by parliament are less strict than the package proposed and adopted by the EU Council. The proposed revisions would have required 75% of the cigarette package to be covered by health warnings, banned all flavorings immediately, and classified e-cigarettes with more than a certain amount of nicotine as pharmaceuticals. The revisions passed by parliament now go back to the EU Council for reconciliation. Of the 2008-2012 annual average U.S. unmanufactured tobacco exports of $1.19 billion, $412 million (about 34%) were exported to the EU-27. While the size of the impact of the TPD revisions is uncertain, just an 8% reduction in U.S. unmanufactured tobacco exports to the EU-27 could reduce the annual value of U.S. tobacco farm output by $37.6 million.

The World Health Organization's Framework Convention on Tobacco Control (FCTC) entails recommendations similar to the FDA and TPD in a treaty to which 177 countries are parties. While enforcement and adoption of the recommendations vary among party countries, the FCTC is leading to wider global adoption of smoking and tobacco manufacturing restrictions, anti-smoking education, and increased taxation.

China and other southeast Asian countries are notable exceptions to declining cigarette consumption in much of the world, particularly the more developed countries. Cigarette production in China has increased from 1.875 trillion in 2004 to 2.445 trillion in 2011 and is projected to continue to increase at a rate of about 3% per year. Increased production of upper-end premium cigarettes seems to mean that Chinese cigarette producers want more flavor-style tobacco like that produced in the United States. In evidence of this increased demand for flavor-style tobacco, China National Tobacco Corporation has made substantial investments in tobacco procurement in Zimbabwe in recent years, and this year the corporation opened procurement offices in North Carolina.

Flue-Cured Production and Market

A very wet 2013 growing season led to lower yields and some abandoned acreage. USDA forecasts average yield for 2013 to be 2,024 pounds per acre, down from 2,296 pounds per acre in 2012. Record high prices are evidence of the short supply of the crop. Average price per pound may exceed $2.15. USDA estimates production at 439 million pounds, down from 473 million pounds produced in 2012 and down from early-season expectations for nearly 500 million pounds of production for 2013. Many industry and production experts think the USDA estimate is too optimistic and that 2013 production will be less than 439 million pounds.

Preseason prices offered in contracts, while not as high as actual prices paid, were up from those offered in 2012, in an attempt to increase U.S. flue-cured production for 2013. The wet season caused some acreage to be abandoned, but most of the reduction in crop size was due to lower yields caused by excessive rain. A 2011 U.S. crop devastated by weather, lackluster Brazilian production, and increased demand from China resulted in short global supplies of flavor-style flue-cured tobacco. It was hoped that increased U.S. acreage for 2013 would alleviate the tight supply conditions. USDA forecasts harvested acreage for 2013 to be 216,000 acres, up from 206,000 acres in 2012.

Given a 2013 U.S. flue-cured crop that will be smaller than expected, buyers will attempt to increase 2014 production in the southern hemisphere. With the Brazil crop planted, hopes are for a 1.4 billion pound crop for 2014. Universal Leaf Tobacco Company estimates the 2013 crop from Brazil at 1.34 billion pounds. Zimbabwe produced about 364 million pounds of good-quality flue-cured in 2013. According to the Zimbabwe Tobacco Association, the average price per pound for the 2013 season was $1.67 per pound, up slightly from the 2012 season. Should the very tight supply situation be alleviated by larger good-quality flue-cured crops in Brazil and Zimbabwe in 2014, then 2014 U.S. prices likely will fall back below $2 per pound. With very tight supplies and lower tobacco inventories held by many manufacturers, contract prices offered in early 2014 will be very sensitive to estimates of the crop size and quality of the Southern Hemisphere flavor-style producers. Given the continued declining demand for tobacco products in the United States and European Union, tobacco prices will also be very dependent on continued robust demand from China.

Table 1-1. U.S. flue-cured tobacco production, 2004 to 2013, in million pounds

Year	Florida	Georgia	North Carolina	South Carolina	Virginia	U.S. Total
2004	9.8	46.7	344	63.4	57.6	521.5
2005	5.5	27.8	273.9	39.9	33.7	380.8
2006	2.9	30.1	324.0	48.3	42.0	447.2
2007	n/a	39.8	376.8	46.1	41.0	503.8
2008	n/a	33.6	384.7	39.9	41.0	499.2
2009	n/a	28.0	417.6	38.8	42.0	526.4
2010	n/a	27.4	348.6	36.0	39.9	451.9
2011	n/a	26.8	248.0	26.3	43.5	344.6
2012	n/a	22.5	377.2	25.2	48.0	472.9
2013	n/a	29.2	340.0	17.1	52.9	439.2

Source: USDA, NASS, Crop Production Report, September 2013

Export estimates are not yet available for the 2012 crop, but exports should be higher than the 2011 crop estimate of 248 million pounds. With a small, low-quality crop in 2011, domestic use saw a substantial decrease to 159 million pounds, down from 210 million for the 2010 crop. Prior to the 2010 and 2011 crops, both of which were adversely affected by weather, exports had been on an upward trend. This trend is expected to have resumed with the good quality of the 2012 and 2013 crops. Domestic use has been on a downward trend since 2004. It may recover from the very low level of the 2011 crop, but not to pre-2011 crop levels. The upward trend in exports has been driven by more competitively priced U.S. tobacco since the buyout and increased global demand for flavor-style flue-cured tobacco, due mainly to the growing Chinese market. The downward trend in domestic use is driven by declining U.S. cigarette consumption and factors leading to less tobacco being used per cigarette produced in the United States.

Table 1-2. Flue-cured tobacco production, stocks, supply, and disappearance (farm sales wt. million lb)

Marketing Year	*Beginning Stocks*	*Production*	*Total Supply*	*Ending Stocks*	*Total Use*	*Exports*	*Domestic Use*
2004-2005	822.8	499.3	1,322.2	796.0	526.2	188.6	337.6
2005-2006	796.0	380.9	1,176.9	604.0	572.8	258.4	314.4
2006-2007	604.0	446.5	1,050.5	493.2	557.3	247.0	310.3
2007-2008	493.2	503.8	997.0	396.8	600.2	305.0	295.3
2008-2009	396.8	499.2	896.0	360.3	535.6	304.2	231.5
2009-2010	360.3	525.4	885.7	398.8	486.9	303.1	183.8
2010-2011	398.8	451.9	850.7	381.9	468.8	258.9	209.9
2011-2012	381.9	344.6	726.5	319.2	407.3	248.4	158.9

Sources: USDA-AMS Tobacco Stocks as of April 1, 2013. USDA-NASS. USDA-FAS GATS

Burley Production and Market

The U.S. and global markets for burley are following similar trends displayed by the U.S. flue-cured market—tight supplies entering 2013, challenging growing conditions this year, and expectations of a strong marketing season. Following a decline of more than 25% last year in world burley production, tobacco buyers were hopeful that Kentucky and surrounding states would supply more burley in 2013. World burley production likely rebounded in 2013, but most of the growth occurred in lower quality/filler-style markets. U.S. burley contract volume and acres planted were likely up this year, but excessive summer rains in some areas destroyed acreage and likely caused yields to be below average.

According to the latest available USDA crop report, U.S. burley production in 2013 is forecast at 201.7 million pounds, only 2% below last year's official crop size. However, many production specialists and industry officials believe this estimate to be optimistic, with a crop more likely in the 180-190 million pound range. Harvested U.S. burley acres are projected to be up 4,000 acres in Kentucky but only 1,200 acres higher beltwide. Average burley yields across the belt are estimated by USDA at 1,966 pounds per acre, versus last year's 2,021 pounds per acre. Consequently, global burley supplies of quality/full flavor burley remain very tight as U.S. producers prepare for the upcoming 2013-2014 marketing season.

Table 1-3. U.S. burley tobacco production, 2004 to 2013, in million pounds

Year	Kentucky	Tennessee	Pennsylvania	North Carolina	Others	U.S. Total
2004	206.7	46.1	n/a	6.6	32.8	292.2
2005	143.5	34.0	4.8	5.0	16.1	203.4
2006	153.3	30.8	11.6	6.6	15.0	217.1
2007	154.0	20.8	10.8	6.6	15.2	207.4
2008	147.0	24.7	9.9	5.6	14.3	201.5
2009	161.3	26.9	9.4	6.3	11.0	214.9
2010	140.4	24.9	10.1	4.0	8.2	187.6
2011	128.0	22.5	11.0	3.4	7.4	172.3
2012	151.7	29.0	11.5	4.0	8.5	204.7
2013	156.0	21.8	12.8	4.5	6.6	201.7

Source: USDA, NASS, Crop Production Report, September 2013

U.S. burley disappearance (domestic use plus exports) in recent years has stabilized at around 210 to 220 million pounds. Tight U.S. burley supplies have limited export opportunities in recent years despite favorable exchange rates. However, the value of the U.S. dollar has been increasing of late, which does raise some concern over U.S. price competitiveness in international markets. Domestic use continues to be hindered by declining domestic consumption, but the rate of decline in U.S. cigarette consumption/production has fallen over the past couple of years, which has supported domestic burley demand amid tight world burley supplies. Plus, it is unclear whether anticipated FDA regulation on tobacco products has adversely affected import leaf demand.

A 2013 U.S burley crop expected to be near 200 million pounds (an outcome that remains uncertain at the present time) will likely be less than the level needed by tobacco manufacturers and dealers and should create a seller's market for this upcoming marketing season. Early contract price schedules indicated that market prices for top-quality U.S. burley would average around $2.00 per pound, but the current supply/demand balance could once again lead to some price adjustments this fall and winter, especially if an excellent-quality crop materializes during the curing season and anticipated marketings fall well below 200 million pounds.

While the market appears favorable for 2013, it is important to realize that increasing short-term market opportunities and higher prices for U.S. burley growers are being driven more by tight supplies and not by overall demand expansion. Based on the anticipated supply/demand balance, look for U.S. burley contract volume requests to potentially increase again in 2014 (subject to 2013 marketings). A multitude of long-term uncertainties remain, including immigration reform, future crop insurance changes, U.S. and global tobacco regulations, and the impact of a small but growing market for harm reduction tobacco products.

Of particular long-term concern for burley are the potential implications of flavoring and additive bans currently being debated in Europe and around the world. Various nontobacco ingredients are added in the manufacturing process to offset some of the taste characteristics evolving from incorporating burley in blended cigarettes. Presently, it is unclear whether full-flavor burley tobaccos (like U.S. burley) would have any advantage over lower-quality/filler-style burley tobaccos if a ban was adopted in a particular market. Besides affecting the overall demand for burley, other regulatory actions to influence manufacturing processes could ultimately affect grower production practices, leading to lower burley yields and profits. Also, a growing market for electronic cigarettes could have a significant adverse impact on U.S. burley demand, both domestically and globally. So despite some short-term optimism, U.S. burley producers have a multitude of factors limiting expansion and reinvestment in future burley production.

Table 1-4. Burley tobacco production, stocks, supply, and disappearance (farm sales weight million lb)

Marketing Year	*Beginning Stocks*	*Production*	*Total Supply*	*Ending Stocks*	*Total Use*	*Exports*	*Domestic Use*
2004-2005	*540.0*	*280.1*	*820.1*	*492.6*	*327.5*	*227.6*	*99.9*
2005-2006	*492.6*	*203.4*	*696.0*	*403.4*	*292.6*	*200.4*	*92.3*
2006-2007	*403.4*	*217.1*	*620.5*	*296.2*	*324.4*	*259.8*	*64.6*
2007-2008	*296.2*	*207.4*	*503.6*	*256.2*	*247.4*	*192.1*	*55.3*
2008-2009	*256.2*	*201.5*	*457.7*	*239.2*	*218.5*	*140.0*	*78.5*
2009-2010	*239.2*	*214.9*	*454.0*	*237.7*	*216.4*	*116.0*	*100.4*
2010-2011	*237.7*	*187.6*	*425.3*	*208.2*	*217.1*	*118.8*	*98.3*
2011-2012	*208.2*	*172.3*	*380.4*	*170.7*	*209.8*	*103.4*	*106.4*

Source: USDA-AMS Tobacco Stocks as of April 1, 2013

Dark Tobacco Situation and Outlook

U.S. dark tobacco growers continue to benefit from growing domestic snuff sales and limited foreign competition. U.S. snuff consumption has been increasing annually since the mid-1980s on the heels of new product introductions, successful marketing programs, smoking restrictions, and perceived lower health risks compared to combustible tobacco products. Domestic snuff sales were up 3.3% in 2012, with a 4% growth rate during the first half of 2013—slightly below annual growth patterns experienced over the past decade. On the supply side, dark tobacco acres have been adjusting over the past few years in response to an excessive crop produced in 2008 when new companies entered the marketplace. After several years of acreage adjustment, U.S. dark tobacco acreage was up around 2,000 acres this year, with USDA projecting a 10% larger dark tobacco crop in 2013 compared to last year (although some industry officials project smaller increases). Based on contract prices, look for 2013 dark fire-cured prices for quality leaf to be in the neighborhood of $2.60 per pound and near $2.25-$2.30 per pound for dark air-cured. Despite continued product sales growth, a noticeably larger 2013 crop may cause the industry to reevaluate additional acreage expansion in 2014. Nevertheless, the outlook for the U.S. dark tobacco growing sector remains very favorable given projected sales growth for smokeless tobacco products in the United States.

Table 1-5. Flue-cured tobacco—machine harvest—eastern North Carolina: 2013 estimated costs per acre

	Unit	Quantity	Price or Cost/Unit	Total Per Acre	Your Farm
1. Gross receipts					
Stalk position		**Yield**	**Price/lb**		
Lugs	lb	0.00	$0.00	$0.00	
Cutter	lb	0.00	$0.00	$0.00	
Leaf	lb	0.00	$0.00	$0.00	
Tips	lb	0.00	$0.00	$0.00	
Total receipts:				$0.00	
2. Variable costs					
Plants (greenhouse)	thou	6.20	$34.50	$213.90	
Multipurpose fumigation	gal	10.50	$17.13	$179.87	
Fertilizer					
8-8-24	cwt	5.00	$34.00	$170.00	
24s liquid	cwt	1.25	$16.00	$20.00	
Lime (prorated)	ton	0.33	$55.75	$18.40	
Herbicides	acre	1.00	$55.47	$55.47	
Insecticides	acre	1.00	$46.07	$46.07	
Sucker control	acre	1.00	$188.38	$188.38	
Hauling	lb	2500.00	$.05	$125.00	
Cover crop	acre	1.00	$25.00	$25.00	
Curing fuel	gal	325.00	$1.29	$419.25	
Electricity	kwh	1580.00	$0.08	$126.40	
Crop insurance	$	1.00	$120.00	$120.00	
Baling supplies	$	2500.00	$0.003	$7.50	
Tractor/machinery	acre	1.00	$233.94	$233.94	
Labor					
Preharvest	hrs	46.25	$9.98	$461.58	
Harvest/baling	hrs	23.54	$9.98	$234.93	
Postharvest	hrs	9.00	$9.98	$89.82	
Interest on op. cap.	$	$563.02	5.0%	$28.15	
Total variable costs				$2,763.66	
3. Income above variable costs					
4. Fixed costs					
Tractor/machinery	acre	1.00	$212.41	$212.41	
Bulk barn	acre	1.00	$132.58	$132.58	
Green leaf box loading sys.	acre	1.00	$38.75	$38.75	
Baler	acre	1.00	$7.50	$7.50	
Total fixed costs				$391.24	
5. Total costs				$3,154.90	
6. Net returns to land, risk, and management					

** Crop insurance: 65% based premium. No disaster subsidies.*

** Please note: This budget is for planning purposes only.*

Prepared by Gary Bullen and Loren Fisher, North Carolina State University, Department of Agricultural and Resource Economics.

Table 1-6. Flue-cured tobacco—machine harvest—piedmont North Carolina: 2013 estimated costs per acre

	Unit	Quantity	Price or Cost/Unit	Total per Acre	Your Farm
1. Gross receipts					
Stalk position		**Yield**	**Price/lb**		
Lugs	lb	0.00	$0.00	$0.00	
Cutter	lb	0.00	$0.00	$0.00	
Leaf	lb	0.00	$0.00	$0.00	
Tips	lb	0.00	$0.00	$0.00	
Total receipts				$0.00	
2. Variable costs					
Plants (greenhouse)	thou.	6.20	$34.50	$213.90	
Multipurpose fumigation	gal	10.50	$17.13	$179.87	
Fertilizer					
6-6-18	lb	$580.00	$.29	$168.20	
15.5-0-0	lb	$560.00	$.28	$156.80	
Lime (prorated)	ton	0.33	$55.75	$18.40	
Herbicides	acre	1.00	$55.47	$55.47	
Insecticides	acre	1.00	$46.07	$46.07	
Sucker control	acre	1.00	$188.38	$188.38	
Hauling	lb	2500.00	$0.05	$125.00	
Cover crop	acre	1.00	$25.00	$25.00	
Curing fuel	gal	325.00	$1.29	$419.25	
Electricity	kwh	1580.00	$0.08	$126.40	
Crop insurance	$	1.00	$120.00	$120.00	
Irrigation	cycle	3.00	$80.01	$240.03	
Baling supplies	$	2500.00	$0.003	$7.50	
Tractor/machinery	acre	1.00	$275.49	$275.49	
Labor					
Preharvest	hrs	46.25	$9.98	$461.58	
Harvest/baling	hrs	23.54	$9.98	$234.93	
Post harvest	hrs	9.00	$9.98	$89.82	
Interest on op. capital	$	$651.29	5.0%	$32.56	
Total variable costs				$3,184.65	
3. Income above variable costs					
4. Fixed costs					
Tractor/machinery	acre	1.00	$234.54	$234.54	
Bulk barn	acre	1.00	$132.58	$132.58	
Baler	acre	1.00	$7.50	$7.50	
Irrigation	acre	1.00	$67.08	$67.08	
Total fixed costs				$441.70	
5. Total costs				$3,626.35	
6. Net returns to land, risk, and management					

** Crop insurance: 65% based premium. No disaster subsidies.*

** Please note: This budget is for planning purposes only.*

Prepared by Gary Bullen and Loren Fisher, North Carolina State University, Department of Agricultural and Resource Economics.

Table 1-7. Flue-cured tobacco—hand harvest—piedmont North Carolina: 2013 estimated costs per acre

	Unit	Quantity	Price/Cost per Unit	Total per Acre	Your Farm
1. Gross receipts					
Stalk position		**Yield**	**Price/lb**		
Lugs	lb	0.00	$0.00	$0.00	
Cutter	lb	0.00	$0.00	$0.00	
Leaf	lb	0.00	$0.00	$0.00	
Tips	lb	0.00	$0.00	$0.00	
Total receipts				$0.00	
2. Variable costs					
Plants (greenhouse)	thou	6.00	$34.50	$207.00	
Multipurpose fumigation	gal	10.50	$17.13	$179.87	
Fertilizer					
6-6-18	lb	580.00	$0.29	$168.20	
15.5-0-0	lb	560.00	$0.28	$156.80	
Lime (prorated)	ton	0.33	$55.75	$18.40	
Herbicides	acre	1.00	$55.47	$55.47	
Insecticides	acre	1.00	$46.07	$46.07	
Sucker control	acre	1.00	$188.38	$188.38	
Hauling	lb	2500.00	$0.05	$125.00	
Cover crop	acre	1.00	$25.00	$25.00	
Curing fuel	gal	325.00	$1.29	$419.25	
Electricity	kwh	1580.00	$0.08	$126.40	
Crop insurance	$	1.00	$120.00	$120.00	
Irrigation	cycle	3.00	$80.01	$240.03	
Baling supplies	$	2500.00	$0.003	$7.50	
Tractor/machinery	acre	1.00	$157.14	$157.14	
Labor					
Preharvest	hrs	46.25	$9.98	$461.58	
Harvest/bailing	hrs	59.60	$9.98	$594.81	
Postharvest	hrs	9.00	$9.98	$89.82	
Interest on op. capital	$	$588.67	5.0%	$29.43	
Total variable costs				$3416.15	
3. Income above variable costs					
4. Fixed costs					
Tractor/machinery	acre	1.00	$93.29	$93.29	
Bulk barn	acre	1.00	$132.58	$132.58	
Bailer	acre	1.00	$7.50	$7.50	
Irrigation	acre	1.00	$67.08	$67.08	
Total fixed costs:				$300.45	
5. Total costs				$3,716.60	
6. Net returns to land, risk, and management					

** Crop insurance: 65% based premium. No disaster subsidies.*

** Please note: This budget is for planning purposes only.*

Prepared by Gary Bullen and Loren Fisher, North Carolina State University, Department of Agricultural and Resource Economics.

2. Complying with North Carolina Farm Labor Regulations

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Tobacco growers who employ workers must comply with a set of ever-changing federal and state farm labor laws, including laws pertaining to migrant labor, tax withholding, minimum wage rates, and insurance. This summary provides only a general overview of the laws that affect farm workers. For detailed information about your legal requirements as an agricultural employer, contact the appropriate agency.

Immigration

The Immigration Reform Control Act of 1986 requires employers to hire only U.S. citizens and aliens who are authorized to work in the United States. Employers must complete the I-9 form for every employee hired after 1986. The I-9 must be completed within the first three days of employment or on the first day of employment if the length of employment is less than three days. Employers must keep the I-9 either for three years or for one year after the end of employment, whichever is longer. The I-9 form is designed to verify an individual's identity and eligibility to work in the United States. An employer must accept documents that are listed on the I-9 as verification. An employer is not allowed to request additional documentation or to refuse documents that appear authentic. Employers may not refuse to hire a worker whose employment authorization expires at a later date. For forms and additional information about this requirement, contact United States Citizenship and Immigration Services, Charlotte Suboffice, 6130 Tyvola Centre Drive, Charlotte, NC 28217, or visit the bureau's Web site: www.uscis.gov.

E-Verify became mandatory on July 1, 2013, for businesses that have more than 25 employees. Employers that hire temporary seasonal workers for fewer than nine months within a consecutive 12-month period and private employers with 24 or fewer employees are not required to use E-Verify. At the time of this writing, it is not clear whether the E-Verify hiring requirement applies to an employer who does not employ 25 or more workers on a permanent basis if that employer brings more than 25 workers on a temporary or time-limited basis.

E-Verify is a free Internet-based system for matching an employee's Social Security number with other I-9 information. In most cases, employers who submit an employee's information to E-Verify will receive one of two types of feedback from the system: either the information is verified, or the system returns a tentative nonconfirmation (TNC). If an employer receives a TNC for an employee, the employer should follow the directions that E-Verify provides. E-Verify is not a replacement for the I-9 form and should not be used until after an employee has completed the I-9 form. E-Verify can be used only for new hires. Although use of the E-Verify system is voluntary for some employers, once an employer uses E-Verify for one new hire, the employer must continue to use it for all new hires. Many other rules, regulations, and requirements apply to E-Verify, and employers must understand them. Go to www.nclabor.com/legal/e_verify.htm for North Carolina regulations. Also, go to www.uscis.gov and select "E-Verify Home page" in the far right-hand column. Be sure to read all information on the E-Verify site, particularly the E-Verify Quick Reference Guide and E-Verify User Manual for Employers under "Manuals and Guides" and information on employees' rights under "For Employees."

Employment Discrimination

Employers who employ 15 or more workers must consider all qualified applicants for employment. All employees, including part-time and temporary workers, are counted for this purpose. Employment includes, but is not limited to, the employment application, hiring, promotion, pay, and termination. The Civil Rights Act of 1964 prevents employment discrimination against individuals because of their membership in a protected class. Protected classes are currently defined as race, color, religion, sex, age (40 and older), disability, and national origin. For details, contact the U.S. Equal Employment Opportunity Commission: www.eeoc.gov.

Taxes

Social Security and Medicare Taxes

Agricultural employers must withhold and pay Social Security taxes on wages paid to their employees if they employ one or more agricultural workers (including parents, children age 18 or older, and spouses) and they meet either of these two requirements:

- They paid the employee at least $150 in cash wages in the year.
- They paid a total of at least $2,500 in cash wages to all employees in the year.

The 2014 Social Security rate was 6.2% for both the employee and employer portions. The maximum annual wage on which Social Security taxes must be paid will be $117,000 in 2014. Medicare tax remains at 1.45% for both employee and employer, with no wage limit. Self-employed producers must pay both portions of the Social Security and Medicare taxes. Agricultural employers are exempt from withholding and paying Social Security taxes on wages paid to work-authorized aliens under the H2-A program. For more information, contact the United States Social Security Administration or visit the agency's website: www.ssa.gov.

Income Taxes

Agricultural producers must withhold federal and state income taxes from agricultural wages if the wages are subject to Social Security tax withholdings. Each employee should complete both form W-4 (Employee's Federal Withholding Allowance Certificate) and form NC-4 (North Carolina Employee's Withholding Allowance Certificate). The employer should keep copies of both documents.

Unemployment Taxes

Employers must pay federal and state unemployment tax if they paid cash wages of $20,000 or more for agricultural labor during any calendar quarter in the current or preceding year or if they employed at least 10 persons in agricultural labor for some portion of the day in 20 different weeks during the preceding calendar year. H2-A wages are considered for meeting the $20,000 wage test. This tax may not be deducted from the employee's salary. Federal unemployment tax is paid only on the first $7,000 of each employee's wages. The federal tax rate is 6.0%. A credit of up to 5.4% is usually granted, depending on the situation, making the effective tax rate 0.6%. North Carolina unemployment tax is paid only on the first $20,900 of each employee's wages in 2014. The state tax rate is between 0% and 6.84%, depending on the credit or debt ratio. The new-business starting rate is 1.2%.

For detailed information about federal unemployment taxes, contact the Internal Revenue Service. The IRS has 10 local offices in North Carolina; to find the nearest one, visit www.irs.gov or call (800) 829-4933. For information about state income taxes, contact the North

Carolina Department of Revenue, 501 North Wilmington St., Raleigh, NC 27604. Phone: (877) 252-3052. Web: www.dor.state.nc.us. You may also contact the Employment Security Commission of North Carolina, 700 Wade Ave., Raleigh, NC 27605. Phone: (919) 707-1170. The ESC has many regional offices. To find the nearest one, visit www.ncesc.com.

Workers' Compensation

Any agricultural employer who regularly employs 10 or more full-time workers must purchase workers' compensation insurance from a private insurer to cover employees should they sustain an injury on the job or contract an occupational disease. Agricultural employers who employ H2-A workers must have workers' compensation insurance regardless of the total number of employees. Specific information on workers' compensation is available from the North Carolina Industrial Commission: (919) 807-2500; (800) 688-8349; or www.ic.nc.gov.

Minimum Wage

The federal minimum wage is $7.25 per hour. Agricultural employers are exempt from paying the minimum wage if they employed fewer than five hundred man-days of agricultural labor in any quarter of the preceding year. A man-day is defined as any day in which one employee is employed for one hour or more. A farm will generally fall under the man-day provision if six or fewer full-time employees are hired.

Travel time to a job site is considered as hours worked, and the employee must be paid for those hours if his or her job would be affected in any adverse way by not using company transportation. For example, if the employee receives instructions during the trip, loads equipment on vehicles, or is required to use company transportation, the trip time must be considered as hours worked. For additional information, contact the U.S. Department of Labor, Employment Standards Administration, Wage and Hour Division, (866) 4-US-WAGE, or visit the division's Web site: www.dol.gov/WHD.

Overtime

The U.S. Department of Labor's new Fair Pay Overtime Initiative does not affect agricultural labor. Agricultural employers are still exempt from paying overtime (1.5 times the regular hourly wage rate for any hours worked in excess of 40 in one week). Christmas tree production is agriculture and is thus exempt. (See U.S. Department of Labor v. NC Growers Association appeal case.)

If an employee performs a mix of agricultural and nonagricultural work within the same week, such as working in the field and selling products at a roadside stand, then the entire week is considered nonexempt. For these nonexempt employees, overtime is calculated per work week, not per pay period. For example, assume that a nonexempt employee is paid every two weeks and works for 46 hours one week and 34 the next in the same pay period. In that scenario, the employer owes the employee 74 hours of standard pay and 6 hours of overtime. For more information, contact the U.S. Department of Labor's Wage and Hour Division at the phone number or web address noted above.

Child Labor Provisions

The minimum age for working in agriculture is 16 if the job is considered hazardous or is performed during school hours. Minors of age 14 or 15 may work in agriculture if the job is not during school hours and not hazardous. An exception is made for operating hazardous equipment if the minor has completed the 4-H training programs for tractor and machine operation through the Cooperative Extension Service of a land-grant university and received the appropriate certification. Minors of age 12 or 13 may be employed with their parents' written consent on a farm where their parents are also employed. Minors of any age may be employed at any time in any occupation on a farm owned and operated by their parents.

In North Carolina it is illegal to hire any youth younger than age 18 unless the youth and a parent or guardian have completed a youth employment certificate, a form provided by the North Carolina Department of Labor. The employer must keep a copy of the properly signed and witnessed certificate on file. This certificate serves as an official statement of the child's age and will serve as a defense against accusations of some child-labor violations. To receive a youth employment certificate or further information, contact the North Carolina Department of Labor at (800) NCLABOR, or visit the department's website: www.nclabor.com.

No child who is younger than age 12 may ride in an open bed or cargo area of a vehicle that is without permanent overhead restraining construction. Exceptions may be made under certain specific circumstances, such as when an adult is present in the bed or cargo area of the vehicle, and the adult is supervising the child. For detailed information about vehicle safety laws, contact the Governor's Highway Safety Program, North Carolina Department of Transportation,(800) 999-9676, or visit the program's website: www.ncdot.org/programs/ghsp.

Joint Employment

The term joint employment denotes a situation in which an individual is considered an employee of two or more persons. Joint employment situations often arise with individuals employed by farm labor contractors and farm owners. If a joint employment relationship exists and a crew leader is unable to pay wages to workers or taxes to the government, then the farm owner could be liable. Joint employment is determined by the following factors:

- Nature and degree of control over workers
- Degree of supervision
- Power to determine pay rates
- Right to hire, fire, or modify employment conditions
- Preparation of payroll and payment of wages

Vehicle Insurance

Agricultural employers, in general, are subject to the Migrant and Seasonal Agricultural Worker Protection Act (MSPA) if they employed five hundred man-days of labor during any calendar quarter. The MSPA requires $100,000 worth of vehicle insurance for every seat in the vehicle. For example, a 15-passenger van must have $1.5 million of insurance. The maximum requirement, including buses, is $5 million per vehicle. For additional information about vehicle insurance, contact the U.S. Department of Labor, (866) 4-USA-DOL, or visit the department's MSPA compliance site: www.dol.gov/compliance/laws/comp-msawpa.htm.

Farm Labor Contractors

A farm labor contractor is a person who recruits, solicits, hires, employs, furnishes, transports, or houses agricultural labor. Commonly known as a crew leader, such a contractor works mostly with migrant or seasonal workers. A farm labor contractor must obtain the appropriate authorization certificates to house and transport laborers and drive transportation. Under joint employment laws, if a farm labor contractor performs a function he or she is not certified in, the farm owner could be held liable. The appropriate certificates of authorization may be obtained by the farm labor contractor from the Wage and Hour Bureau of the North Carolina Department of Labor: (800) NC-LABOR or www.nclabor.com/wh/wh.htm. Authorization certificates may also be obtained from any office of the North Carolina Employment Securities Commission. To find an office in your area, call (919) 733-4329 or visit www.ncesc.com.

Migrant Housing

If an agricultural producer provides housing to one or more migrant or seasonal workers, the workers are covered under the Migrant Housing Act. The producer must register the housing and notify the North Carolina Department of Labor 45 days before any workers arrive. The housing must meet certain standards, which can be obtained from the North Carolina Department of Labor's Bureau of Agricultural Safety and Migrant Housing. To register migrant housing, call (919) 807-2923 or obtain the registration form online: www.nclabor.com/ash/ashform.htm.

Field Sanitation

Agricultural employers who employ 11 or more workers on any given day or provide housing for one or more workers must provide:

- One field toilet per 20 workers or fraction thereof
- Hand-washing facilities
- Suitable cool, potable drinking water with individual cups

Poster Requirement

Some North Carolina employers are required to place government posters in conspicuous places that explain employees' rights. If an employee is illiterate, then the poster information must be read to the employee in a manner they can comprehend. These posters are available free of charge from the website listed below. There is no need to buy these free posters from companies who are trying to sell them.

Not all operations will be covered by the same statutes, so the requirements vary by individual business. Visit the following website to determine which poster you are required to display: http://www.dol.gov/oasam/programs/osdbu/sbrefa/poster/matrix.htm.

New Hire Reporting

North Carolina employers are required to report to state government the names, addresses, Social Security numbers, dates of birth, and dates of employment of all new employees. Employers are also required to report their names, addresses, and state employer identification numbers. This must be done within 20 days of a new hire's initial employment. An employer can complete a special form or make a copy of the new employee's W-4, plus the additional information, and send it to the New Hire Reporting Program, P.O. Box 900004, Raleigh, NC 27675-9004. An employer can also submit the information electronically at http://newhire-reporting.com/NC-Newhire/default.aspx. For more information, call (888) 514-4568.

The North Carolina Department of Labor administers the state's labor laws. For detailed information about wages and overtime, child labor laws, migrant labor, work conditions, and other labor laws that affect agricultural workers, contact the department: (800) NCLABOR or www.nclabor.com.

New Laws and Regulations

Many changes in labor law are being proposed at the time of this writing (November 2013). All producers are encouraged to stay informed about changes that may occur before this guide is published again.

3. Selecting a Variety

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According to a recent survey, NC 196 was the most popular variety of flue-cured tobacco planted in North Carolina during 2013. NC 196 was grown on 54% of the tobacco acres in the state. Other popular varieties were K 326 (10%), NC 71 (6%), CC 27 (5%), and NC 299, K 346, GF 318, and CC 27 (3% each). Figure 3-1 shows the most popular varieties planted since 2009. To select the right variety for your fields, consider the information produced during variety testing at a research station in your area.

Variety Testing

The variety testing program conducted through the Agricultural Research Service at North Carolina State University evaluates breeding lines through the Regional Minimum Standards Program and commercial varieties through the North Carolina Official Variety Test.

The purpose of the Regional Minimum Standards Program is to ensure that varieties planted by growers are acceptable to the tobacco industry. Once a breeding line is genetically stable, it can be entered into the Regional Small Plot Test (RSPT) conducted cooperatively by university researchers in Georgia, South Carolina, North Carolina, and Virginia. Breeding lines that pass the minimum standards for chemical quality in the RSPT can be entered in the Regional Farm Test (RFT). In the RFT, researchers plant breeding lines at nine locations. Four of the RFT locations are in North Carolina. If a breeding line passes the RFT, which includes a smoke test, it is eligible for release as a commercial variety.

The purpose of the North Carolina Official Variety Test (OVT) is to assist growers with variety selection. The OVT is conducted at these research stations:

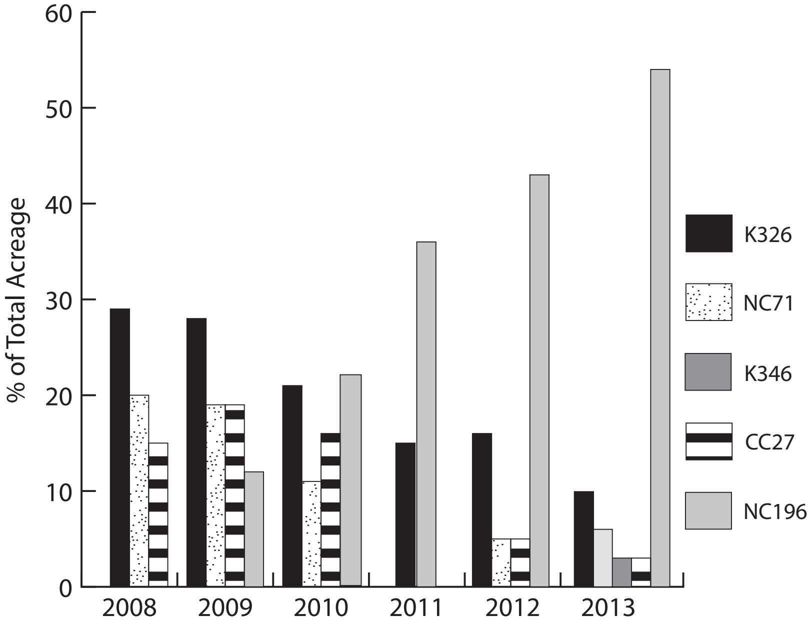

Figure 3-1. County Extension agent estimates of plantings of several popular varieties, 2009 to 2013

Border Belt Research Station—Whiteville
Lower Coastal Plain Research Station—Kinston
Upper Coastal Plain Research Station—Rocky Mount
Oxford Tobacco Research Station—Oxford

Note that the OVT is conducted in fields with little, if any, soil-borne disease, such as black shank and Granville wilt. Therefore, the yield and quality differences among varieties will differ depending on disease pressure. For example, K 326 is one of the highest-yielding varieties in the OVT, but its yield would be much lower in fields with high pressure from black shank and Granville wilt.

Variety Selection

The research findings reported in this guide can help you select the right variety for your fields.

Consider disease resistance first. Table 8-3 in chapter 8, "Managing Diseases," provide a list of popular varieties and their ratings for resistance to black shank and Granville wilt, the two diseases that pose the most serious threats to flue-cured crops in North Carolina. (Table 8-3 also lists varieties' resistance to tobacco mosaic virus.) Determine the level of disease resistance that you need based on field history, length of rotation, and crops grown in rotation with tobacco.

After you determine the necessary level of disease resistance, consider agronomic characteristics, such as yield, quality, and holding ability. Multiyear data, such as the three-year average shown in Table 3-1 and the two-year average shown in Table 3-2, are better than single-year data. Averaging information across years removes much of the environmental effect and provides a stable picture of a variety's performance over time. However, single-year data (Table 3-3) and individual location data (Tables 3-4 through 3-7) are helpful when you wish to see data collected from a specific growing region and under certain climatic conditions.

Consider holding ability—the ability of a variety to hold its ripeness during the harvest period. Figures 3-2 through 3-7 in this chapter compare the value of the last priming for several popular varieties based on harvest schedule.

New Varieties

CC 143, GL 395, and NC 925 are new varieties available for 2014. Agronomic data for these new varieties can be found in Tables 3-1 through 3-7. Disease resistance information can be found in chapter 8, "Managing Diseases."

Table 3-1. Performance of commercial varieties in the North Carolina Official Variety Test, three year average, 2011-2013

Variety	Yield (lb/a)	Value ($/a)	Price ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in.)	Leaf Spacing (in.)	Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
CC 13	2667	4696	176.18	86	65	17.8	39	2.17	15.76	2.55	7.6
CC 27	2718	4561	168.9	83	65	17.8	38	2.15	15.46	2.74	7.07
CC 304	2559	4267	166.06	81	63	17.6	40	2.27	16.16	2.84	6.96
CC 33	2601	4519	173.23	85	67	18.3	39	2.12	15.55	2.57	7.56
CC 37	2583	4390	170.55	84	66	17.7	38	2.17	16.3	2.73	7.1
CC 67	2495	4254	170.92	84	64	18.1	39	2.18	15.84	2.79	6.88
CC 700	2733	4582	169.66	83	64	17.5	38	2.2	16.51	2.77	6.91
GF 318	2727	4721	172.69	84	64	17.9	40	2.26	17.12	2.69	7.17
GL 338	2601	4486	171.4	84	64	17.7	38	2.17	16.08	2.85	6.83
GL 368	2598	4298	164.95	81	65	17.9	40	2.22	15	3.28	5.46
GL 395	2636	4403	166.46	82	64	17.9	39	2.21	14.93	3.01	5.66
K 326	2921	5105	174.68	86	65	17.7	37	2.1	17.34	2.58	7.81
K 346	2356	4026	170.33	83	64	17.8	38	2.16	15.9	2.79	7.44
NC 196	2710	4702	173.2	85	68	18.1	38	2.13	16.61	2.63	7.44
NC 291	2706	4400	163.47	81	65	17.6	36	2.07	16.32	2.94	6.51
NC 297	2651	4421	165.81	82	65	17.8	37	2.09	16.21	3	6.58
NC 299	2733	4692	171.03	84	67	17.7	37	2.13	16.74	2.68	7.07
NC 471	2258	3867	171.28	83	66	18.4	41	2.21	15.71	2.98	6.65
NC 606	2469	4366	176.94	86	66	17.6	39	2.23	16.6	2.87	6.95
NC 71	2845	4769	166.74	82	65	17.5	36	2.07	16.12	2.96	6.15

Table 3-1. (continued)

Variety	Yield (lb/a)	Value ($/a)	Price ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in.)	Leaf Spacing (in.)	Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
NC 72	2734	4629	169.93	84	66	17.7	39	2.2	16.82	2.57	8.11
NC 92	2695	4442	164.07	81	66	17.9	39	2.17	16.67	3.21	6.19
NC 925	2689	4339	160.93	80	64	17.7	37	2.08	16.32	2.71	7.52
PVH 1118	2577	4439	171.96	84	64	17.9	39	2.21	15.9	2.86	6.6
PVH 1452	2562	4539	176.27	86	65	17.9	38	2.13	15.62	2.85	6.68
PVH 2110	2631	4349	163.99	80	69	19.1	40	2.09	15.76	2.55	7.71
PVH 2248	2615	4489	172.13	84	65	18.1	38	2.11	14.73	3	5.53
PVH 2275	2542	4320	170.63	83	65	18.1	39	2.14	15.27	2.71	6.82
SPEIGHT 168	2431	4141	170.5	84	66	17.8	37	2.11	15.62	2.84	6.6
SPEIGHT 220	2558	4338	168.84	82	66	17.8	38	2.14	15.27	3.1	5.84
SPEIGHT 225	2306	3969	171.17	84	64	17.7	38	2.17	14.87	2.76	6.63
SPEIGHT 227	2315	3919	168.21	82	67	18.3	38	2.08	15.55	2.69	7.05
SPEIGHT 236	2549	4403	171.21	84	66	17.7	38	2.14	15.07	2.72	6.87
Test Average	2599	4419	169.83	83	65	17.9	38	2.15	15.93	2.81	6.85

Table 3-2. Performance of commercial varieties in the North Carolina Official Variety Test, two-year average, 2012–2013

Variety	Yield (lb/a)	Value ($/a)	Price ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in.)	Leaf Spacing (in.)	Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
CC 1063	2750	4711	172.4	83	61	17.6	39	2.24	15.79	2.73	7.63
CC 13	2676	4770	178.46	86	62	17.6	39	2.24	16.2	2.37	8.63
CC 27	2747	4654	170.64	82	61	17.6	39	2.22	16.14	2.56	8.18
CC 304	2611	4378	167.91	81	60	17.3	41	2.39	16.63	2.65	8.02
CC 33	2623	4564	173.44	83	64	17.8	39	2.23	16.17	2.37	8.74
CC 35	2959	5120	171.84	82	66	18.5	44	2.37	17.53	2.37	9.62
CC 37	2592	4542	176.04	84	62	17.4	39	2.24	16.24	2.66	7.62
CC 67	2534	4343	172.27	83	61	18	41	2.26	16.29	2.62	7.75
CC 700	2686	4540	171.44	82	61	17.1	39	2.29	16.36	2.62	7.54
CC 901	2379	4222	177.37	85	61	17.4	39	2.25	16.42	2.69	8.2
GF 157	2449	4306	177	85	61	17.5	40	2.28	15.68	2.48	7.88
GF 318	2790	4906	176.31	85	60	17.7	41	2.36	17.65	2.59	7.91
GL 338	2540	4460	175.55	84	61	17.4	39	2.23	16.66	2.63	7.82
GL 368	2534	4319	169.71	82	63	17.7	40	2.29	16.1	3	6.43
GL 395	2604	4330	165.59	80	61	17.5	40	2.31	15.66	2.78	6.48
K 326	2868	5094	177.46	85	61	17.4	38	2.19	17.46	2.45	8.6
K 346	2375	4205	176.55	85	60	17.4	39	2.25	16.09	2.64	8.62
NC 196	2667	4678	175.02	84	64	17.7	39	2.2	17.01	2.46	8.45
NC 291	2749	4513	165.57	80	61	17.3	37	2.16	16.57	2.86	7.18
NC 297	2602	4304	165.15	80	61	17.5	38	2.19	16.66	2.73	7.57
NC 299	2794	4929	177.27	85	63	17.5	39	2.23	16.88	2.53	7.77
NC 471	2220	3951	178.22	85	62	17.8	41	2.28	16.68	2.77	7.87

Table 3-2. (continued)

Variety	Yield (lb/a)	Value ($/a)	Price ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in.)	Leaf Spacing (in.)	Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
NC 606	2450	4435	181.3	86	62	17.4	40	2.28	16.81	2.7	7.85
NC 71	2829	4729	166.93	81	61	17.1	36	2.14	16.32	2.82	6.69
NC 72	2657	4446	168.27	82	62	17.4	39	2.28	16.96	2.38	9.16
NC 92	2735	4628	168.65	81	62	17.7	40	2.26	17.32	2.86	7.14
NC 925	2562	4124	160.28	78	60	17.2	37	2.17	16.71	2.49	8.65
PVH 1118	2601	4554	175.15	84	61	17.6	40	2.29	16.5	2.63	7.55
PVH 1452	2562	4648	180.7	86	61	17.3	38	2.21	16.29	2.62	7.83
PVH 2110	2667	4607	172.45	83	64	18.8	41	2.19	16.7	2.4	9.04
PVH 2248	2625	4611	175.9	85	61	17.9	39	2.19	15.44	2.82	6.21
PVH 2254	2819	4680	168.13	81	62	18.5	41	2.25	17.23	2.34	9.67
PVH 2275	2506	4402	176.11	84	62	17.9	40	2.25	16.09	2.48	7.93
SPEIGHT 168	2361	4104	173.85	84	63	17.4	38	2.19	15.89	2.64	7.54
SPEIGHT 220	2534	4374	173.13	84	62	17.3	39	2.24	15.96	2.88	6.69
SPEIGHT 225	2252	3946	174.55	84	61	17.3	39	2.28	14.95	2.56	7.49
SPEIGHT 227	2334	4027	171.61	82	64	18	39	2.15	15.74	2.51	7.97
SPEIGHT 236	2542	4532	176.46	85	62	17.3	38	2.24	15.19	2.55	7.79
Test Average	2600	4492	173.02	83	62	17.6	39	2.25	16.39	2.61	7.89

Table 3-3. Performance of commercial varieties in the North Carolina Official Variety Test, combined over three locations, 2013

Variety	Yield (lb/a)	Value ($/a)	Price ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in.)	Leaf Spacing (in.)	Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
CC 1063	2723	4397	164.24	80	63	17.8	41	2.29	18.22	2.01	10.92
CC 13	2617	4596	176.05	85	64	17.8	41	2.34	18.62	1.66	12.42
CC 143	2758	4042	150.05	75	65	18.5	42	2.27	19.68	1.73	13.46
CC 27	2797	4321	156.18	77	63	17.8	41	2.31	18.61	1.83	11.7
CC 304	2522	4036	159.81	78	62	17.6	43	2.42	18.42	2.05	10.84
CC 33	2505	4066	162.6	79	66	18.6	42	2.28	18.58	1.6	12.63
CC 35	2661	4221	160.19	78	67	18.7	45	2.4	19.47	1.66	13.89
CC 37	2574	4350	171.15	83	65	17.8	42	2.34	17.9	1.94	10.49
CC 67	2494	4201	168.49	82	62	18.4	43	2.34	18.6	1.86	11.19
CC 700	2419	4041	169.12	82	63	17.5	40	2.27	17.96	1.91	10.37
CC 901	2235	3848	172.67	84	64	18.2	42	2.3	18.76	1.79	12.1
CU 110	2538	3804	150.88	75	62	18.5	42	2.28	17.83	1.76	11.73
CU 124	2391	4144	170.24	83	67	18.9	42	2.25	18.29	1.82	11.94
CU 144	2515	4046	161.64	80	64	18.3	42	2.3	19.02	1.77	12.09
GF 157	2445	4107	170.55	82	63	18.2	43	2.38	17.44	1.8	10.86
GF 318	2830	4689	166.77	81	62	17.9	43	2.41	18.36	1.84	10.36
GL 338	2439	4071	167.37	82	63	17.9	41	2.28	18.46	1.95	10.4
GL 362	2443	4208	168.57	82	62	17	39	2.28	19.59	1.81	12.48
GL 368	2224	3403	155.23	76	65	17.8	42	2.4	17.63	2.26	8.69
GL 395	2537	4076	159.95	78	63	18.2	42	2.29	17.4	2.14	8.65
K 326	2599	4288	166.96	81	64	17.8	40	2.28	18.83	1.77	11.67
K 346	2194	3640	166.8	81	62	17.8	41	2.31	18.73	1.88	12.8
NC 196	2544	4147	163.25	80	67	18.1	41	2.27	18.91	1.72	12.01

Table 3-3. (continued)

Variety	Yield (lb/a)	Value ($/a)	Price ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in.)	Leaf Spacing (in.)	Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
NC 291	2551	4012	159.06	78	64	17.9	39	2.17	18.99	1.99	10.4
NC 297	2297	3492	153.62	76	64	18	39	2.18	18.58	2.07	10.54
NC 299	2715	4468	167.23	82	65	18.2	41	2.27	18.36	1.86	10.44
NC 471	2107	3656	174.77	84	65	18.2	43	2.38	18.76	1.97	11.2
NC 606	2350	4166	178.33	86	64	17.6	42	2.41	19.11	1.87	11.15
NC 71	2737	3984	146.64	73	64	17.4	38	2.18	17.93	2.11	8.99
NC 72	2322	3720	161.63	80	65	18	41	2.31	18.36	1.69	12.92
NC 92	2604	4149	159.15	78	64	17.9	42	2.32	18.69	2.13	9.45
NC 925	2436	3318	137.15	70	62	17.6	39	2.25	18.47	1.78	12.02
NC 938	2847	4654	166.3	81	63	17	40	2.4	18.74	1.58	14.05
NC 939	2744	4389	160.17	78	63	17.3	40	2.34	18.21	1.77	10.98
PVH 1118	2445	4146	170.9	83	63	18.2	42	2.3	18.37	1.91	10.28
PVH 1452	2460	4327	175.56	85	63	17.8	40	2.27	17.79	1.94	10.74
PVH 2110	2468	3889	159.39	78	67	19.5	43	2.23	18.23	1.74	12.77
PVH 2248	2598	4390	170.04	83	64	18.2	41	2.24	17	2.2	8.11
PVH 2254	2485	4210	171.53	83	65	18.7	42	2.26	19.76	1.59	14.46
PVH 2275	2301	3944	172.41	84	65	18.7	42	2.27	18.77	1.76	11.52
SPEIGHT 168	2149	3750	173.32	84	65	17.5	39	2.23	16.76	1.94	10.37
SPEIGHT 220	2561	4400	170.8	83	64	18	41	2.29	17.68	2.11	9.01
SPEIGHT 225	2080	3554	170.47	83	64	17.7	41	2.31	16.62	1.86	10.6
SPEIGHT 227	2257	3868	169.82	82	66	18.3	41	2.23	17.91	1.76	11.45
SPEIGHT 236	2519	4419	172.17	84	65	17.3	41	2.37	17.47	1.79	11.25
Test Average	2490	4081	164.87	80	64	18.0	41	2.30	18.35	1.87	11.25

Table 3-4. Performance of commercial varieties in the North Carolina Official Variety Test at Kinston, NC, 2013

Variety	Yield (lb/a)	Value ($/a)	Price ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in.)	Leaf Spacing (in.)	Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
CC 1063	2574	4784	185.85	89	60	18.5	38	2.05	17.63	1.88	9.78
CC 13	2418	4500	186.08	89	63	18	40	2.24	18.23	1.48	12.48
CC 143	2437	4337	177.1	86	64	18.7	41	2.18	18.8	1.62	11.97
CC 27	2795	5185	185.54	89	60	17.7	40	2.26	18.13	1.6	12.02
CC 304	2202	3651	166.03	81	58	17.3	40	2.29	18.53	1.54	12.37
CC 33	2507	4508	179.77	87	65	19.1	41	2.12	17.73	1.25	14.55
CC 35	2728	4931	180.65	86	67	19.8	44	2.25	17.13	1.22	14.12
CC 37	2175	4024	184.86	89	63	18.1	39	2.16	18.07	1.46	12.5
CC 67	2219	4088	183.69	88	59	18.9	41	2.18	17.97	1.69	10.77
CC 700	2170	4034	185.88	89	60	18	38	2.1	17.17	1.56	11.07
CC 901	2305	4303	186.8	90	62	18.5	39	2.14	17.43	1.66	10.6
CU 110	2258	3613	159.89	79	62	18.7	37	1.99	16.03	1.55	10.44
CU 124	2453	4553	185.58	89	66	19.3	42	2.19	15.9	1.64	9.82
CU 144	2442	4346	179.02	87	64	18.7	40	2.14	19.97	1.5	13.51
GF 157	2032	3739	184.08	89	61	18.8	40	2.12	16.73	1.69	9.94
GF 318	2367	4358	184.09	88	58	18.3	40	2.19	17.17	1.6	10.88
GL 338	2239	3992	177.51	86	60	18.5	40	2.14	16.63	1.58	10.91
GL 362	2371	3952	166.24	81	59	17.1	35	2.05	18.73	1.67	11.42
GL 368	2310	3946	170.09	83	62	18.3	41	2.27	17.03	2.16	8.13
GL 395	2339	3975	170.73	84	61	18.3	39	2.13	16.63	1.98	8.53
K 326	2473	4563	184.48	89	63	18.4	39	2.11	18.37	1.55	12.03
K 346	2125	3808	179.39	86	58	18.4	38	2.05	17.53	1.71	10.43
NC 196	2323	3919	169.16	83	63	18.3	39	2.12	17.93	1.62	11.17

Table 3-4. (continued)

Variety	Yield (lb/a)	Value ($/a)	Price ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in.)	Leaf Spacing (in.)	Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
NC 291	2352	4322	183.71	88	60	18	36	1.98	17.2	1.73	10.06
NC 297	2284	4074	177.96	86	61	18.6	37	1.97	17.53	1.79	9.9
NC 299	2139	3974	185.81	89	64	17.6	38	2.15	17.7	1.65	10.79
NC 471	2066	3857	186.94	89	63	18.6	43	2.3	18	1.57	11.65
NC 606	2137	3948	184.76	89	61	18.7	40	2.14	18.7	1.83	10.26
NC 71	2664	4724	176.97	86	60	17.5	35	2.02	17.17	1.9	9.16
NC 72	2246	4168	185.56	89	62	17.9	38	2.12	18	1.55	12.18
NC 92	2526	4134	164.25	81	60	17.9	38	2.14	17.87	1.96	9.31
NC 925	2296	3414	149.7	75	61	17.9	37	2.08	18.53	1.44	13.04
NC 938	2536	4544	179.24	88	62	17.5	38	2.18	18.87	1.21	16.35
NC 939	2727	4832	176.95	86	60	17.8	38	2.15	17.93	1.6	11.23
PVH 1118	2291	4276	186.6	89	60	18.8	39	2.08	17	1.67	10.17
PVH 1452	2294	4192	182.02	88	61	17.6	39	2.22	16.5	1.68	10.11
PVH 2110	2528	4689	185.55	89	65	20	42	2.08	16.4	1.57	10.66
PVH 2248	2490	4650	186.77	89	62	18.1	38	2.08	15.47	2.01	7.87
PVH 2254	2594	4825	186.03	89	61	19.3	39	2.05	18.4	1.49	12.59
PVH 2275	2301	4285	186.24	89	64	18.6	39	2.11	16.87	1.61	10.62
SPEIGHT 168	2245	4147	184.6	89	63	17.8	37	2.06	14.8	1.98	7.54
SPEIGHT 220	2459	4336	176.39	86	60	17.8	39	2.18	18.3	1.73	10.59
SPEIGHT 225	2061	3777	183.2	88	64	18.1	39	2.14	15.17	1.76	8.86
SPEIGHT 227	2349	4335	184.49	88	66	19.5	40	2.04	16.7	1.55	10.79
SPEIGHT 236	2148	3697	171.03	84	63	18.1	38	2.11	17.47	1.58	11.12
Test Average	2355	4229	179.50	87	62	18.3	39	2.13	17.47	1.65	10.98

Table 3-5. Performance of commercial varieties in the North Carolina Official Variety Test at Oxford, NC, 2013

Variety	Yield (lb/a)	Value ($/a)	Price ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in.)	Leaf Spacing (in.)	Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
CC 1063	3109	4753	153.32	74	59	17.8	40	2.23	16.73	2.73	6.6
CC 13	2829	4979	175.97	84	59	18.7	41	2.18	17.07	2.28	7.75
CC 143	3597	4488	125.6	63	59	18.6	40	2.16	18.73	2.43	7.74
CC 27	3029	4101	135.78	68	59	18.3	39	2.14	17.67	2.61	7.05
CC 304	3051	5125	169.52	81	57	18.4	41	2.21	16.5	3.09	5.4
CC 33	2527	4292	170.21	81	60	18.9	41	2.19	19.57	2.07	9.55
CC 35	3145	4482	144.68	71	59	18.9	42	2.25	18.9	2.56	7.48
CC 37	2904	4432	152.34	74	58	17.2	40	2.3	16.9	2.8	6.08
CC 67	2836	4801	169.42	82	59	19.1	41	2.16	18.03	2.62	7.04
CC 700	3159	4803	153.56	75	61	17.5	38	2.18	17.33	2.75	6.37
CC 901	2587	4090	158.07	77	59	18.7	42	2.25	17.97	2.59	7.08
CU 110	3062	4395	143.7	71	58	19.1	41	2.17	17.77	2.46	7.24
CU 124	3025	5310	176.1	84	61	18.9	41	2.15	17.33	2.68	6.59
CU 144	2924	4549	157.01	76	58	18.5	40	2.19	16.7	2.48	7.25
GF 157	2991	4844	163.99	79	60	18.7	41	2.21	16.07	2.4	6.76
GF 318	3159	4789	152.04	74	59	18.7	44	2.34	17.9	2.22	8.2
GL 338	2923	4634	159.57	77	60	17.7	38	2.14	18.4	2.74	6.79
GL 362	2982	5790	194.24	91	60	17.9	39	2.19	17.8	2.48	7.78
GL 368	2861	3933	140.07	69	61	18	41	2.26	16.2	3.06	5.4
GL 395	3119	5009	158.16	76	58	18.7	41	2.22	17.6	2.74	6.42
K 326	2760	4251	156.13	76	60	18.4	40	2.2	18.67	2.39	8.16
K 346	2903	4562	157.5	76	60	18.6	41	2.19	17.03	2.84	6.05

Table 3-5. (continued)

Variety	Yield (lb/a)	Value ($/a)	Price ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in.)	Leaf Spacing (in.)	Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
NC 196	3162	5254	167.14	81	60	18.5	40	2.13	17.5	2.24	7.94
NC 291	3097	4401	142.86	70	60	18.7	40	2.14	18.53	2.65	7.23
NC 297	2828	3791	134.87	67	60	18.1	40	2.22	16.4	3.01	5.49
NC 299	3077	5064	165.68	80	60	18.9	40	2.12	17.83	2.15	8.31
NC 471	2537	4105	162.77	78	61	18.1	42	2.3	16.97	3.04	5.59
NC 606	2836	4660	163.09	79	60	17.5	40	2.32	17.7	2.45	7.29
NC 71	2963	3653	123.64	63	59	17.9	37	2.04	18.97	2.45	7.88
NC 72	3116	4573	149.31	73	61	18.3	41	2.22	16.47	2.45	6.94
NC 92	2817	4472	157.36	76	61	18.3	41	2.22	18.87	2.85	6.68
NC 925	3099	3914	126.22	64	59	18.2	40	2.18	16.67	2.68	6.37
NC 938	3618	5684	160.16	77	58	18.1	41	2.26	17.47	2.36	7.52
NC 939	2796	4597	164.7	80	59	18.1	38	2.11	17.5	2.33	7.52
PVH 1118	2804	4286	153.23	75	58	18.2	39	2.17	18	2.47	7.34
PVH 1452	3012	5334	177.89	84	59	18.7	40	2.16	16.97	2.52	7.12
PVH 2110	3009	4205	142.03	70	63	19.8	42	2.14	17.2	2.63	6.7
PVH 2248	2635	4180	158.83	77	58	18.3	40	2.19	17.23	2.55	6.82
PVH 2254	2918	4560	158.45	77	63	18.8	41	2.17	18.07	2.23	8.18
PVH 2275	2622	4035	153.77	75	60	19.3	42	2.18	18.63	2.3	8.56
SPEIGHT 168	2423	4351	178.62	85	62	17.9	39	2.21	15.57	2.53	6.61
SPEIGHT 220	2855	5223	181.36	85	59	17.9	40	2.24	16.6	2.84	5.93
SPEIGHT 225	2673	4366	163.53	78	59	18	40	2.23	15	2.62	5.75
SPEIGHT 227	2587	4458	171.39	82	60	18.1	39	2.19	17.6	2.46	7.56
SPEIGHT 236	3514	6589	189.4	90	60	18	40	2.22	15.5	2.56	6.21
Test Average	2944	4626	158.07	77	60	18.4	40	2.20	17.42	2.56	7.03

Table 3-6. Performance of commercial varieties in the North Carolina Official Variety Test at Whilteville, NC, 2013

Variety	Yield (lb/a)	Value ($/a)	Price ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in.)	Leaf Spacing (in.)	Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
CC 1063	2486	3655	153.55	76	69	17.2	44	2.6	20.3	1.43	16.37
CC 13	2605	4309	166.12	82	71	16.7	43	2.61	20.57	1.23	17.01
CC 143	2239	3301	147.43	75	73	18.2	45	2.48	21.5	1.14	20.67
CC 27	2567	3677	147.23	73	72	17.2	44	2.54	20.03	1.29	16.03
CC 304	2314	3333	143.89	73	71	17.2	48	2.77	20.23	1.53	14.75
CC 33	2482	3397	137.81	69	73	17.7	45	2.53	18.43	1.48	13.79
CC 35	2111	3249	155.24	77	76	17.5	47	2.71	22.37	1.19	20.07
CC 37	2644	4595	176.26	86	74	17.9	46	2.56	18.73	1.56	12.9
CC 67	2427	3712	152.36	77	69	17.1	46	2.68	19.8	1.28	15.76
CC 700	1929	3285	167.94	82	69	17.1	43	2.54	19.37	1.43	13.69
CC 901	1813	3149	173.14	84	70	17.3	43	2.52	20.87	1.13	18.62
CU 110	2295	3403	149.05	75	67	17.7	47	2.68	19.7	1.28	17.51
CU 124	1696	2570	149.05	76	73	18.3	44	2.41	21.63	1.14	19.41
CU 144	2179	3243	148.9	76	69	17.6	45	2.58	20.4	1.32	15.51
GF 157	2313	3737	163.58	80	68	17.3	49	2.82	19.53	1.32	15.87
GF 318	2965	4920	164.16	80	70	16.9	46	2.71	20	1.7	12
GL 338	2157	3587	165.03	82	70	17.5	45	2.55	20.33	1.54	13.51
GL 362	1976	2882	145.22	75	69	16.1	42	2.59	22.23	1.29	18.25
GL 368	1502	2330	155.52	77	72	17.1	45	2.66	19.67	1.57	12.54
GL 395	2154	3245	150.96	75	70	17.6	44	2.51	17.97	1.69	10.99
K 326	2564	4048	160.27	79	68	16.5	41	2.55	19.47	1.37	14.81
K 346	1553	2549	163.52	81	68	16.3	43	2.71	21.63	1.08	21.91
NC 196	2148	3268	153.45	77	78	17.4	45	2.56	21.3	1.29	16.94
NC 291	2203	3312	150.62	75	73	16.9	40	2.38	21.23	1.58	13.92

Table 3-6. (continued)

Variety	Yield (lb/a)	Value ($/a)	Price ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in.)	Leaf Spacing (in.)	Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
NC 297	1779	2611	148.03	74	70	17.2	40	2.36	21.8	1.41	16.23
NC 299	2929	4366	150.21	76	72	18.1	46	2.55	19.53	1.8	12.22
NC 471	1718	3004	174.6	85	71	17.9	45	2.54	21.3	1.3	16.35
NC 606	2078	3889	187.15	89	72	16.7	47	2.78	20.93	1.34	15.9
NC 71	2584	3574	139.3	71	72	16.8	42	2.49	17.67	1.99	9.94
NC 72	1604	2420	150.01	76	73	17.7	46	2.59	20.6	1.05	19.65
NC 92	2468	3842	155.82	78	71	17.5	45	2.6	19.33	1.57	12.37
NC 925	1913	2625	135.54	70	67	16.7	42	2.51	20.2	1.22	16.66
NC 938	2388	3733	159.48	80	68	15.3	42	2.76	19.9	1.16	18.29
NC 939	2710	3739	138.87	69	68	16.1	45	2.77	19.2	1.37	14.2
PVH 1118	2241	3877	172.88	84	70	17.7	47	2.64	20.1	1.58	13.32
PVH 1452	2075	3454	166.76	83	69	17.1	42	2.42	19.9	1.61	15
PVH 2110	1866	2772	150.59	75	72	18.6	46	2.46	21.1	1.02	20.94
PVH 2248	2670	4339	164.52	81	72	18.1	45	2.46	18.3	2.04	9.65
PVH 2254	1942	3245	170.11	83	71	18.1	46	2.56	22.8	1.03	22.6
PVH 2275	1979	3512	177.21	87	71	18.3	46	2.52	20.8	1.37	15.37
SPEIGHT 168	1780	2753	156.74	78	72	16.9	41	2.43	19.9	1.32	16.97
SPEIGHT 220	2369	3641	154.65	78	72	18.3	45	2.45	18.13	1.77	10.51
SPEIGHT 225	1505	2518	164.68	82	70	16.9	43	2.54	19.7	1.21	17.21
SPEIGHT 227	1835	2810	153.58	76	72	17.5	43	2.45	19.43	1.27	16.01
SPEIGHT 236	1895	2971	156.1	78	73	15.8	44	2.77	19.43	1.24	16.44
Test Average	2170	3388	157.05	78	71	17.3	44	2.58	20.16	1.39	15.75

Table 3-7. NC State University post-buyout grade index and 2013 price index

Company Buying Grade	*USDA Grade*	*Post-Buyout Grade Index (1-100)*	*2012 Price Index ($/CWT)*
P1	*P2F, P3F, P2L*	*85*	*170*
P2	*P3L, P4F*	*80*	*160*
P3	*P4L*	*70*	*140*
P4	*P5L, P5F*	*50*	*115*
P5	*P4G, P5G, N1L, N1GL*	*20*	*65*
X1	*X1F, X2F, X1L, X2L*	*90*	*170*
X2, X1H	*X3F, X4F, X3L*	*85*	*160*
X3, X2H, X3H	*X4L, X3KM, X3KR, X5F*	*70*	*140*
X4	*X5L, X4KR, X3V, X4V, X4KL, X4KF, X4KM, X3S*	*50*	*112*
X5	*X4KV, X4GK, X4G, X5G, N1XL, N1XO*	*25*	*65*
C1	*C1F, C2F, C1L, C2L*	*95*	*190*
C2, C1H	*C3F, C4F, C3L*	*90*	*185*
C3, C2H, C3H	*C5F, C4L, C4KR*	*80*	*158*
C4	*C5L, C4KM, C4KL, C4KF, C4V, C4S*	*60*	*122*
C5	*C4G, C4GK*	*30*	*75*
B1, B1X, B2X	*B1L, B2L, B1F, B2F, B1FR, B2FR*	*100*	*215*
B2, B1H	*B3F, B3K, B3FR, B4FR,*	*95*	*206*
B3, B2H, B3H	*B3L, B4F, B4K*	*85*	*188*
B4	*B4L, B3KM, B3KR, B4KM, B4KR*	*75*	*145*
B5	*B3V, B4V, B3KF, B3KL, B3S, B5L, B4S*	*60*	*120*
B6	*B4KL, B4KF, B5V, B5KL, B4KV, B5KV, B4GK, B5GK, B4G, B5G*	*40*	*70*
BT	*N1BO, N1R, N1GR, N1GG, N2*	*20*	*70*
T, T1X	*H3F, H4F, H4FR, H4K*	*100*	*213*
T2, T2X	*H5F, H5FR, H5K, B5FR*	*95*	*205*
T3, T1H, T2H	*B5F, B5K*	*90*	*185*
T4, T3H	*B5KR, B5KM*	*75*	*135*
T5	*B6K, H6K, N1K*	*60*	*100*
T6	*B6KV, N1KV*	*40*	*60*

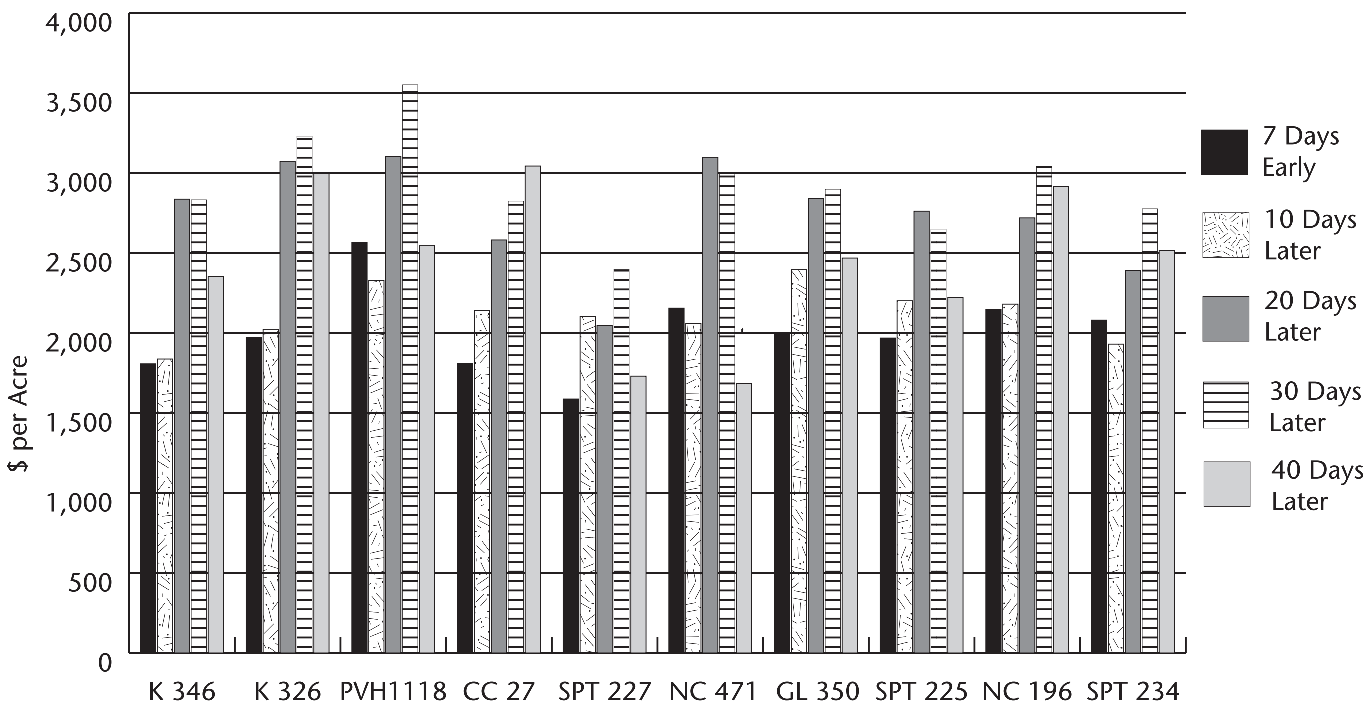

Figure 3-2. Effect of harvest schedule on the value of last priming, 2008

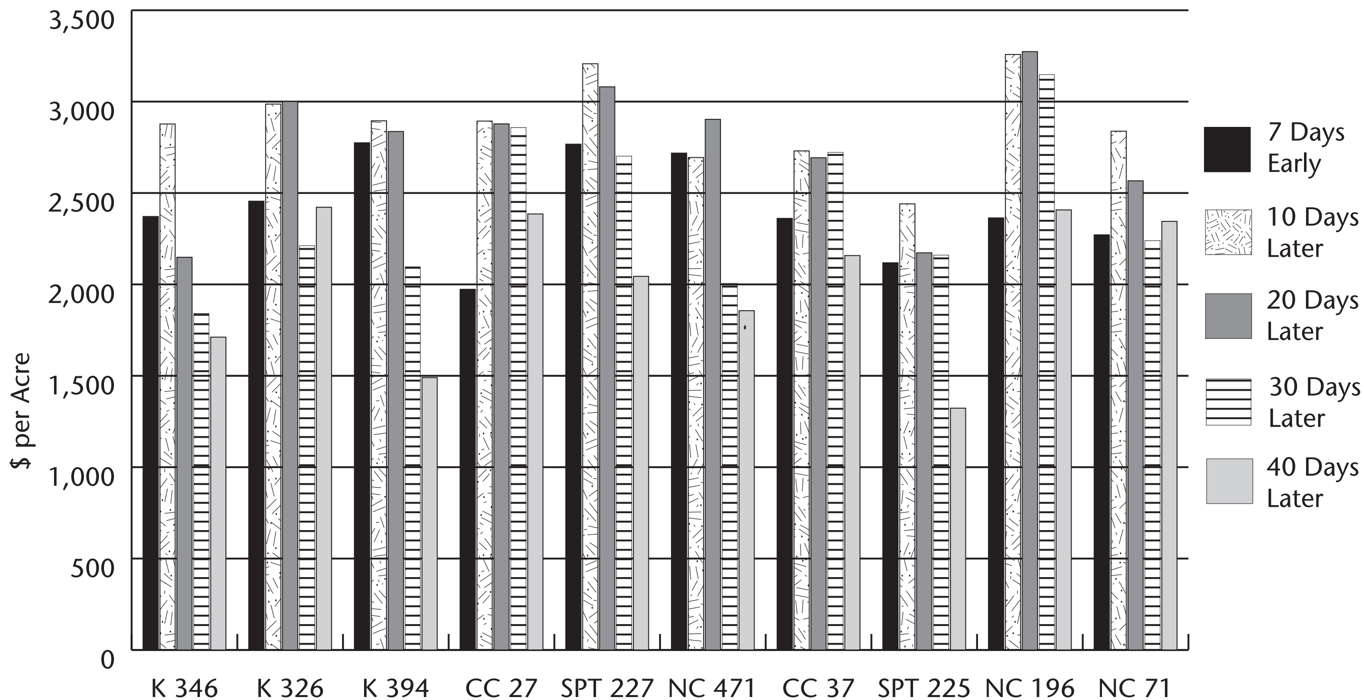

Figure 3-3. Effect of harvest schedule on the value of last priming, 2009

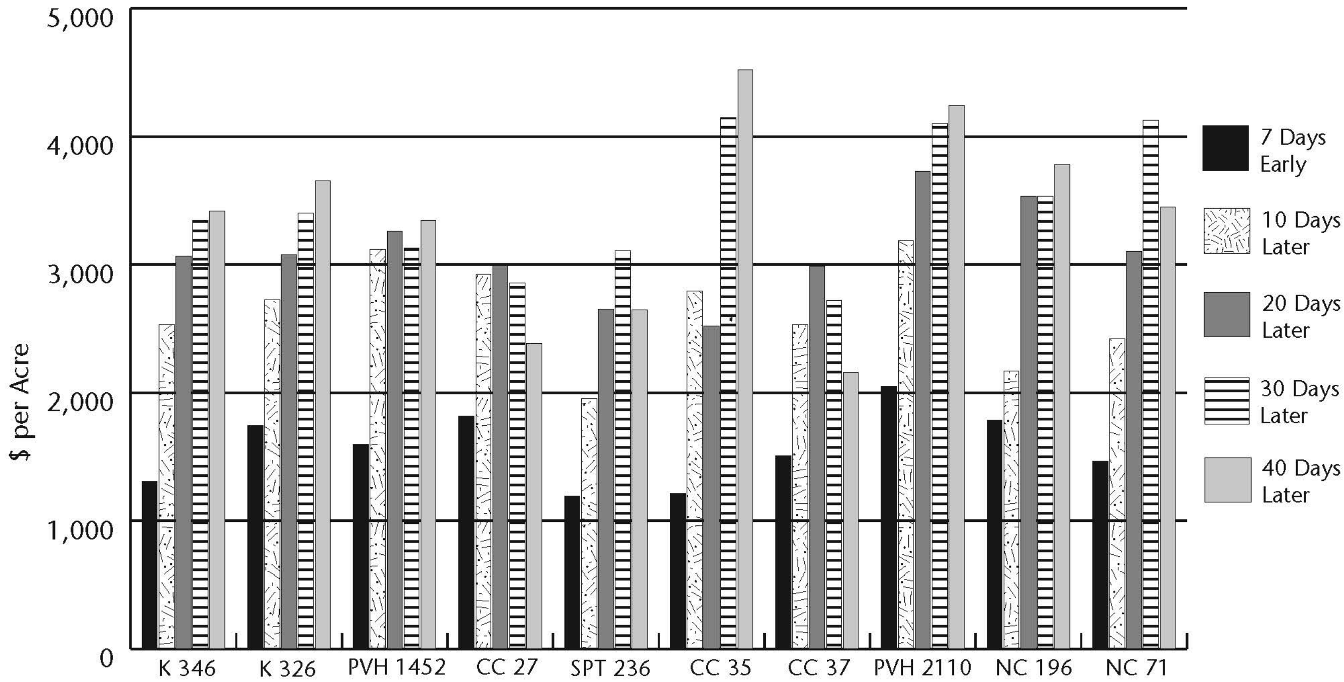

Figure 3-4. Effect of harvest schedule on the value of last priming, 2010

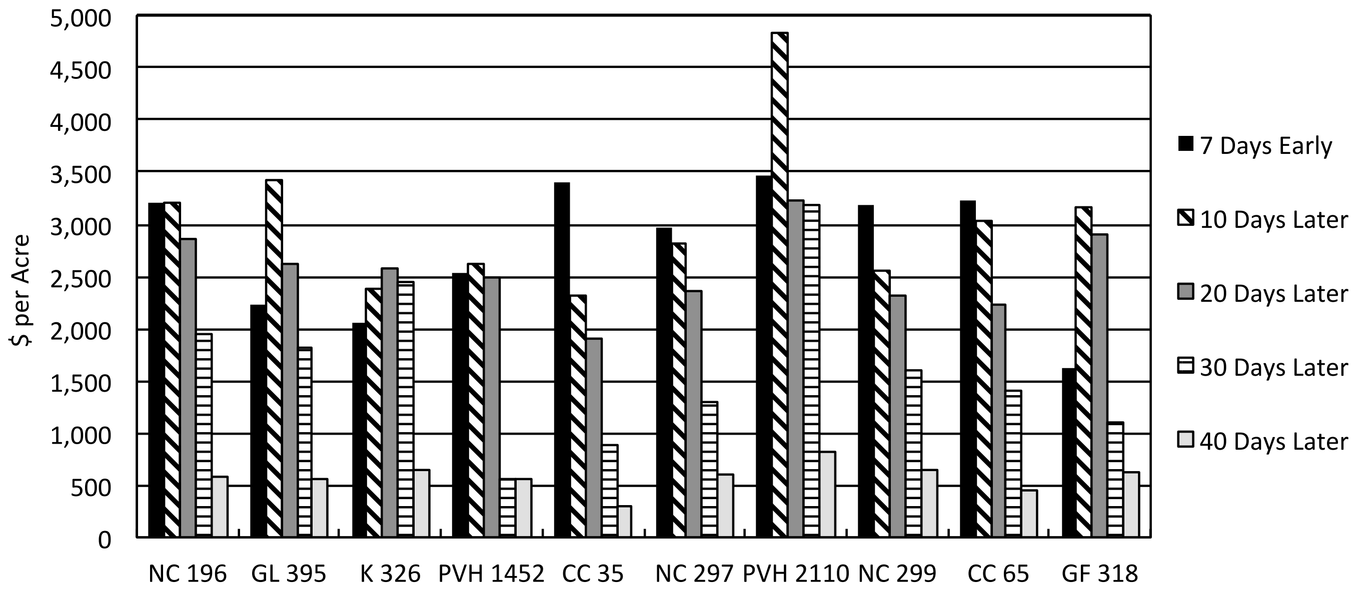

Figure 3-5. Effect of harvest schedule on the value of last priming, 2011

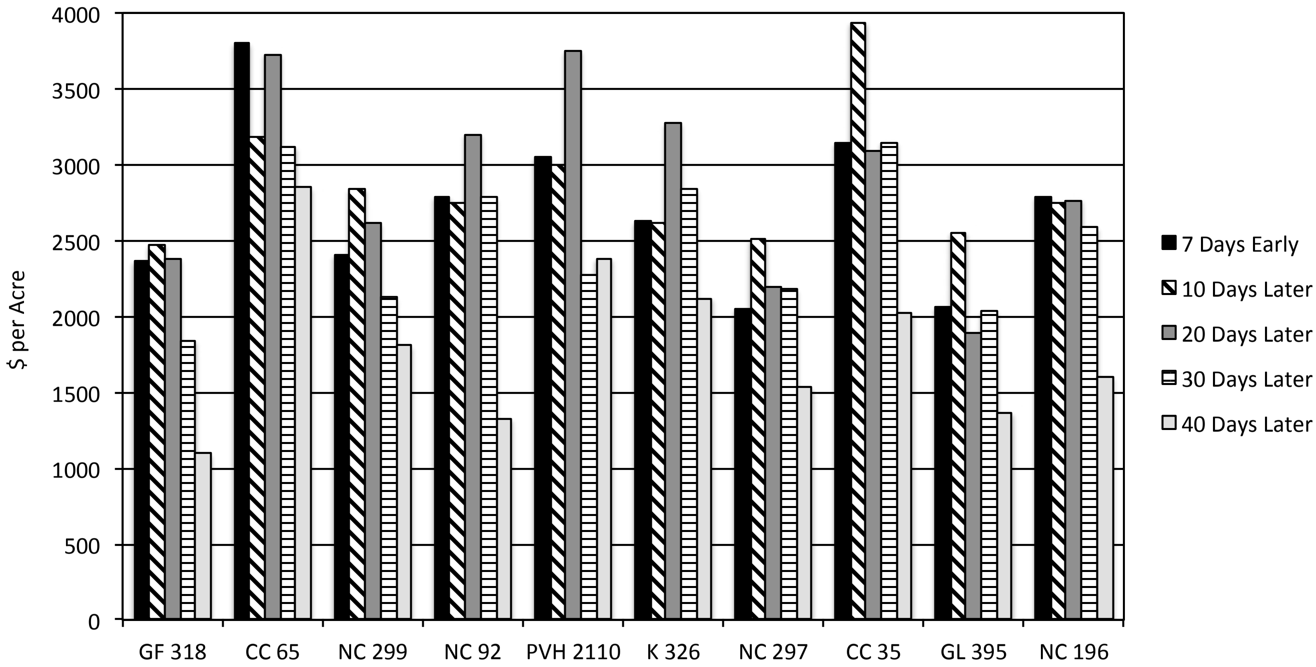

Figure 3-6. Effect of harvest schedule on the value of last priming, 2012

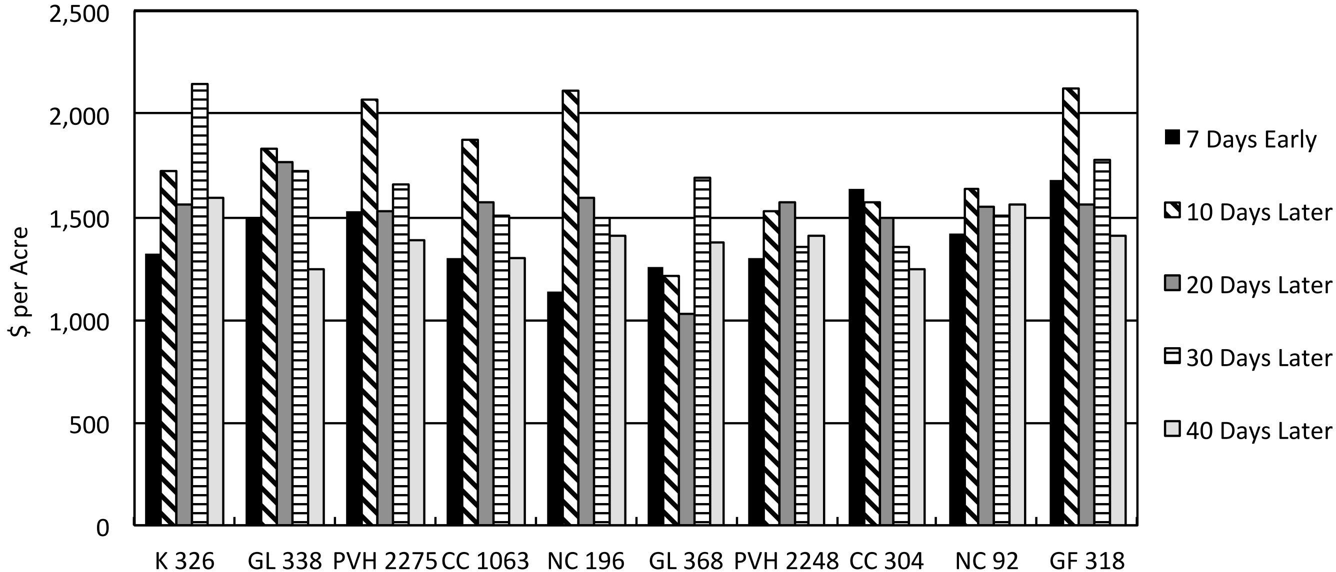

Figure 3-7. Effect of harvest schedule on the value of last priming, 2013

4. Producing Healthy Transplants in a Float System

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Profitability remains a concern to many growers as a result of rapidly increasing production costs. The first step in minimizing heating-fuel costs is to avoid seeding too early. Most growers have learned that it only takes 60 days to produce a transplant and that seeding before the second week in February increases fuel usage and the cost of transplant production.

Nearly all of the costs in transplant production are on a whole-greenhouse basis. Thus, the best way to decrease the cost on a per-transplant basis is to increase usability. Therefore, management practices that improve stands and promote uniform growth decrease production costs. Nearly all management practices affect usability, but these are some of the most important:

1. Consider the materials.
- Analyze the water source and manage alkalinity.
- Select a uniform, high-quality growing medium with a low and well-mixed nutrient charge.
- Consider tray design.
- Use seeds with high germination rates and acceptable pelleting materials.

2. Promote uniform emergence.
- Sow seeds during sunny periods.
- Fill trays uniformly.
- Place seeds uniformly (in the center of the dibble).
- Provide a warm temperature (68°F to 70°F at night).
- Control ants and mice.

3. Promote uniform growth.
- Monitor fertilizer salts in the medium and leach with water from overhead when necessary.

- Continue to analyze water and manage alkalinity when necessary.
- Clip properly.
- Manage insects and diseases.

4. Prevent stand loss.

- Provide proper ventilation and airflow to prevent heat injury.
- Avoid early seeding, high nitrogen rates, and hot daytime temperatures that promote stem rot diseases.
- Fumigate trays with methyl bromide or purchase new trays.

Consider the Materials

Analyze the Water Source and Manage Alkalinity

Water quality management is an important part of successful transplant production. Bicarbonate levels (alkalinity) are high in water from many areas, particularly in eastern counties, and boron is absent from the water in many counties in the piedmont. Have a water sample analyzed from each potential water source before beginning transplant production.

The North Carolina Department of Agriculture and Consumer Services (NCDA&CS) analyzes water at a nominal cost. Growers receive a detailed report about the nutritional suitability of each water sample for transplant production.

Collect a twenty-ounce sample from each potential water source. A clean, nonreturnable drink bottle with a screw-on cap makes an excellent sample bottle. Rinse the bottle (but do not use soap) several times and allow the water to run several minutes before collecting the sample. Forms and assistance are available from county Cooperative Extension centers.

Wells usually provide the most desirable water. Municipal sources are also satisfactory, but the water occasionally requires acidification to reduce bicarbonates. Avoid pond or river water unless it comes from a municipal source due to potential contamination with disease-causing organisms. Herbicides that injure tobacco also could be carried by soil runoff into farm ponds.

Select a High-Quality Growing Medium

Typical tobacco media consist primarily of peat combined with vermiculite and perlite in various proportions. Consider a medium's particle size distribution and nutrient charge to determine its suitability for transplant production. Particle size in a soilless medium is similar to soil texture and is determined by the relative amounts and size of the mix's components. The particle size distribution of a medium determines many characteristics that are important in plant growth, such as aeration, water holding capacity, drainage, and capillarity (wicking). Research has shown that a wide range of particle sizes is suitable. After you find a medium with a good range of particle sizes for tobacco production, make sure that it is free of sticks, stems, clods, and weed seeds. Evaluate its moisture content, uniformity, and fertilizer charge.

Consider Tray Design

A significant factor affecting tray cost to the grower is the cost of fuel. High natural gas prices have increased the cost of manufacturing, while high fuel prices have increased the cost of transportation and delivery.

Tray costs have always been an issue outside the United States because of shipping costs. Polystyrene trays are light, but they are bulky, which makes them expensive to ship. The high cost of growing medium is also a factor overseas. One way to reduce production and shipping costs is to decrease the depth of the tray, which allows more trays to be placed in a shipping container or on a truck. Shallower trays have the additional advantage of requiring less growing medium to fill the cell, which decreases the cost to a grower. Less on-farm storage space is required for shallow trays than for traditional-depth trays.

A few years ago, a glazed tray was introduced that has hardened sidewalls within the cell, which are formed by superheating during the manufacturing process. The idea is that the hardened sidewalls will resist root penetration and be easier to sanitize. However, the tray depth is slightly shallower than a traditional 288-cell tray. This difference in depth results in slightly smaller cells (15 cubic centimeters versus 17 to 17.5 cubic centimeters), which partially offsets the cost of glazing and decreases growing medium requirements by 12 percent. Observations suggest that fewer roots penetrate the tray, but research has not been conducted to determine if disease incidence is different with plants produced in glazed trays versus those produced in traditional trays.

Research has measured the effects of cell density and volume on transplant production (Tables 4-1 and 4-2). Researchers compared four trays differing in cell density and volume filled with three different growing media. They compared the the following trays:

1. A glazed 288-cell tray with a cell volume of 15 cubic centimeters and cell density of 122.5 cells per square foot in 2004 and a traditional 288-cell tray with a cell volume of 18 cubic centimeters and cell density of 122.5 cells per square foot in 2005.
2. A shallow, glazed 288-cell tray with a cell volume of 8.6 cubic centimeters and cell density of 122.5 cells per square foot.
3. A traditional two-hundred-cell tray with a cell volume of 27 cubic centimeters and cell density of 85 cells per square foot.
4. A shallow two-hundred-cell tray with a cell volume of 8.6 cubic centimeters and a cell density of 85 cells per square foot.

Results indicate that two-hundred-cell trays produced larger plants than 288-cell trays. However, there were no differences in plant size due to tray depth. Thus, in a float system, cell density is more important than cell depth (root volume) in affecting plant size. These results indicate that shallow trays can be used without reducing transplant quality and that all media evaluated would be suitable for shallow trays.

(Continued on page 51)

Table 4-1. Effect of cell volume and density on transplant production in the float system, 2004

Treatment	ISM[1] (%)	Spiral Root (%)	Total Plants (%)	Usable Plants (%)	Stem Length (cm)	Stem Diameter (mm)
Trays						
Glazed 288 traditional (15 cc per cell)	95	3	94	88	6.4	3.0
Glazed 288 shallow (8.6 cc per cell)	96	4	92	84	6.3	3.0
200 traditional (27 cc per cell)	96	3	95	90	7.0	3.6
200 shallow (8.6 cc/cell)	95	3	94	87	7.0	3.8
LSD (0.05)	NS	NS	NS	4	0.3	0.3
Growing Medium						
Carolina Gold	95	3	94	87	6.6	3.3
Carolina Choice	96	4	94	88	6.5	3.4
All peat, aggregate free—experimental	96	4	93	86	6.8	3.3
LSD (0.05)	NS	NS	NS	NS	NS	NS

[1] ISM = Modified Index of Synchrony, which is a measure of the uniformity of germination. It is calculated as the percentage of the total germination that occurred over a 48-hour period.
NS = Not statistically significant. Treatments should be considered similar.

Table 4-2. Effect of cell volume and density on transplant production in the float system, 2005

Treatment	Emergence (%)	Total Plants (%)	Usable Plants (%)	Stem Length (cm)	Stem Diameter (mm)
Trays					
288 traditional (17.5 cc per cell)	94	90	79	4.9	2.5
Glazed 288 shallow (8.6 cc per cell)	96	91	81	5.9	2.4
200 traditional (27 cc per cell)	94	91	84	6.2	2.9
200 shallow (8.6 cc/cell)	94	92	84	6.1	2.9
LSD (0.05)	2	NS	NS	0.4	0.3
Growing Medium					
Carolina Gold	93	87	78	5.7	2.6
Carolina Choice	95	93	84	5.8	2.6
All peat, aggregate free—experimental	95	93	84	5.9	2.7
LSD (0.05)	2	5	4	NS	NS

NS = Not statistically significant. Treatments should be considered similar.

(Continued from page 48)

Promote Uniform Emergence

Uniform emergence and growth are necessary to produce a high percentage of usable transplants. Research has shown that even a 3-day delay in emergence in 25 percent of the seedlings could reduce usability (Table 4-3). The researchers seeded random cells within a tray 3, 5, 7, or 12 days after seeding the rest of the tray. In general, the delayed treatments produced fewer usable seedlings than the initial seeding. These results show the importance of uniform emergence and that clipping will not correct the uneven growth from delayed emergence.

Fill and Seed Trays Uniformly

Begin seeding 50 to 55 days before the anticipated transplanting date using only high-quality, pelleted seeds. Make sure that one seed is placed in each cell. Misting trays from overtop after floating has

Table 4-3. Effect of staggered seedling emergence on transplant production, 1999–2000

Treatment	Total Stand at Day 50 %	Usable Transplants at Day 50 %
1999 Experiment		
Check (100% seeded day 1)	89 a	76 a
75% seeded day 1, 25% seeded day 5	89 a	59 b
75% seeded day 1, 25% seeded day 7	90 a	66 ab
75% seeded day 1, 25% seeded day 12	80 b	65 ab
2000 Experiment		
Check (100% seeded day 1)	95 a	91 a
75% seeded day 1, 25% seeded day 3	96 a	85 b
75% seeded day 1, 25% seeded day 5	97 a	78 c

Note: For each experiment, averages followed by the same letter in a column are not statistically different and should be considered similar.

not been shown to speed seedling emergence. However, the use of a premoistened medium decreases the amount of medium that falls through the holes in the bottom of the tray and increases the speed of emergence as compared to a dry medium. Overly wet media do not flow from the hopper box as uniformly as dry media. Be sure the trays are filled uniformly.

Wet new trays before filling them, and screen the planting medium if it contains sticks and clods. Use a moist medium, and pack the medium all the way to the bottom of the cell. Research indicates that taking these precautions will help to prevent dry cells within a tray. Dry cells create a common problem in float systems, particularly with new trays, because they float higher than old trays and because it is difficult to keep the medium from falling through the hole in the bottom of the tray.

Provide a Warm Temperature

The ideal germination temperature for tobacco seeds is approximately 68°F at night and 86°F during the day. Fuel use decreases 15 percent for every five-degree reduction in temperature. Therefore, after maximum seedling emergence is obtained, nighttime temperatures should be reduced to a range of 55°F to 60°F to conserve fuel usage. Daytime temperatures of 80°F to 85°F are adequate for normal growth. Heat injury (browning of leaves or seedling death) has been observed when air temperatures inside the structure exceed 110°F.

Different varieties respond in various ways to germination temperature, and it is very common to see differences in germination rate among varieties in the same greenhouse. The response of three popular varieties to temperature during germination is shown in Figures 4-1 through 4-6. In all varieties the germination was earlier at 68°F night and 86°F day than at 68°F night and 95°F day. However, the delay in germination from high temperatures differed greatly among varieties and, in some cases, between seed lots within a variety. These data show that higher than ideal temperatures, even as low as a 95°F day, can delay emergence, reduce uniformity of emergence, and sometimes even decrease total emergence. For a variety such as K 326, the delay in emergence at high temperatures is relatively small. However, for NC 71 and NC 297, the delay in germination is significant. It is important to remember that these studies were conducted in an incubator. Response to high temperature stress in a greenhouse will

(Continued on page 55)

Figure 4-1. Effect of temperature on the germination of K 326 (2003)

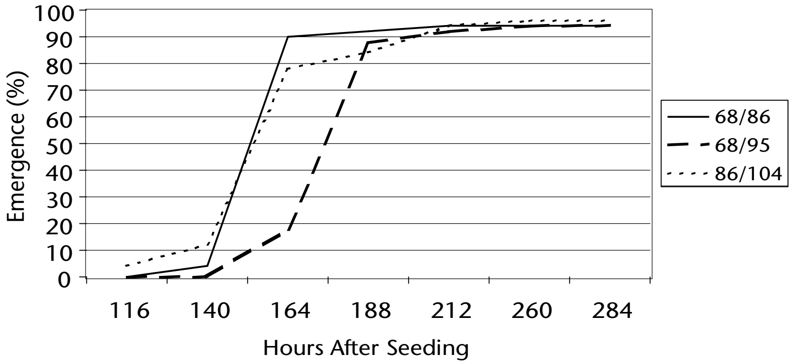


Figure 4-2. Effect of temperature on the germination of K 326 (2004)

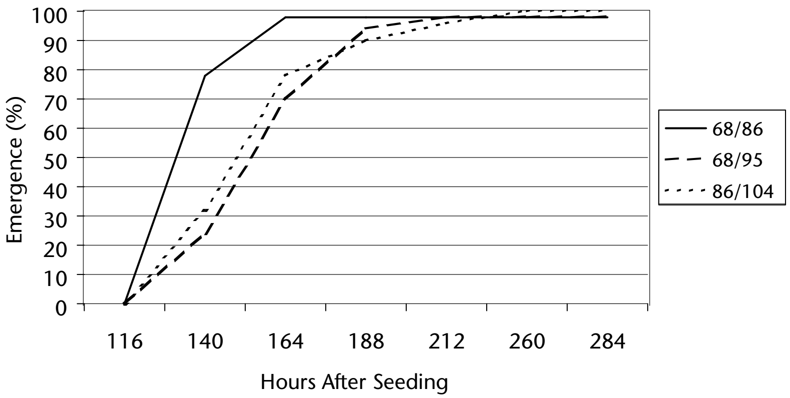


Figure 4-3. Effect of temperature on the germination of NC 71 (2003)

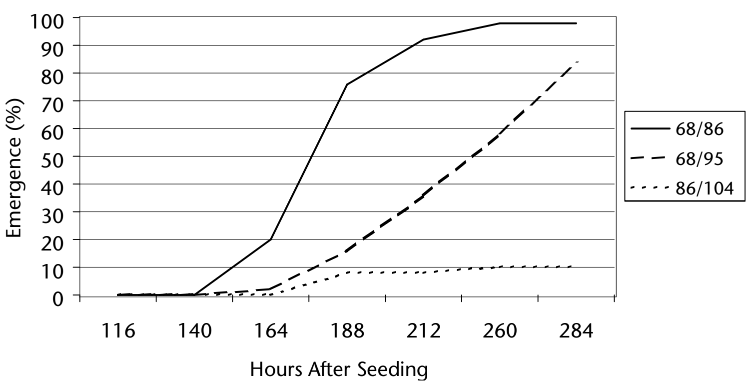


Figure 4-4. Effect of temperature on the germination of NC 71 (2004)

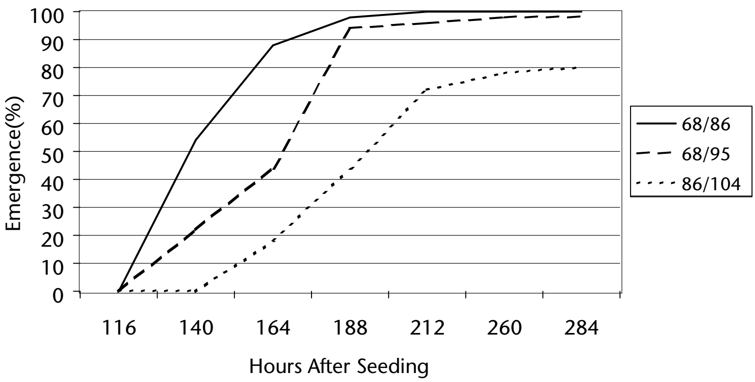


Figure 4-5. Effect of temperature on the germination of NC 297 (2003)

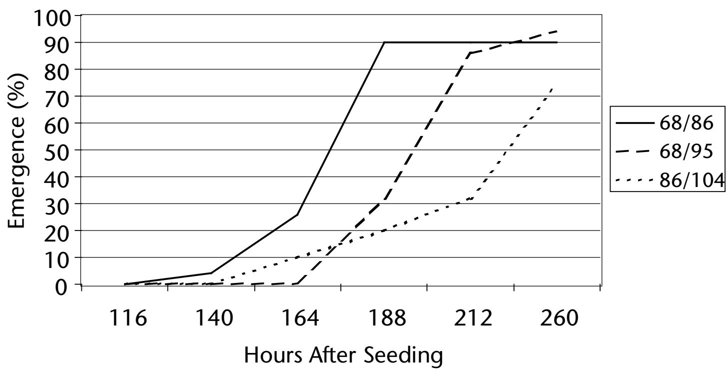
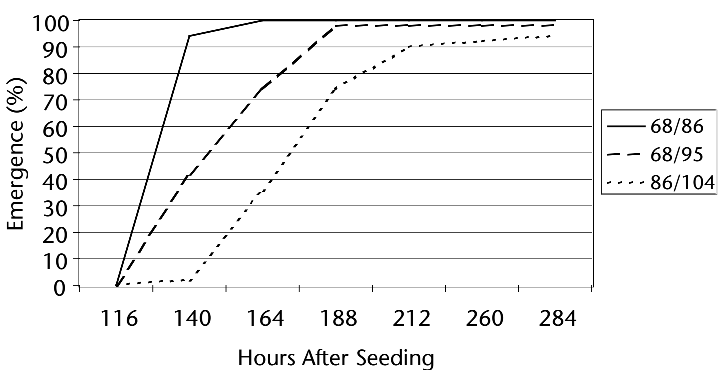


Figure 4-6. Effect of temperature on the germination of NC 297 (2004)



(Continued from page 52)

be greater because delayed germination makes the plants more susceptible to salt injury and disease.

While research has shown 68°F night and 86°F day to be the most favorable temperatures for germination in all tested varieties, it is very common to observe a range of germination times among varieties. Studies conducted with seed from the 2003 Official Variety Test found that most varieties reached maximum germination in seven to eight days when exposed to ideal temperatures of 68°F night and 86°F day. However, the range among varieties was from 6 to 13 days. The germination of most varieties was delayed by 1 day when the daytime temperature was increased from 86°F to 95°F. However, the germination of NC 71 was delayed by 2 days (from 9 days to 11 days).

Promote Uniform Growth

Monitor and Manage Fertilizer Salts in the Growing Medium

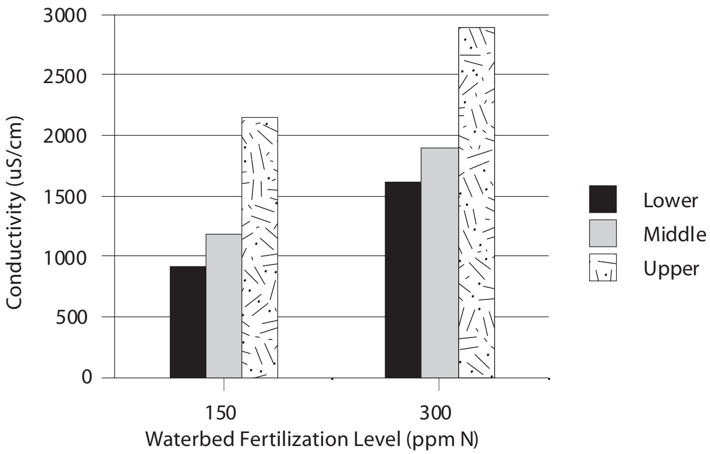
Fertilizer salts injury is the most common nutritional problem in float systems. Fertilizers supply nutrients in the form of salts. When fertilizer is added to the waterbed, these salts dissolve in the water. Then the nutrients move into the growing medium as water is absorbed from the waterbed.

High temperatures, low humidity, and excessive air movement promote water evaporation from the surface of the growing medium, which results in accumulation of fertilizer salts in the medium in the top of the cell. Salts can reach levels high enough to injure seedlings, even when recommended fertilization programs are followed (Figure 4-7). Fertilizer salts levels in the upper half inch are directly related to the total amount of fertilizer applied (in the waterbed and in the medium). Therefore, it is better to use a medium with no fertilizer (or with only a minimal amount) than to use a highly charged medium.

Electrical conductivity is a commonly used indicator of fertilizer salts levels in media and water. Pocket-sized conductivity meters are available for a reasonable price from many farm supply dealerships. When properly calibrated, these meters are very helpful in a salts-monitoring program for float water and growing media.

Salts should be monitored in the growing medium every 24 to 48 hours from seedling emergence until the plant roots grow into the waterbed. Collect a sample of the medium from the upper half inch of the cell from several trays, then add twice as much distilled water as

Figure 4-7. Conductivity of a soilless medium at two fertilization levels and at three depths in the cell



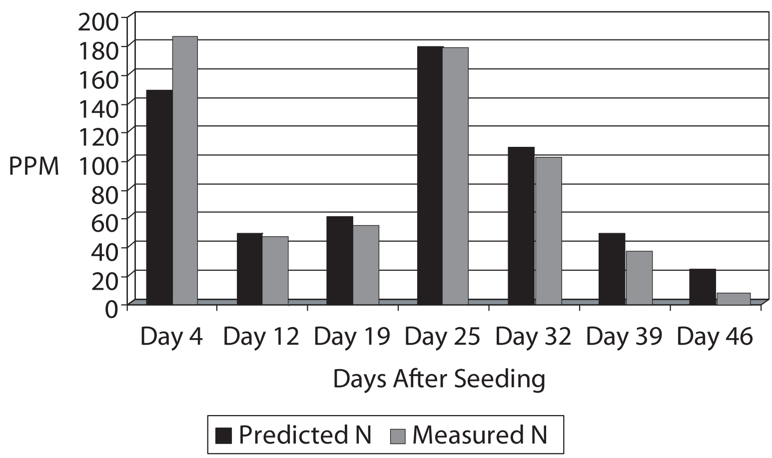
growing medium on a volume basis (a 2:1 water-to-growing-medium dilution). Shake or stir the sample and wait two to three minutes before measuring the conductivity. Normal levels range from 500 to 1,000 microseimens (0.5 to 1 millimhos). Readings of 1,000 to 1,500 microseimens (1 to 1.5 millimhos) are moderately high, and readings above 1,500 microseimens are very high. Apply water from overhead to leach and dilute salts when: (1) conductivity readings are above 1,000 microseimens and plants are pale or stop growing; or (2) conductivity readings are 1,500 microseimens or above.

Fertilize Properly

Growers with fertilizer injection systems have been successful in using a constant application rate of 125 parts per million (ppm) nitrogen from 20-10-20, 16-5-16, or similar ratio fertilizers. For noninjected systems, fertilizer can be added to the water in two steps. Research has shown that excellent transplants can be obtained from an initial application of fertilizer to supply 100 to 150 ppm nitrogen within 7 days after seeding plus a second application to supply 100 ppm nitrogen 4 weeks later. Use a complete fertilizer (with 2-1-2 or 3-1-3 ratio) for the first application. The same fertilizer or ammonium nitrate can be used for the second application. Higher application rates cause tender, succulent seedlings that are more susceptible to diseases. Also, high application rates promote fertilizer salts injury to seedlings as noted above. If high fertilizer salts levels are detected during the first four weeks after seeding (>1,000 microseimens in the medium from the upper half inch of the cell), apply water uniformly from over-top to reduce fertilizer salts levels.

Monitoring waterbed fertility levels. Pocket-sized conductivity meters can be used to monitor fertility levels in waterbeds. Most fertilizer labels contain a chart that provides the expected conductivity level for the initial fertilizer concentration, usually expressed as nitrogen concentration in ppm. Conductivity is useful in measuring the accuracy of fertilizer injectors and how well the fertilizer is mixed throughout the waterbed. Conductivity measurements can also provide a rough estimate of the general fertility status in a waterbed throughout the growing season. It is important to understand that while the chart lists nitrogen concentration, the meter is measuring total conductivity from all salts (nutrients). Therefore, as the season progresses and plants adsorb nutrients from the waterbed at different rates (and water levels fluctuate), the relationship between conductivity and nitrogen concentration becomes less dependable (Figure 4-8). Therefore, collecting a water sample for analysis by the NCDA&CS (or another laboratory) is the only way to get an accurate measure of the concentrations of all nutrients in the waterbed.

Figure 4-8. A comparison of predicted (based on conductivity) and measured nitrogen concentrations in a float bed, 2002



Nitrogen form. Fertilizers commonly provide nitrogen from various combinations of nitrate, ammonium, and urea sources. Tobacco seedlings can use nitrogen in the nitrate and ammonium forms, but urea must be converted to ammonium before the nitrogen can be used by the plant.

Research has shown reduced seedling growth when more than half of the nitrogen in a fertilizer was provided from urea, as compared to all of the nitrogen being supplied as nitrate and ammonium. Similar results have been observed at the University of Kentucky, where Bob Pearce suggests that reductions in plant growth may be a result of nitrite toxicity. Nitrite is an intermediate nitrogen form that occurs when ammonium converts to nitrate. Nitrite can accumulate to levels high enough to cause plant injury when high levels of ammonium are present.

Exclusive use of nitrate nitrogen has been observed to raise the pH of the medium, which causes plant-growth problems similar to those caused by bicarbonates. Therefore, study the fertilizer label carefully to determine the nitrogen form as well as the concentration of nitrogen and micronutrients. The best choice is a fertilizer that contains a balance of nitrogen in the ammonium and nitrate forms.

Phosphorus. Research at Clemson University has shown the need to limit phosphorus concentrations to 35 to 50 ppm in the waterbed. Applying excess phosphorus causes spindly transplants and leaves more phosphorus in the waterbed for disposal after transplant production. Therefore, 20-10-20 and 20-9-20 are better choices than 20-20-20 fertilizer. Other fertilizers, such as 16-5-16, are also good choices because very little phosphorus is left in the float water after the transplants are taken to the field.

Sulfur. A sulfur deficiency is occasionally observed in float systems when the medium was not supplemented with magnesium sulfate (epsom salts) or calcium sulfate (gypsum) and sulfur was not provided by the fertilization program. The major media marketed for tobacco should contain sulfur. Also, some fertilizers such as 16-5-16 contain sulfur. If the sulfur content in a medium is questionable, the fertilizer used does not contain sulfur, or a sulfur deficiency is observed, add Epsom salts to the waterbed at a rate of four ounces per one hundred gallons of water.

Boron. A boron deficiency causes bud distortion and death and has been observed in several float systems. In most cases, the water and the fertilizer did not contain any boron. The best solution to this situation is to choose a fertilizer such as a 20-10-20 with a guaranteed micronutrient charge if the water analysis indicates no boron. If a fertilizer with boron is unavailable, adding no more than 0.25 ounce of Borax per 100 gallons of float water should prevent a deficiency.

Organic fertilization. In recent years, some growers have contracted to grow tobacco organically. Thus far, it has been acceptable to produce transplants with the water-soluble fertilizers typically used in float systems. However, growers may be required to use organic fertilizers during transplant production for USDA organic certification in the future. Studies were conducted to compare seedling production when using bat manure (8-4-1) and Peruvian seabird guano (13-8-2) to seedling production when using the standard water-soluble fertilizer 16-5-16 (Table 4-4).

Results show that seabird guano is a better choice than bat manure when both are applied at the normal rate. Only 33 percent of the nitrogen in bat manure is in a plant-available form, which resulted in small, nitrogen-deficient seedlings when used at the normal rate. Tripling the bat manure rate to compensate for reduced availability resulted in seedlings comparable to the seabird guano. However, a 3× rate of bat guano is very expensive.

Both organic products produced smaller seedlings and a lower percentage of usable seedlings than 16-5-16 in one study, but in another

Table 4-4. Effect of fertilizer on stem length and transplant usability, 2002 and 2003

	Stem Length (cm/plant)		*Usable Transplants (%)*	
Fertilizer	***2002***	***2003***	***2002***	***2003***
16-5-16	*8.7*	*5*	*73*	*88*
Bat manure (8-4-1)	*2.6*	*1*	*0*	*0*
Peruvian seabird guano (13-8-2)	*6.8*	*3*	*77*	*72*
Bat manure (8-4-1) at a 3× rate	—	*3*	—	*84*

study the seabird guano and 16-5-16 produced similar percentages of usable transplants. Based on these results, the Peruvian seabird guano seems to be a better choice than bat manure for organic seedling production. Growers using seabird guano should monitor alkalinity levels in the waterbed closely and correct when necessary.

Calculating parts per million. Because nutrient recommendations in the float system are given on a concentration basis, growers must calculate these concentrations as parts per million (ppm). While this is very different from the traditional pounds per acre or pounds per plant bed, it really is not very difficult to calculate. The following formula is a useful way to calculate the amount of fertilizer necessary for a given concentration in the waterbed.

$$\text{Fertilizer added per 100 gallons} = \frac{\text{Concentration}}{\% \times 0.75}$$

Where:
Fertilizer added per 100 gallons = amount of fertilizer to add to each 100 gallons of water in the waterbed;
Concentration = desired concentration in parts per million;
% = concentration of the nutrient in the fertilizer.

Example: *A grower wishes to obtain 100 parts per million nitrogen from 16-5-16. This product is 16 percent nitrogen. Therefore:*

$$\frac{100}{16 \times 0.75} = \text{8.3 ounces of 16-5-16 per 100 gallons of water.}$$

Clip Properly

Proper clipping is an important practice that can increase the number of usable transplants and improve transplant hardiness, stem-length uniformity, and stem diameter. A properly clipped plant is essential for carousel transplanters because uniform stem lengths are needed to transplant seedlings at the proper depth, and excessive foliage disturbs the timing mechanism. Clipping can also be used to delay transplanting when field conditions are unfavorable. Research has shown that maximum usability is obtained with three to five clippings. However, many growers clip 15 to 20 times. Too many clippings indicate that the greenhouse was seeded too early. Early seeding increases heating costs as well as the potential for collar rot. Another problem is improper clipping (clipping too early and too close to the bud), which reduces stem length, increases stem rots, and slows plant growth in the field.

Research conducted by Walter Gutierrez of North Carolina State University showed that collar rot infection increased when clipping residue was left on tobacco stems and leaves. Therefore, to reduce the incidence of this disease, remove as much residue as possible. Use high-suction rotary mowers and properly collect residue with reel mowers to accomplish this.

Research conducted by David Reed at Virginia Tech showed that the severity of clipping affects stem length at the time of transplanting. For example, severe clipping (0.5 inch above the bud) decreased stem length but did not increase stem diameter as compared to normal clipping (1.5 inches above the bud). Therefore, there is no advantage in severe clipping. Dr. Reed found that severe clipping early in the season was particularly detrimental, resulting in very short transplants that grew slowly in the field. Additional work in North Carolina indicated that severe clipping, down to the bud, immediately before transplanting reduced early-season growth and delayed flowering.

Current recommendations are to begin clipping at three- to five-day intervals when total plant height is two to 2.5 inches above the tray and to set the blade height at one to 1.5 inches above the bud. This procedure provides the best balance of uniformity, stem length, and disease management.

5. Managing Nutrients

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Although the cost of fertilizing tobacco has increased significantly, the good news is that there is a wide range in the cost of fertilization programs, and some programs offer significant savings without sacrificing yield or quality. Recent research conducted in North Carolina has consistently shown that programs utilizing all-nitrate or UAN nitrogen products produce tobacco leaf with similar yield and quality. The most recent studies conducted by Dr. Robbie Parker compared 32 percent UAN (25 percent nitrate 75 percent ammonium), ammonium nitrate (50 percent nitrate, 50 percent ammonium), and calcium nitrate (100 percent nitrate) to supply all of the nitrogen to the crop. The study was conducted at research stations near Oxford and Kinston, North Carolina, in 2004, 2005, and 2006. Yield and quality were not affected by nitrogen source at any location during any year of the study.

The bottom line on ammonium versus nitrate is that under our conditions, nitrification is rapid enough that UAN products that contain 75 percent of the nitrogen as ammonium (such as 30 percent and 24S) are equally acceptable as nitrogen sources compared with all-nitrate products (such as calcium nitrate). Growers should feel comfortable using any of these products and should base the decision on factors such as application technology and cost, because crop response is not an issue.

A recent survey of county Extension agents found that 50 percent of tobacco acreage received at least some of its nitrogen from UAN products, and approximately 25 percent of acreage received all of its nitrogen from a UAN product. Consider the following practices to reduce fertilization costs:

- **Use UAN products, such as 30 percent or 24S, for at least the side-dress application if not the entire nitrogen program. See treatments 5, 6, and 7 in Table 5-1.**
- **Apply no more phosphorus than recommended from the soil test.** More than 90 percent of the soil test reports from

(Continued on page 64)

Table 5-1. Effect of fertilizer treatment on tobacco yield, value, and grade index at three North Carolina locations, 2005

Treatment	Onslow			UCPRS			CCRS			Average		
	Yield (lb/a)	Value ($/a)	Grade Index	Yield (lb/a)	Value ($/a)	Grade Index	Yield (lb/a)	Value ($/a)	Grade Index	Yield (lb/a)	Value ($/a)	Grade Index
1. 6-6-18 667 lb/acre + 15.5-0-0 194 lb/a	2,799a	3,191a	75a	2,031a	2,963a	91a	3,266a	3,767a	75a	2,699	3,307	80
2. 6-3-18 667 lb/a + 15.5-0-0 194 lb/a	2,784a	3,284a	77a	2,170 a	3,251a	93a	3,256a	3,521a	70a	2,737	3,352	80
3. 0-0-22 540 lb/a + CN-9 64 GPA	3,350a	3,717a	70a	2,068a	3,021a	91a	3,249a	4,019a	79a	2,889	3,585	80
4. 0-0-22 540 lb/a (broadcast) + CN-9 64 GPA	3,408a	3,865a	73a	2,226a	3,290a	92a	3,142ab	3,577a	74a	2,925	3,577	80
5. 0-0-30 400 lb/a + 30% UAN 21.5 GPA	3,241a	3,507a	68a	1,966a	2,717a	86a	3,247a	3,725a	74a	2,818	3,316	76
6. 0-0-30 400 lb/a + 30% UAN 21.5 GPA + 9-45-15 11 lb/a TPW	3,215a	3,711a	75a	1,759a	2,450a	86a	3,166a	3,980a	79a	2,713	3,380	80
7. 0-0-30 400 lb/a + 15.5-0-0 452 lb/a + 9-45-15 11 lb/a TPW	3,191a	3,487a	71a	2,016a	2,927a	91a	3,118ab	3,896a	79a	2,775	3,437	80
8. 6-3-18 667 lb/a + 15.5-0-0 194 lb/a + 9-45-15 11 lb/a TPW	3,466a	4,066a	74a	1,869a	2,741a	91a	3,276a	3,664a	73a	2,870	3,490	79
9. 6-6-18 667 lb/a + 15.5-0-0 194 lb/a + 9-45-15 11 lb/a TPW	3,000a	3,389a	74a	1,732a	2,486a	89a	2,882c	3,335a	75a	2,538	3,070	79
10. 12-4-17 500 lb/a + 13-44 76 lb/a	3,243a	3,663a	72a	2,174a	3,163a	91a	2,982bc	3,712a	79a	2,800	3,513	81

Treatment results followed by the same letter within a column should be considered similar.

(Continued from page 62)

tobacco fields in the coastal plain and 50 percent from fields in the piedmont recommended not applying fertilizer phosphorus. Growers reluctant to not apply any phosphorus can apply 5 pounds of phosphorus in the transplant water, which has been shown to equal the growth response of 40 pounds of phosphorus banded in the complete fertilizer (Figure 5-1).

- **Based on current fertilizer prices, the most economical program involves the application of a potash material, such as potassium sulfate or potassium magnesium sulfate (or blend), to supply all of the potassium suggested by the soil test report and a UAN product to supply all of the nitrogen (Table 5-1).** If soil phosphorus levels are high to very high, then no more than 5 pounds of phosphorus in the transplant water is sufficient to provide rapid early-season growth.
- Research in North Carolina also indicates that recommended potassium rates can be reduced to 75 pounds of K_2O per acre on soils that have a medium to high potassium index, fine to medium soil texture, and relatively shallow depth to clay (less than 10 inches) without reducing yield or quality. Potassium can also be broadcast-applied and incorporated prior to forming plant beds as much as 30 days before transplanting on soils with characteristics similar to those previously mentioned. This alternative approach to potassium fertility fits extremely well with production systems in which producers are only making independent applications of nitrogen and potassium.

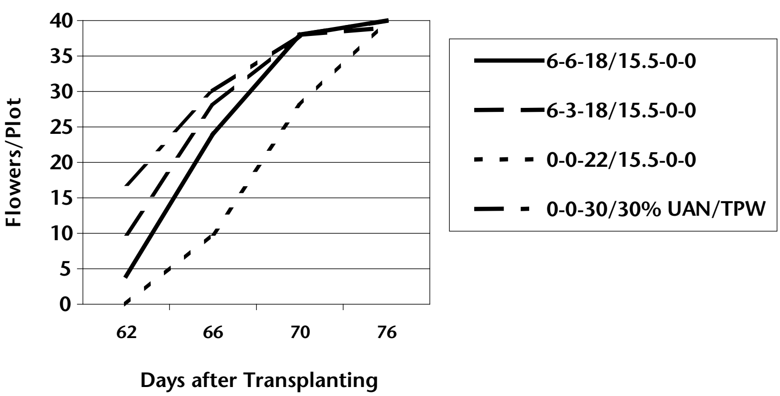

Figure 5-1. Effect of phosphorus application on flowering rate at the Upper Coastal Plain Research Station, 2005

Table 5-2. Effect of fertilizer treatment on tobacco yield, grade index, price, and value at two North Carolina locations, 2008

	Cunningham Research Station			Oxford Tobacco Research Station		
Treatment	Yield (lb/a)	Value ($/a)	Grade Index	Yield (lb/a)	Value ($/a)	Grade Index
6-6-18 667 lb/a + 15.5-0-0 226 lb/a	2,974a	5,138a	84a	2,496a	4,198a	80a
8-8-28 + Avail 500 lb/a + 15.5-0-0 226 lb/a	2,895a	5,002a	84a	2,491a	4,338a	83a

Treatment results followed by the same letter within a column should be considered similar.

It is likely that early broadcast applications of potassium with current rate recommendations would only be of concern with combinations of conditions that included coarse soil textures, low potassium indices, and/or excessive rainfall.

- **Avoid products that add cost without improving profitability.** For example, the product Avail has been shown—under conditions of limited soil phosphorus outside of the tobacco production region in North Carolina—to improve phosphorus uptake. However, phosphorus levels in most of our tobacco fields are very high. Studies conducted during 2008 showed no advantage of including Avail in the fertilizer for tobacco produced in fields with typical soil phosphorus levels (Table 5-2).

Soil Testing

Have your soil tested. This is the first step in planning an economical and environmentally sound fertilization program. Testing is provided as a free service by the North Carolina Department of Agriculture and Consumer Services. Each soil sample is analyzed to determine pH and the available levels of most major nutrients, such as phosphorus (P_20_5), potassium (K_2O), calcium (Ca), magnesium (Mg), and sulfur (S). The analysis also determines soil levels of several micronutrients, such as manganese (Mn), copper (Cu), and zinc (Zn). The soil test report suggests application rates for lime and for each nutrient that should meet crop needs under good growing conditions.

The nutrient rates suggested on the soil test report reflect only what is found in the sample. Therefore, each sample should be taken properly so it adequately represents the field where the crop is to be grown. Take samples every three years (coastal plain) or four years (piedmont) from fields tended regularly by the same grower. For unfamiliar fields or those out of tobacco production for several years, take samples four to six months before the first tobacco crop. *Submitting samples in the fall rather than winter or spring will enable you to receive soil test reports quickly and allow more time for planning fertilization programs.* Soil boxes and instructions for taking samples can be obtained at your county Cooperative Extension Center.

Liming and Soil pH

Provide the ideal pH of 5.8 to 6.0 through the application of dolomitic limestone. This is a key step in a cost-effective and responsible nutrient management plan. Low pH causes greater solubility of soil aluminum (and manganese in piedmont soils), which reduces root growth and development. Therefore, liming to promote healthy root systems improves drought tolerance and nutrient absorption, sometimes resulting in better yields.

In previous research trials, limed plots produced higher yields than unlimed plots regardless of the nitrogen rate (Table 5-3). Also, note that the yield of unlimed plots that received 15 pounds per acre of *extra* nitrogen was no higher than that of limed plots that received 15 pounds per acre *less* than suggested nitrogen. These data indicate the following:

- Extra nitrogen cannot overcome the adverse effects of low soil pH.
- Lower nitrogen rates are possible when acid soils are limed according to soil test suggestions.

Quick Reference Guide to Fertilization

1. *Have a soil sample tested to determine nutrient and lime needs.* Use dolomitic lime, if needed, to adjust pH and supply magnesium as well as calcium. Do not overlime!

Table 5-3. Effects of lime and nitrogen on tobacco yield

Nitrogen Rate (lb/a)	*Yield (lb/a)*	
	No Lime Used	*Lime Used*
Suggested –15	*2,272*	*2,497*
Suggested	*2,434*	*2,688*
Suggested +15	*2,405*	*2,516*

Table 5-4. Effect of nitrogen rate on tobacco yield and value at the Lower Coastal Plain Experiment Station, 2004–2006

Nitrogen Rate (lb/a)	2004		2005		2006	
	Yield (lb/a)	Value ($/a)	Yield (lb/a)	Value ($/a)	Yield (lb/a)	Value ($/a)
0	2,232	4,381	2,513	3,500	1,971	2,880
20	2,590	4,543	2,773	3,800	2,056	3,005
40	2,825	4,935	2,939	4,086	2,063	2,998
60	3,002	5,288	3,027	4,247	2,033	2,855
80	3,051	5,357	3,009	4,183	2,053	2,928
100	—	—	2,799	3,866	2,029	2,774
120	—	—	2,893	3,923	2,012	2,701

2. *Use a base nitrogen rate of 50 to 80 pounds per acre.* Your portion of the rate range will depend on topsoil depth and texture, previous crop grown, and personal experience (Table 5-4).
3. *Apply 20 to 30 pounds of sulfur per acre on deep, sandy soils.* Sulfur application recommendations are now provided in soil test reports. Read the label to be sure that the complete (N-P-K) fertilizer contains sulfur. If the complete fertilizer does not provide this nutrient, then apply a sidedresser containing sulfur.
4. *Determine and make leaching adjustments for nitrogen losses with caution, only after leaching occurs.* Do not assume that leaching will occur and apply extra nitrogen up front in the growing season.
5. *Use a method of fertilizer application that maximizes nutrient uptake efficiency but minimizes fertilizer salts injury and early-season leaching losses*. Examples include the *bands at transplanting* and *bands within 10 days after transplanting* methods. The latter method is more risky than the first on poorly drained soils because frequent rains after transplanting could delay fertilizer application for more than 10 days.

In-Season Adjustments

Adjustments for Leaching

Leaching occurs when certain nutrients move below normal rooting depth due to excessive water moving (percolating) through the root

Table 5-5. Nitrogen adjustments for leaching

Topsoil Depth	*Estimated Water Percolated through Soil*	*Percentage of Applied Nitrogen to Replace after Transplanting*[a]		
		1–3 Weeks	***4–5 Weeks***	***6–7 Weeks***
Less than 10 inches to clay	*1 inch*	*0*	*0*	*0*
	2 inches	*20*	*10*	*0*
	3 or more inches	*30*	*20*	*0*
10 to 16 inches to clay	*1 inch*	*30*	*20*	*0*
	2 inches	*45*	*30*	*10*
	3 or more inches	*60*	*40*	*15*
17 or more inches to clay	*1 inch*	*50*	*25*	*15*
	2 inches	*75*	*35*	*20*
	3 or more inches	*100*	*45*	*25*

[a] Apply about one pound of potassium ($K_2$0) for each pound of nitrogen used as a leaching adjustment if the topsoil is deeper than 10 inches.

zone of deep, sandy soils. Leaching of nitrogen is more likely to reduce yield and quality than leaching of other nutrients. Although leaching losses of sulfur, magnesium, and potassium sometimes occur, their effects on yield and quality are relatively small.

More than 50 to 80 pounds of nitrogen per acre may be needed if leaching occurs, but determining the correct amount to replace is one of the most difficult and risky tasks in tobacco production. A general guide to leaching adjustments for nitrogen is shown in Table 5-5. The amount of nitrogen to replace is expressed as a percentage of the suggested base rate that was applied before leaching occurred. If you used excess nitrogen before leaching occurred, subtract the number of excess pounds from the number of replacement pounds calculated. This guide is based on three major factors that influence the amount of leaching:

- ***Topsoil depth to clay.*** Topsoil depth is used in the guide because water usually moves more freely and in larger quantities through deeper topsoil. The mass of tobacco roots normally occurs in the upper 12 to 14 inches of soil. Therefore, the deeper the clay below rooting depth, the more likely it is that nitrogen will leach below the root mass.
- ***Age of the crop when leaching occurs.*** Crop age is included in the guide because plants absorb more of the needed nutrients as they get older, and the amounts left in the soil and subject to leaching decrease as the crop grows. Also, as the plants get

larger, their leaves form a canopy that sheds some of the water to the row middles, reducing the amount of water passing through the fertilized zone.

- ***Estimated amount of water (in inches) that moves through the root zone.*** A reasonable estimate of the amount of water that enters the soil and ultimately percolates through the root zone is necessary to calculate the leaching adjustment. The amount of rainfall alone usually is not a good indication of how much leaching has occurred. Factors such as soil texture and slope, crust formation, duration of rainfall, and the amount of moisture already in the soil also are important.

Unfortunately, a practical method that includes these many percolation factors has not been developed, but growers who have experienced similar rainfall on their land in past years can make reasonable estimates. An invaluable tool in making leaching adjustments is an up-to-date record of daily rains and estimates of how much of each rain soaked into the soil.

Because phosphorus leaches very little in our soils, it is both expensive and unnecessary to use phosphorus-containing fertilizers, such as 6-6-18, to make leaching adjustments. Some growers do this, however, to supply additional sulfur (S), magnesium (Mg), or both, along with nitrogen, for adjustments on deep, sandy soils. These nutrients can be supplied at less cost and just as effectively by using 13-0-14 or an 8-0-24 that guarantees sulfur and magnesium but contains no phosphorus. Another alternative is to mix equal amounts of Sul-Po-Mag (K-Mag) and one of the 1:0:0 ratio sidedressers. For example, an equal mixture of 15.5-0-0 fertilizer and Sul-Po-Mag gives an 8-0-11 N-P-K analysis, which also provides 5 percent magnesium and 11 percent sulfur. (If additional nitrogen is not needed, about one hundred to 150 pounds of Sul-Po-Mag per acre usually will supply adequate sulfur and magnesium.)

Adjustments for Drowned and Partially Drowned Tobacco

Distinguishing between drowning and leaching is often confusing because excess water causes both problems. Leaching is usually not a serious problem on soils that have clay within 10 to 12 inches of the surface because percolation through the root zone is restricted. If the soil becomes saturated, oxygen starvation and then root decay will begin unless the saturated condition is alleviated within about 24 hours. Usually, the plants yellow and partially or completely wilt. Wilting is a symptom of drowning and indicates that leaching losses are minimal because water remains in the root zone rather than moving through it. Although some nitrogen may be moved down to the clay, causing a temporary deficiency, it will be absorbed later as root growth resumes.

In most drowning situations, adding 10 to 15 pounds of extra nitrogen usually benefits the crop if it was not overfertilized with nitrogen before drowning. However, using the leaching adjustment procedure for a drowned crop often overestimates the amount of nitrogen to replace and may delay ripening and cause curing problems later in the season.

Heavy, frequent rains may cause drowning (root injury). Deep rooting is limited as long as the soil remains saturated, confining root development to the upper six to 10 inches. Many growers make at least one application of dry or liquid fertilizer after drowning in an attempt to reduce losses in yield and quality. Experiments were conducted on research stations near Kinston and Clayton in 1995 to study the effects of soil-applied fertilizers on the yield and quality of partially drowned tobacco (the term *partially drowned* is used because the tobacco remained wilted for only several days and then recovered). The fertilizers used are shown in Table 5-6; the results are averages of two nitrogen rates at Kinston (15 and 30 pounds per acre) and one nitrogen rate at Clayton (20 pounds per acre). All fertilizer treatments, made in one application on June 20, improved yield and value per acre compared to the nonfertilized control. The 16-0-0 and 30 percent liquid nitrogen fertilizers increased yield and value about 10 percent, and the 15-0-14 and 8-0-11 fertilizers increased yield and value about 15 percent. This indicates that the potassium supplied by the 15-0-14 and 8-0-11 fertilizers may have improved yield more

Table 5-6. Effects of fertilizer additions on yield and value of partially drowned tobacco, 1995[a]

Fertilizer Treatment[a]	*Application Method*	*Yield (lb/a)*	*Grade Index*	*Price ($/cwt)*	*Value ($/a)*
None	—	*1,714*	*77*	*173.50*	*2,974*
16-0-0	*BC-OT*	*1,887*	*77*	*174.60*	*3,294*
30% nitrogen	*WB-RM*	*1,873*	*79*	*175.50*	*3,288*
15-0-14	*BC-OT*	*1,961*	*76*	*173.80*	*3,408*
8-0-11	*BC-OT*	*1,996*	*77*	*174.50*	*3,483*

[a] Average results of tests conducted at research stations near Clayton and Kinston. N rates for each fertilizer were 15 and 30 lb/acre at Kinston and 20 lb/acre at Clayton. Adjustments were applied on 6/20/95. BC- OT = broadcast overtop of plants; WB-RM = wide band sprayed in row middle.

Table 5-7. Effects of nitrogen rate adjustments on yield and value of partially drowned tobacco, 1995

Nitrogen Adjustment (lb/a)	Yield (lb/a)	Grade Index	Price ($/cwt)	Value ($/a)
0	1,748	74	180.00	3,146
15[a]	1,946	74	179.30	3,489
30[a]	1,903	76	179.30	3,412

[a] Results averaged over 16-0-0, 30 percent liquid N, 15-0-14, and 8-0-11 fertilizers for each N rate. Test conducted at Lower Coastal Plain Research Station near Kinston.

than the 16-0-0 and 30 percent liquid nitrogen fertilizers that supplied only nitrogen. None of the fertilizers improved grade index or average market price compared to the control.

The results in Table 5-7 indicate that using fertilizers at rates to provide 30 pounds of nitrogen per acre was no more effective than using them at rates to provide 15 pounds of nitrogen per acre. In addition, the nitrogen rate did not affect grade index or average market price. The plant roots in these tests never recovered from the water injury. Therefore, the crops did not respond fully to the applied nutrients. Unfortunately, the results of these tests indicate that much of the extra fertilizer applied to drowned crops does not benefit them. Observations on farms in 1995 indicated that the more severe the drowning (root injury), the less likely the crops were to recover, regardless of the kinds or rates of fertilizers used.

Time and Method of Fertilizer Application

Proper placement and timing of fertilizer applications provide maximum return for each dollar spent on fertilizers. Fertilizers should be applied at the proper time and with the proper method to maximize nutrient use by the crop while minimizing leaching losses and fertilizer salts injury to roots. Four methods of fertilizer application have been evaluated in on-farm tests under a wide range of soil and climatic conditions. Results varied among locations, primarily because of differences in soil moisture at and following transplanting:

- If soil moisture was adequate but not excessive, the *bands at transplanting* and *bands within 10 days after transplanting* methods yielded moderately better than the *broadcast* or *one band deep* methods.

- If early leaching conditions occurred, best results were obtained with the *bands within 10 days after transplanting* method, with *bands at transplanting* being a close second, and the *broadcast method* giving the poorest results.
- When the soil was dry, which contributed to fertilizer injury, the *bands within 10 days after transplanting* method gave the best results, and the *one band deep* method the poorest results.
- Overall, the *bands at transplanting* and *bands within 10 days after transplanting* methods produced better yields more consistently than the *broadcast* and *one band deep* methods. These methods are also more environmentally sound than pretransplant methods because nutrient uptake is more efficient and leaching losses are reduced.

Understanding the Nutritional Needs of the Plant

Primary Nutrients

Nitrogen (N). Nitrogen has a greater effect on tobacco yield and quality than any other nutrient. Too little nitrogen reduces yield and results in pale, slick cured leaf. Too much nitrogen may increase yield slightly but may also make mechanical harvesting and curing more difficult, delay maturity, extend curing time, and result in more unripe cured leaf. Excessive nitrogen also stimulates sucker growth, which can lead to excessive use of maleic hydrazide (MH) and increase problems with hornworms and aphids. **Nitrogen is also very leachable, and overapplication may contribute to groundwater contamination in deep, sandy soils.**

Soil analysis is not used to estimate the nitrogen rate needed for a specific tobacco field in North Carolina. Rather, the 50- to 80-pound-per-acre range shown on the soil test report is based on information from numerous field tests conducted across the state. In these tests, a base nitrogen rate of 50 to 80 pounds per acre has given consistently good results on most soils in most seasons. This is the total amount of nitrogen supplied by normal applications of the N-P-K fertilizer and the sidedresser but does not include additional nitrogen sometimes needed for leaching adjustments. The lower portion of the range is suggested for fine-textured, fertile soils, especially where legumes such as soybeans or peanuts were grown the previous year. The higher portion of the range is suggested for coarse-textured soils with topsoils deeper than 15 inches to clay.

Table 5-8. Base nitrogen rates for tobacco in relation to topsoil depth

Topsoil Depth (inches)	*Nitrogen Rate[a] (lb/a)*
5	50
10	60
15	70
20+	80

[a] *Does not include leaching adjustments.*

Suggested nitrogen rates for several average topsoil depths are shown in Table 5-8. Determine your portion of the nitrogen rate range primarily by topsoil depth, or depth to clay. Fields with deeper, sandier topsoils usually are more leachable and contain less nitrogen as humic matter than those with shallower, more heavily textured topsoils. Generally, you should reduce the nitrogen rates shown by about 5 to 10 pounds per acre if the previous crop was a legume or the variety to be planted is known to mature late or cure poorly when overfertilized with nitrogen. Even greater nitrogen rate reductions may be needed on dark soils with 1 percent or more humic matter.

Also, when tobacco follows a heavily fertilized but poor corn crop (less than 75 bushels per acre), the residual nitrogen available for the tobacco may be as high as that left by soybeans or peanuts.

Only 15 pounds of extra nitrogen may reduce leaf quality, particularly in dry seasons. Both drought and excess nitrogen delay maturity and increase the amount of unripe tobacco. The first step to increasing the amount of ripe tobacco is to use a reasonable base nitrogen rate (particularly if irrigation is not available and mechanical harvesting is used), depending on topsoil depth, previous crop, variety to be grown, and experience. Also, be cautious and conservative with leaching adjustments for nitrogen. The second step is to delay harvest, if necessary, and make three or more primings so that each priming will have a high percentage of ripe leaves. The rate of ripening depends primarily on the amount and distribution of water, the nitrogen rate, soil type, and variety, so base your harvest rate on these factors, not on the calendar date or how fast your neighbor's tobacco is being harvested.

The normal ripening process is caused by partial nitrogen starvation, which should begin about topping time. Therefore, nitrogen in the soil should be nearly depleted by flowering. Overapplication of nitrogen, prolonged drought, or both extend nitrogen uptake beyond topping time and therefore delay ripening because the crop is still absorbing nitrogen. Leaves harvested when they are high in nitrogen are more difficult to cure and often turn dark at the end of yellowing and into the early leaf-drying stage. This problem is increased by dry, hot conditions, which cause the leaves to appear riper than they really are.

Phosphorus (P_20_5) and potassium (K_20). Phosphorus is not very leachable, even in sandy soils, and a good tobacco crop only removes about 15 pounds per acre (as P_20_5). However, many times this amount has been applied to tobacco fields over the years, resulting in at least "high" levels of available phosphorus in about 85 percent of the fields used for tobacco.

Potassium is leachable, especially in deep, sandy soils, and a good crop removes about 90 pounds per acre (as K_20). However, about 60 percent of our tobacco soils contain at least "high" levels of available potassium because of more abundant soil sources and excessive application. Also, subsoils in tobacco fields often contain substantial amounts of potassium and other leachable nutrients that are seldom measured by soil tests because only topsoils are usually sampled (Table 5-9).

These results represent primarily coastal plain soils and should be considered as preliminary at this point. But they do provide additional evidence that application of several leachable nutrients above soil test recommendations usually does not improve tobacco yield and quality, but does increase production costs. In addition, overapplication increases the potential for these nutrients to reach our ponds and streams by soil and water movement.

Secondary Nutrients

The secondary nutrients of concern for tobacco are calcium (Ca), magnesium (Mg), and sulfur (S). These nutrients are called secondary because they are usually needed by most crops in smaller amounts than the primary nutrients. However, they must be available in adequate amounts for good yields and quality.

Table 5-9. Average soil test levels of several nutrients in topsoils and subsoils of 13 flue-cured tobacco fields, 1999–2000

	Soil Nutrients				
	(Availability Index)[a]			*(% of CEC)*	
Soil Horizon	*P*	*K*	*S*	*Ca*	*Mg*
Topsoil	*123*	*56*	*41*	*45*	*12.9*
Subsoil	*35*	*63*	*122*	*48*	*17.3*

[a] *0–10 = very low; 11–25 = low; 26–50 = medium; 51–100 = high; 100+ = very high.*

Calcium and magnesium (dolomitic lime). If soil pH is kept within the desirable range of 5.8 to 6.0 with dolomitic limestone, the available levels of calcium and magnesium will usually be high enough to meet the needs of the crop. Otherwise, 40 to 50 pounds of calcium (Ca) and 15 to 20 pounds of magnesium (Mg) per acre are needed from the N-P-K fertilizer. Even with proper liming, some magnesium deficiency may occur on deep, sandy soils (more than 15 inches to clay) under severe leaching conditions. In these instances, supplying 15 to 20 pounds of magnesium per acre in the fertilizer may be desirable in the second and third seasons after lime application. However, using N-P-K fertilizers containing calcium and magnesium will not substitute for using dolomitic lime if soil pH is too low. Be especially aware of low soil pH. The state's latest soil test summaries show that about 30 percent of the tobacco fields tested in the last several years have had a pH lower than 5.5, and piedmont soils generally were more acid than those in the coastal plain.

Sulfur (S). Sulfur deficiencies are most likely on deep, sandy soils (more than 15 inches to clay) that are low in humic matter (less than 0.5 percent). Because sulfur leaches, deficiencies are more likely in these soils following heavy rainfall in the winter and spring, especially if sulfur is omitted from the fertilizer of the next tobacco crop.

Symptoms of sulfur deficiency are very similar to (and are often mistaken for) symptoms of nitrogen deficiency. When a plant is low in nitrogen, the lower leaves are paler than the upper leaves and "burn up" prematurely. However, sulfur deficiency begins as yellowing in the buds; the leaves gradually pale from top to bottom, and the lower leaves do not "burn up" prematurely unless nitrogen is also deficient. Because sulfur is required for nitrogen use in the plant, adding high rates of nitrogen to sulfur-deficient crops will not turn the crops green, and can, in fact, reduce leaf quality. Therefore, accurate diagnosis of the deficiency is very important and often requires tissue analysis.

Soil tests for sulfur are sometimes unreliable. Therefore, to reduce the chance of sulfur deficiency on deep, sandy soils, add 20 to 30 pounds of sulfur (S) per acre from the N-P-K fertilizer every year. Sulfur deficiency occurring before lay-by can be corrected by banding one hundred to 150 pounds of Sul-Po-Mag or potassium sulfate (0-0-50) as soon as possible after the deficiency is identified. However, sulfur deficiency on soils less than about 12 inches to clay is often temporary, even when no extra sulfur is applied, because adequate sulfur is usually contained in subsoils (Table 5-9) and will be absorbed as roots reach this depth.

The soil test report for tobacco shows a $ symbol in the "Suggested Treatment" block for copper (Cu) and zinc (Zn), and a $pH symbol for manganese (Mn), if the availability index for one of these micronutrients is low. The $ symbol indicates that corrective treatment may be beneficial, but it is uncertain that tobacco will respond to application of copper or zinc. The $pH symbol appears on the report when soil pH is greater than 6.1 and the manganese availability index is less than 26 (low or very low). The symbols also call attention to an enclosed note, also identified by a $ symbol, that provides information on suggested rates, sources, and application methods for these three micronutrients.

Crops differ in their response to micronutrients, and tobacco is considered less sensitive to low soil levels than other crops, such as corn, soybeans, and small grains. Micronutrients are also somewhat expensive, depending on the kind and source. Therefore, their application for tobacco is not likely to be beneficial unless indicated by soil or tissue analyses. When in doubt, use tissue analysis or strip testing on several rows to confirm a micronutrient need.

Copper (Cu) and zinc (Zn). Known deficiencies of copper or zinc are extremely rare for tobacco. Rates suggested on the soil test report will be sufficient for several years, and future test results should be used to determine if and when copper and zinc should be reapplied.

Manganese (Mn). Manganese deficiency begins to show on the lower leaves as flecks very similar to those caused by high ozone concentrations in the air (commonly called *weather fleck*). While weather fleck can occur anywhere in the state, manganese deficiency occurs primarily on low-manganese, overlimed soils in the coastal plain. Using too much lime causes soil pH to increase, which reduces manganese availability to plant roots. Tobacco plants that develop manganese deficiency are grown on soils with a pH of 6.2 or higher and low levels of soil manganese (availability index less than 26). Based on recent soil test results, 7 percent of the tobacco soils in the coastal plain were pH 6.5 or above. Therefore, tobacco planted in these soils is at risk for manganese deficiency, particularly on soil types such as Goldsboro, which have slightly higher organic matter than other coastal plains soils. Tobacco performs well when soil pH stays in the 5.8 to 6.0 range. Other major crops, such as soybeans, corn, and small grains, also perform well in this pH range if soil phosphorus is high. Therefore, when these crops are in rotation with tobacco, they usually should not be limed at rates higher than those suggested by the soil test for tobacco.

Tissue analysis of flecked leaves, along with a soil test, is the best way to distinguish between manganese deficiency and weather fleck. However, it is important to submit leaf and soil samples as soon as flecking occurs because several days are required to complete analyses. If the problem is manganese deficiency, a corrective treatment should be made as soon as possible. If weather fleck is the culprit, only cooler, drier weather will help.

Manganese deficiency can be corrected by soil or foliar application of several manganese sources. Manganese sulfate is a relatively soluble, inexpensive source that can be used for soil or foliar treatment. The more expensive chelated sources generally perform satisfactorily as foliar sprays but are not superior to sulfates when applied to the soil. For soil applications, mixing the manganese source with acid-forming fertilizers increases its effectiveness, and banding is usually better than broadcasting. Do not broadcast manganese on soils with a pH greater than 6.1 because it will be converted to a less available form. For band application, special blends may be required because premium fertilizers usually do not contain enough manganese to correct a deficiency. When applying manganese, the general recommendation for actual Mn in North Carolina is to add about three pounds per acre banded, 10 pounds per acre broadcast, or 0.5 pound per acre as a foliar spray. Foliar application of manganese is an efficient way of correcting an unexpected deficiency because lower rates are often as effective as much higher rates of soil-applied manganese.

Chloride (Cl). There is no suitable soil test for chloride, but this nutrient is included in most N-P-K tobacco fertilizers. You will apply sufficient chloride when you use N-P-K fertilizers guaranteeing chloride at rates suggested in Table 5-8. Suggested rates of most fumigants also supply adequate amounts of chloride as chlorine; when Telone C-17 or Chlor-O-Pic is used, the N-P-K fertilizer does not need to contain chloride. Otherwise, the fertilizer should include enough chloride to provide a maximum of 20 to 30 pounds per acre. Higher rates will not improve yield but can reduce quality. Chloride may not be included in some fertilizers, particularly blends or liquids, unless requested by the grower.

Excessive rates or improper application of some micronutrients can cause toxicity. Contact your county Extension agent if you suspect you had a micronutrient problem in 2011 or if your soil test indicates that a problem might occur in 2012. Your agent can help you decide whether treatment is advisable and, if so, which sources, rates, and application methods are most effective.

6. Managing Weeds

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Herbicides are only part of a total weed management program that should include crop rotation, early stalk and root destruction, and cultivation. Total reliance on herbicides is costly, less effective, environmentally detrimental, and unsound weed management. A rapidly growing tobacco crop aids weed control by shading beds and row middles. Weed problems are much worse when crop growth is restricted because of disease problems, fertilizer injury, or chemical injury. Therefore, it is important to follow practices that promote healthy tobacco roots: crop rotation, disease control, fertilizer application during or within ten days after transplanting, proper pesticide usage, and liming.

Some weeds, such as nutsedge, ragweed, and pigweed, differ in susceptibility to herbicides (Table 6-1). Therefore, keeping accurate field records of the species and population of weeds will help you select the proper herbicide and apply it at the right rate.

The herbicides labeled for use on tobacco control weeds in three ways:

- They restrict cell division during seed germination (Prowl, Tillam, and Devrinol).
- They are absorbed by emerging roots and shoots before affecting photosynthesis (Command).
- They affect plant metabolism (Spartan or Spartan Charge, Aim, and Poast).

Most of these herbicides have little effect on weed seeds that do not germinate (dormant seeds) or when applied after weeds emerge (except for Poast and Aim, which only affect emerged weeds). It is common for susceptible weeds to emerge before they are controlled in fields treated with Spartan Charge, particularly after it rains following a prolonged dry period.

(Continued on page 80)

Table 6-1. Expected weed control from herbicides labeled for use in tobacco

Weeds	*Command*	*Devrinol*	*Poast*	*Prowl*	*Spartan Charge*	*Tillam*	*Aim*
Barnyardgrass	*E*	*GE*	*E*	*GE*	*F*	*GE*	*N*
Bermudagrass	*PF*	*P*	*FG*	*P*	*P*	*P*	*N*
Broadleaf signalgrass	*E*	*G*	*E*	*G*	*F*	*P*	*N*
Crabgrass	*E*	*E*	*GE*	*E*	*F*	*E*	*N*
Crowfootgrass	*E*	*E*	*FG*	*E*	*F*	*E*	*N*
Fall panicum	*E*	*G*	*E*	*GE*	—	*G*	*N*
Foxtails	*E*	*E*	*E*	*E*	*F*	*E*	*N*
Goosegrass	*E*	*E*	*GE*	*E*	*F*	*G*	*N*
Johnsongrass (seedlings)	*G*	*F*	*E*	*G*	—	*G*	*N*
Sandbur	*G*	—	*FG*	*G*	—	*G*	*P*
Texas panicum	*G*	—	*E*	*G*	*F*	*P*	*N*
Nutsedge	*P*	*P*	*N*	*P*	*E*	*FG*	*N*
Cocklebur	*F*	*P*	*N*	*P*	*FG*	*P*	*G*
Common purslane	*FG*	*E*	*N*	*P*	*G*	*G*	*G*
Hairy galinsoga	*G*	*PF*	*N*	*P*	*G*	*P*	*P*
Jimsonweed	*G*	*P*	*N*	*P*	—	*P*	*G*
Lambsquarters	*G*	*G*	*N*	*G*	*E*	*G*	*G*
Morningglory	*P*	*P*	*N*	*P*	*E*	*P*	*E*
Pigweed	*P*	*G*	*N*	*G*	*E*	*G*	*E*
Prickly sida	*E*	*P*	*N*	*P*	*G*	*P*	*P*
Ragweed, common	*G*	*F*	*N*	*P*	*P*	*P*	*N*
Ragweed, giant	*PF*	*PF*	*N*	*P*	—	*P*	*N*
Sicklepod	*P*	*P*	*N*	*P*	*P*	*P*	*P*
Smartweed	*G*	*P*	*N*	*P*	*E*	*P*	*G*

Note: Ratings are based on average to good soil and weather conditions for herbicide performance and on proper application rate, technique, and timing.
E = Excellent control, 90% or better. *G = Good control, 80%–90%.*
F = Fair control, 60%–80%. *P = Poor control, 1%–59%.*
N = No control.

(Continued from page 78)

Problem Weeds

Nutsedge

High populations of yellow nutsedge, purple nutsedge, or both are often a problem in tobacco fields. Yellow nutsedge occurs throughout North Carolina, and purple nutsedge is normally found in eastern and southeastern counties. Purple nutsedge has a reddish-purple to brown seedhead, and the bitter-tasting tubers occur in chains connected by rhizomes. Yellow nutsedge has a yellow seedhead with single, sweet-tasting tubers on each rhizome. Purple nutsedge is more difficult to control than yellow nutsedge.

Spartan Charge and Tillam are both labeled for nutsedge control. Spartan Charge provides excellent control of both nutsedge species (although slightly better control of yellow than purple), and Tillam provides good control (Table 6-1). Studies have found that labeled and below-labeled rates of Spartan 4F (down to 6.0 ounces of Spartan 4F) provided good to excellent control of yellow nutsedge. Control was poor at one location with pretransplanting (PRE-T) applications of Spartan 4F at labeled and below-labeled rates, which was likely due to low soil moisture at and immediately following transplanting.

Yellow nutsedge control from Tillam and Spartan Charge is similar for the first 2 to 3 weeks after transplanting. However, late-season nutsedge and grass control are poor with Tillam. Tillam is short-lived in the soil, so applying it several weeks before transplanting, which is common in fumigated fields, greatly decreases control. Spartan Charge provides season-long control of nutsedge and better grass control than Tillam. However, there are significant rotational restrictions on the Spartan Charge label for cotton and sweet potatoes. If either of these two crops is planned for the year following tobacco, Tillam is the only herbicidal option for nutsedge control.

In fields with a history of high grass populations, try combinations with Command (soil incorporated or applied to the soil surface before transplanting), Prowl (soil incorporated), or a remedial application of Poast (over-the-top or directed).

Morningglories

Several species of morningglory occur in tobacco fields throughout North Carolina. Morningglory vines wrap around leaves and stalks, interfere with harvest, and end up as foreign matter in cured leaves. This is especially true when mechanical harvesters are used. Spartan Charge is the only herbicide labeled for tobacco that will control morningglories pre-emergent. Although control of morningglories is more consistent when Spartan Charge is incorporated before transplanting (PPI), injury to tobacco is less likely with PRE-T applications of Spartan Charge than with PPI applications. Aim will control morningglories after emergence, but it must be applied in a manner that prevents contact of spray solution with the tobacco plant and must be applied prior to layby or after first harvest (see the discussion of Aim in "Herbicide Application Post-directed Prior to Layby or After First Harvest" section below).

Annual Grasses

Large crabgrass, goosegrass, and broadleaf signalgrass are the most common grass species found in tobacco fields. Command, Prowl, and Poast offer excellent control of these grasses. Command and Prowl provide similar grass control but offer different strengths depending on location, rotation, and application method as described on their respective labels. If small grains are grown for harvest immediately after tobacco or if the set-back requirements for susceptible plants cannot be met for Command, then Prowl is the better choice. If common ragweed is expected, Command is preferable and can be tank-mixed with Spartan Charge or Tillam for improved grass control (compared to Spartan Charge or Tillam alone).

In past studies, pretransplant-incorporated treatments of Spartan Charge/Prowl resulted in significant tobacco stunting, and the Tillam 6E/Prowl combination has also resulted in excessive stunting. If Prowl is needed in combination with Spartan Charge, broadcast and incorporate the Prowl before bedding to comply with the current label. Then apply the Spartan Charge to the soil surface on knocked-down beds just before transplanting. Poast can be applied overtop to actively growing grass weeds up to 42 days before harvest. One advantage of Poast is that it can be used for remedial control of grass weeds in fields where populations are not known or when problems develop after transplanting.

Common Ragweed

The presence of common ragweed in tobacco fields is related to higher incidence of Granville wilt because populations of the disease-causing bacterium can survive on the roots of this weed. Ragweed control in a rotational crop and especially in skip-rows and field borders is necessary to reduce populations of this weed and the persistent soilborne bacteria that cause Granville wilt. Command offers good control, and Devrinol provides fair control.

Redroot Pigweed and Palmer Amaranth

These large, aggressive weeds can grow as tall as tobacco and interfere with harvest. Spartan Charge and Prowl provide the best control, and Tillam and Devrinol provide good control pre-emergent. Based on these limited data, it appears that control of redroot pigweed is good to excellent at lower-than-labeled rates of Spartan Charge, but that Palmer amaranth control is poor with lower than labeled rates. Prowl and Devrinol can be applied at layby for additional residual control of pigweed. Neither have post-emergence activity on pigweed, and both must be applied before emergence of a new flush of weeds for any kind of acceptable control to be realized. In situations where dry conditions may have prevented full activation and maximum control with Spartan Charge, additional residual pigweed control may be needed to prevent late-season applications. (See the discussion of layby herbicides later in this chapter.) Aim will control small redroot pigweed and Palmer amaranth after emergence, but it must be applied in a manner that prevents contact of spray solution with the tobacco plant and must be applied prior to layby or after first harvest (see the discussion of Aim in "Herbicide Application Post-directed Prior to Layby or After First Harvest" section below).

Horsenettle

Horsenettle (or ball brier) is a deep-rooted perennial that is present in tobacco fields throughout North Carolina. This weed is a host for tobacco mosaic virus, but none of the herbicides labeled for tobacco control it. Control measures in a rotational crop such as corn are effective and can reduce the potential for tobacco mosaic virus when tobacco is planted in following years.

Cultivation

Herbicides can reduce the number of cultivations needed to produce a profitable, high-quality crop. However, properly timed cultivations are still an important weed and crop management tool.

Cultivation helps manage weeds not controlled effectively by herbicides. It also can improve weed control with soil-surface-applied herbicides, such as Command and Spartan Charge, in dry periods soon after transplanting. However, excessive and deep cultivation can decrease the effectiveness of surface-applied herbicides by removing them from row-middles. Extend weed control with these herbicides by limiting deep cultivation to lay-by time.

Cultivation is also a good crop management tool. For example, building a high row ridge improves drainage, which aids disease management and decreases drowning. Cultivation also improves aeration and water penetration by decreasing crusting. However, excessive cultivation increases leaching of potassium and nitrogen, injures root systems, increases leaf scald in hot weather, spreads tobacco mosaic virus, and contributes to soil erosion.

Herbicide Selection and Application

Certain herbicides may be soil incorporated or applied to the soil surface before transplanting, within 7 days after transplanting, or at lay-by (Table 6-3). There are advantages and disadvantages to each application time depending on the herbicide and weed population. Remember that proper identification of weeds is essential for proper herbicide selection (Table 6-1) and that county Extension agents can help with identification. Also, always read the label before purchasing an herbicide to see whether the product controls the problem weed, to determine the proper rate, and to be aware of rotational restrictions.

Spartan and Spartan Charge

Spartan 4F has been the formulation for sulfentrazone used for several years in flue-cured tobacco. Sulfentrazone is also sold under the brand name of Spartan Charge, which contains a premix of sufentrazone and carfentrazone-ethyl, the active ingredient in Aim herbicide. Both Spartan and Spartan Charge are labeled for use in flue-cured tobacco. However, the formulated amount of the active ingredient sulfentrazone is different. Growers should refer to the label as well as the conversion table below (Table 6-2) for conversion of the rate of Spartan Charge to deliver the correct amount of active ingredient. The addition of carfentrazone-ethyl to Spartan Charge does not increase residual activity over Spartan 4F but may provide additional burndown activity of broadleaf weeds, if any are present, when making a typical

PRE-T or PPI application. Spartan Charge is not labeled for a layby application directed at the base of tobacco plants.

In this chapter, discussion of the use of Spartan is interchangeable with Spartan Charge. Growers are reminded, however, to refer to the label for the appropriate rates given a particular soil texture.

Table 6-2. Conversion table for rate of Spartan DF and Spartan Charge

Spartan 4F	*Pounds Active Sulfentrazone*	*Spartan Charge*
4 oz	*0.125*	*5 oz*
4.5 oz	*0.141*	*5.75 oz*
6 oz	*0.188*	*7.6 oz*
6.9 oz	*0.215*	*8.75 oz*
8 oz	*0.250*	*10.2 oz*
10 oz	*0.313*	*12.7 oz*
12 oz	*0.380*	*15.2 oz*

Pretransplant-Incorporated Herbicides (PPI)

Pretransplant-incorporated herbicides offer several advantages. Growers can tank-mix them with other chemicals to save one or more trips across the field, and rainfall isn't as essential for activity with them as it is for surface-applied herbicides. In addition, when poor field conditions delay transplanting, pretransplant-incorporated herbicides help prevent weed growth that may start in the freshly prepared soil.

The most important disadvantage is crop injury. Prowl, Tillam, and Devrinol have the potential to limit root growth and cause slow early-season growth (stunting). Stunting is most likely during cool, wet springs. Poor incorporation, applying high rates, and tank-mixing two or more of these herbicides increase the chance of root injury.

Command occasionally causes leaf whitening, which is not a concern because the plant color returns to normal and growth is not restricted. Spartan Charge does not affect root growth directly; however, foliar symptoms and stunting have been observed. Foliar symptoms include browning along the lateral veins and midveins and the leaf area between the lateral veins. As with other herbicides, stunting is more severe with cool temperatures, low rainfall, or other environmental stresses. Also, using a proper application rate and uniformly incorporating Spartan Charge is critical. The activity of Spartan

Charge is strongly related to soil texture and organic matter, with injury most likely on coarse-textured, low-organic-matter soils.

Studies have found few differences in stunting between labeled and below-labeled rates of Spartan (down to 6.0 ounces of Spartan 4F).This is important to note, because using Spartan Charge at rates below what is labeled may not provide desirable control of all susceptible weeds. In fact, the application method rather than the rate had the greatest impact on stunting in all treatments in these studies. Stunting ranged from 0 to 8 percent when Spartan 4F was applied PRE-T compared to 3 to 31 percent with PPI applications. Therefore, the most consistent way to reduce risk for stunting from Spartan is to apply it PRE-T. The primary risk associated with PRE-T applications of Spartan Charge is that early-season weed control may be limited when soil moisture is low at (or immediately following) transplanting. Also, recovery from stunting is typically rapid, especially under favorable growing conditions, and no yield loss has been recorded in multiple tests when labeled rates of Spartan 4F were used.

Spartan Charge is often tank-mixed with Command to broaden the spectrum of weeds controlled by either herbicide alone. In addition, field, greenhouse, and laboratory research has shown that adding Command in a tank mix with Spartan 4F can reduce injury. In some cases, when Spartan 4F injury was severe, plots treated with a Spartan 4F and Command tank mix had half as much early season stunting as those treated with Spartan 4F alone.

If stunting from any herbicide occurs, it is important to remember that slow plant growth is due to a poor root system or herbicidal effect rather than a lack of nutrients. Applying more nitrogen will not increase the growth rate but will contribute to rank growth, slow ripening, more unripe grades, and lower prices at the warehouse.

Poor incorporation is an important factor in crop injury. Uneven incorporation leads to areas of concentrated herbicide in the soil. When tobacco is transplanted into an area of high concentration, root growth is restricted, resulting in root-bare areas often found on shanks of stunted plants when Prowl, Tillam, or Devrinol was applied. With Spartan Charge or Command, the roots absorb more of the chemical, which results in foliar symptoms.

Tractor speed, disk shape, and disk size are all important for uniform incorporation. Finishing or smoothing harrows with small, spherical disks and field cultivators incorporate chemicals more uniformly than cutting harrows with cone-shaped disks. Also, finishing harrows and field cultivators incorporate the chemical half as deep as the implements run, whereas larger cutting harrows incorporate approximately two-thirds as deep as the disks are run. Deep incorporation increases the probability that the herbicide will contact tobacco root systems and injure them.

Tractor speed should be at least 4 to 6 miles per hour (mph), and the field should be cross-disked to distribute the chemical more evenly. Disking once and bedding the rows will not incorporate the herbicide uniformly. You should never rely on the bedding operation alone to incorporate an herbicide. Doing so drastically increases the probability of crop injury while decreasing the effectiveness of the herbicide. Herbicides should always be incorporated with the proper equipment before bedding. Rebedding fields treated with a surface application of Spartan Charge can cause significant plant injury. This is because the rebedding operation concentrates the herbicide in the root zone of tobacco.

Research has found no consistent differences in Spartan 4F injury related to incorporation equipment in any of four experiments. Researchers considered the effects of no incorporation before bedding; incorporation with a disk; incorporation with a field cultivator; and PRE-T application to the soil surface. The lowest levels of injury were consistently observed with PRE-T applications. The type of incorporation equipment is only one factor that can influence distribution of the herbicide in the soil. Crop injury also can result from soil-applied herbicide movement during bedding and transplanting. Also, recent research using radio-labeled Spartan 4F shows that uptake, translocation, and metabolism in tobacco is very rapid and that metabolism of Spartan 4F by tobacco is likely the source of crop tolerance. Therefore, crop injury can occur because of poor incorporation of Spartan Charge, decreased metabolism due to transplant stress, or both.

Injury can be reduced by applying pretransplant herbicides at the lowest labeled rate that field and weed conditions allow, incorporating the herbicide properly, and applying only one PRE-T-incorporated herbicide (with the exception of Command, which can be safely tank-mixed with other herbicides).

Devrinol and Command may leave residues that stunt small-grain growth, as indicated on the product label, especially when they are soil-incorporated. If the small-grain crop is used only as a cover crop, this stunting is not a problem. The potential for carryover can be reduced by making band applications to the soil surface rather than by using soil incorporation or broadcast surface application. Check the label for restrictions on rotational crops and the use of cover crops.

Herbicide Application to Soil Surface Before Transplanting (PRE-T)

Command and Spartan Charge are labeled for soil-surface application before transplanting in addition to the more traditional pretransplant-incorporated method. This method is common in other crops but new to tobacco.

When applying herbicides PRE-T, apply other chemicals, including insecticides, nematicides, and fumigants, in the usual way before bedding. Before transplanting, knock down the beds to transplanting height and apply the herbicides to the soil surface. For best results, knock down the beds as close as possible to the time of transplanting (keeping in mind the worker reentry restriction on the Spartan Charge and Command labels). Do not knock off additional soil during transplanting.

Herbicides applied to the soil surface depend on water to move into the soil where weed seeds germinate. Therefore, the PRE-T application method fits well in irrigated situations. If rainfall does not occur within three to five days, a light cultivation may aid in activating the herbicide. Lack of rainfall early in the season can result in reduced weed control when herbicides are applied to the soil surface. Reduced weed control due to low soil moisture was observed with Spartan4F applied PRE-T in some fields.

Spartan Charge has excellent activity on nutsedge, morningglories, and pigweeds. It is the only herbicide labeled for tobacco that controls morningglories, and it controls nutsedge better than Tillam. Spartan Charge controls grass better than Tillam but not as well as Prowl or Command. If high populations of annual grasses are expected, combinations of Command/Spartan Charge or Prowl/Spartan Charge provide better control than Spartan Charge alone (Table 6-1).

Studies have shown that tank-mixing Spartan 4F with below-labeled rates of Command can enhance control of large crabgrass when compared to equivalent rates of Command alone. Spartan 4F tank-mixed with half the labeled rate of Command controlled large crabgrass as well as a full rate of Command applied alone. Therefore, not only can tank-mixing Spartan Charge/Command reduce injury to tobacco from Spartan Charge; you can use a reduced rate of Command and still obtain excellent control of large crabgrass. Spartan 4F tank-mixed with Devrinol showed similar enhancement of grass control. However, Devrinol does not give as good season-long control of annual grasses as Command. This represents only one year of data, so results may vary from one year to the next. Also, if ragweed is a problem, then reducing the rate of Command would not give adequate control.

Because of potential carryover of Spartan Charge, there is an 18-month planting restriction for cotton and a 12-month restriction for sweet potatoes. Therefore, careful planning for these crops in rotation with tobacco will be necessary if Spartan Charge is applied.

Herbicide Application Overtop Within 7 Days After Transplanting (OT)

Command and Devrinol are labeled for application overtop of tobacco within seven days after transplanting. This method provides weed control similar to PRE-T application and offers the flexibility of application after transplanting. Application at transplanting is usually preferable to waiting up to seven days because it saves a trip through the field and the herbicide is in place before weed seedlings emerge.

Herbicide Application at Lay-by

In fields with high row ridges, previously applied herbicides are moved along with treated soil from between the rows onto the row ridge. This justifies lay-by applications of herbicide to row middles in fields with a history of severe grass problems.

Lay-by applications help extend grass control when a short-lived herbicide such as Tillam is used. Also, a lay-by application of Devrinol or Prowl following the earlier soil-incorporated Tillam will extend grass and small-seeded broadleaf (such as Palmer amaranth) control, and crop injury will be less than when a tank mix of Tillam and Devrinol or Prowl is used.

Some growers use drop nozzles to apply the herbicides to the row middles at lay-by. Devrinol can contact tobacco buds without injury. But avoid applying Prowl to tobacco buds to prevent injury. As with overtop applications, applying Devrinol and Tillam at layby depends on rainfall to move the chemicals into the soil and to make them active on germinating weed seed. They must be applied after a lay-by cultivation, which is necessary to remove existing weeds.

Using a herbicide at lay-by usually increases weed control in wet seasons. But yield is seldom increased unless weed populations are heavy. Therefore, lay-by applications should be considered on a year-to-year basis and used only when the season and weed situation justify the treatment.

There has been renewed interest in layby herbicide applications because of the prevalence of Palmer amaranth in many areas of North Carolina. Where dry conditions may have prevented maximum activation and control from PRE-T or PPI applications, Palmer amaranth has the ability to germinate mid- and late-season in the rows as well as row middles. In these situations, a layby herbicide should be considered. Unfortunately, there are few herbicide options that will provide postemergence control of Palmer amaranth; therefore, it is critical to recognize where the need for additional residual control will be needed and make the applications prior to pigweed emergence.

Herbicide Application Postemergent Overtop

Poast can be applied to actively growing grasses in newly transplanted tobacco up to 42 days before harvest. Application rates vary from one to 1.5 pints per acre, depending upon the size of grass weeds. Grasses must be fully covered by spray to ensure control. Add two pints of crop oil concentrate or one pint of Dash HC spray adjuvant according to label directions. Apply Poast overtop or directed in a band.

Poast may be desirable in many of the same situations mentioned in the above discussion of herbicide applications at lay-by. The main difference between Poast and other grass herbicides labeled for use on tobacco is that it is applied to actively growing grass weeds after emergence (see label for maximum height of weeds controlled). This allows growers to delay grass herbicide application until grass populations are known, or to provide control of grasses after other measures have failed.

Herbicide Application Post-directed Prior to Layby or After First Harvest

Aim can be applied using a shielded sprayer or hooded sprayer to emerged, actively growing weeds in the row middles prior to layby. Aim can also be applied after first harvest when nozzles are directed underneath the crop canopy. Damage can result if spray solution contacts the tobacco plant. Do not apply when conditions favor drift. Refer to the Aim label for specific recommendations regarding application precautions in tobacco. Also refer to the "Sprayer Calibration" section below for information on banded applications.

Weed Seed Contamination in Cured Tobacco

There is growing concern over weed seed contamination in tobacco exported to foreign markets. Weed seed have been found in shipments of tobacco to China. Many of those weed species are listed on the Chinese government's quarantine list. At this point the Chinese government has not exercised the right to reject shipments, but this could change in the future. Weed seed contamination is a likely result of mechanical harvesters pulling in entire plants during the harvesting process. Growers should be aware that even when whole plants are removed prior to curing, the seed are often left behind.

Practical ways to reduce weed seed in cured tobacco:

- Use an appropriate weed control program. Weed control programs are comprehensive plans that involve the use of labeled herbicides for tobacco production, post-transplanting cultivation, and hand weeding to remove larger weeds that herbicides or cultivation do not control.
- Consider deep tillage (> 8 inches) during field preparation. This will bury viable weed seed at a depth where germination is not feasible. Research in other crops has demonstrated that when certain seed are buried at this depth and left in place for an extended period of time (36 months), their viability is reduced to less than 10%.
- Keep field borders free of weeds. As mechanical harvesters turn around at the end of harvest rows, they can pull up any large weeds that are present.
- Be aware that the high temperature (165°F) reached during the stem-drying phase is not high enough to kill seed.
- If fields display excessive weed pressure during the season, use manual labor to remove them before they begin to develop seed. If seed development does take place, hand removal may spread the seed to tobacco leaves. In addition, once weeds are pulled, remove them from the field, as this will prevent the seed bank from being replenished.

Sprayer Calibration

Proper sprayer calibration is essential to getting desired results from any pesticide and to minimize crop injury. Applying too much herbicide wastes money, could harm the environment, and may cause excessive root injury or pose a threat of carryover in the soil. Too little herbicide may give inadequate weed control.

Before calibration of a field sprayer, certain equipment repairs may be needed. Refer to the 2013 *North Carolina Agricultural Chemicals*

Manual for proper cleaning procedures, nozzle selection, and other steps to be taken.

Broadcast Applications

Step 1. After completing the necessary cleaning and repairs, fill the tank with clean water and calculate your speed under field conditions. It is always more accurate to calibrate a sprayer under field conditions than on a hard surface. Never rely on a tractor speedometer. Measure off 88 feet in the field, travel this distance, and record the time. Eighty-eight feet per minute equals 1 mph, so if you travel this distance in 15 seconds, for example, you are going 4 mph (20 seconds equals 3 mph).

Step 2. Using the desired pressure, catch the output from each nozzle with the tractor engine speed in revolutions per minute (rpm) set for the speed you traveled in the field; the tractor does not need to be in motion for you to measure the output. Catch the output from each nozzle in jars (or other suitable containers) for one minute, measure the water in fluid ounces or milliliters, and determine the average output of all nozzles. If a nozzle has an output that is 10 percent lower or higher than the average, replace it.

Step 3. Convert the average output per nozzle into gallons per minute (gpm) per nozzle using the following formula. For example, if the average output is 25 ounces per nozzle per minute:

$$gpm = \frac{25\ oz/nozzle/minute}{128\ oz/gal} = 0.195\ gpm\ per\ nozzle.$$

$$Then,\ gpa\ (gal/a) = \frac{gpm \times 5{,}940}{mph \times w}$$

where mph *is the previously calculated speed and* w *is the average nozzle spacing in inches.*

An example. You have a 10-nozzle boom with a nozzle spacing of 18 inches. You travel 88 feet in the field in 20 seconds, or 3 mph (see Step 1).

With the tractor standing still and the motor running at the same rpm traveled in the field, you catch the output from each nozzle at a desired pressure for 1 minute. You find that the average output for all 10 nozzles is 25 ounces per nozzle, or, if you are measuring in milliliters, 739 milliliters per nozzle (3,785 ml = 1 gallon).

Calculate gpm : $\dfrac{25 \text{ oz}}{128 \text{ oz/gallon}} = 0.195 \text{ gpm}$

or $\dfrac{739 \text{ ml}}{3{,}785 \text{ ml/gallon}} = 0.195 \text{ gpm}$

Now that you have gpm and mph you can calculate gpa:

$$gpa = \frac{gpm \times 5{,}940}{mph \times w}$$

$$gpa = \frac{0.195 \times 5{,}940}{3 \times 18}$$

$$gpa = 21.5$$

Suppose you want to apply 1.5 pints of an herbicide per acre, and you want to mix three hundred gallons. To determine how much herbicide to add to three hundred gallons of water:

$$\frac{\text{(recommended rate) (gal to mix)}}{\text{gpa}} = \frac{\text{(1.5 pt) (300 gal)}}{\text{21.5 gpa}} = \text{21 pints}$$

This three hundred gallons will treat 14 acres (300 gal / 21.5 gpa = 14 acres). Therefore, you would add 21 pints of herbicide per three hundred gallons of water.

Band Applications

Band applications of overtop herbicides provide an excellent opportunity to minimize costs without sacrificing weed control. Calibration for band applications is quite simple, but take care to calibrate correctly to avoid excessive application. If you attempt to band Spartan Charge over the bed before transplanting, be especially sure to calibrate properly. Serious crop injury will occur if rates that are intended for the field acre are concentrated into an 18- to 24-inch band.

To calibrate a sprayer for band application, use the previous gpa formula. However, instead of using the nozzle spacing for *w* in the formula, simply substitute the width of the band you are spraying. This will give you the number of gallons per treated acre, not per field acre. Once you obtain the number of gallons per treated acre, you must convert it to gallons per field acre using the following formula:

$$\frac{\text{gpa}}{\text{(per field acre)}} = \frac{\text{Band width (inches)}}{\text{Row spacing (inches)}} \times \text{gpa (per treated acre)}$$

An example. You wish to apply Devrinol 50 DF at a rate of four pounds per treated acre in a 16-inch band on 48-inch rows. You follow the previously described calibration procedure (time the distance to travel 88 feet, catch output from nozzles, etc.) and obtain the average gallons per minute (gpm) per nozzle and the tractor speed (mph). Fill in the values in the formula, but substitute the band width for the average nozzle spacing (w).

$$\text{gpa} = \frac{\text{gpm} \times 5{,}940}{\text{mph} \times w}$$

$$\text{gpa} = \frac{0.195 \times 5{,}940}{3 \times 16} = 24 \text{ (per treated acre)}$$

The sprayer is putting out 24 gallons per treated acre; or, put another way, the sprayer is putting out 24 gallons per acre in the treated band. But this rate will cover more than one acre of tobacco because you are spraying only one-third of the land. To obtain the number of gallons per field acre, use the previously mentioned formula:

$$\frac{\text{gpa}}{\text{(per field acre)}} = \frac{\text{Band width (inches)}}{\text{Row spacing (inches)}} \times \text{gpa (per treated acre)}$$

$$\frac{\text{gpa}}{\text{(per field acre)}} = \frac{16}{48} \times 24 = 8 \text{ gpa (per field acre)}$$

The sprayer is applying eight gallons per acre of land. But for every 24 gallons of water added to the tank, you add four pounds of Devrinol 50 DF. Suppose you add 150 gallons of water to your tank. To figure the acreage of tobacco this will cover:

$$\frac{\text{150 gallons}}{\text{8 gallons/acre}} = 18.75 \text{ acres}$$

To figure the amount of Devrinol 50 DF to add to the tank:

$$\frac{\text{150 gallons}}{\text{24 gallons/acre}} = 6.25 \times 4 \text{ pounds} = \text{25 pounds of Devrinol 50 DF per 150 gallons of water}$$

Or for every 24 gallons of water added to the tank, add four pounds of Devrinol 50 DF.

It is easy to see how band applications save money on herbicides. In this example, you can spray three acres of tobacco with the band application method for the same cost as spraying one acre with a broadcast application.

Other calibration methods are described in the *2012 North Carolina Agricultural Chemicals Manual*.

Calibrating a Sucker Control Boom with Three Nozzles per Row

The formula used to calibrate a broadcast application can be used to calibrate a sucker control boom with multiple nozzles per row. The only difference is that the output from the three nozzles for a given row should be combined and regarded as one nozzle. Then the output from the three nozzles should be converted into gpm, and the result should be entered into the formula.

An example. You have a four-row boom with three nozzles per row (two TG-3s on the outside and a TG-5 in the center). Your row spacing is 48 inches and you want to travel 3 mph, so you adjust your speed to travel 88 feet in 20 seconds. You catch the output from all three nozzles on a particular row. (Catch the output for each nozzle separately to make sure that similar-size nozzles are within 10 percent of each other.) Then combine the output for all three nozzles for 1 minute. Suppose it totals 4,550 milliliters, or 154 ounces.

$$gpm = \frac{4{,}550 \text{ ml/min}}{3{,}785 \text{ ml/gallon}} \text{ or } \frac{154 \text{ oz/min}}{128 \text{ oz/gal}} = 1.20 \text{ gpm}$$

Then enter that value into the formula:

$$gpa = \frac{1.20 \times 5{,}940}{3 \times 48} = 49.5$$

If you want to apply a 4 percent contact solution, add two gallons of contact per 48 gallons of water. This will apply a 4 percent contact at 49.5 gallons of total solution per acre.

Some Useful Information for Calibrating a Sprayer

88 ft/minute = 1 mph
1 gallon = 128 ounces
= 4 quarts
= 8 pints
= 16 cups
= 3.785 liters
= 3,785 milliliters
1 ounce = 29.6 milliliters
1 milliliter = 1 cubic centimeter

A Precautionary Statement on Pesticides

Pesticides must be used carefully to protect against human injury and harm to the environment. Diagnose your pest problem, and select the proper pesticide if one is needed. Follow label-use directions, and obey all federal, state, and local pesticide laws and regulations.

Table 6-3. Chemical weed control in tobacco. *NOTE: A mode of action code (MOA) developed by the Weed Science Society of America has been added to the Herbicide and Formulation column of this table. Use MOA codes for herbicide resistance management.*

Crop	*Weed*	*Herbicide, Mode of Action, and Formulation*	*Amount of Formulation Per Acre*	*Precautions and Remarks*
TOBACCO, FLUE-CURED Field, before Transplanting	*Most annual grasses and some broadleaf weeds plus nutsedge suppression*	*pebulate, MOA 8 (Tillam) 6 EC*	*2.7 qt*	*Apply to soil surface before bedding and immediately incorporate according to label instructions. Transplant as soon as possible. Early season stunting may occur under unfavorable growing conditions. Does not control cocklebur, morningglory, ragweed, or perennial weeds. Cultivate tobacco at least twice. See label for tank mixes with other pesticides.*
	Some annual grasses and some broadleaf weeds	*napropamide, MOA 17 (Devrinol) 2 EC*	*2 to 4 qt (broadcast, see label for band application)*	*Lower rates usually adequate for most soils. Apply to soil surface and incorporate according to label instructions. Some early-season stunting may occur under unfavorable growing conditions. Does not control cocklebur, morningglory, or perennial weeds. Gives some suppression of ragweed. NOTE: Do not seed crops not specified on label for 12 months after application.*
	Most annual grasses and some broadleaf weeds	*pendimethalin, MOA 3 (Prowl) 3.3 EC (Prowl) H_2O*	*1.8 to 2.4 pt 1.6 to 2.1 pt*	*Can be applied up to 60 days before transplanting. Apply before bedding and incorporate into soil according to label instructions. Some early-season stunting may occur under unfavorable growing conditions. Does not control cocklebur, morningglory, ragweed, or perennial weeds.*
	Annual grasses and some broadleaf weeds	*clomazone, MOA 13 (Command 3 ME) 3 FME*	*2 to 2.67 pt*	*Excellent annual grass control plus control of certain broadleaf weeds, such as prickly sida, jimsonweed, tropic croton, smartweed, and common ragweed. Partial control of cocklebur; does not control pigweed, sicklepod, or morningglory. Some whitening of lower leaves may occur but plants should recover. Do not plant small grains or alfalfa in the fall or following spring after Command application. Apply no more than once per season.*

Table 6-3. *(continued)*

Crop	*Weed*	*Herbicide, Mode of Action, and Formulation*	*Amount of Formulation Per Acre*	*Precautions and Remarks*
TOBACCO, FLUE-CURED Field, before Transplanting (continued)	*Broadleaf weeds, nutsedges, and some grasses*	*sulfentrazone, MOA 14 (Spartan) 4F*	*4.5 to 12 oz*	*Excellent control of pigweed, morningglories, and nutsedges. Application rate is based on soil type and organic matter. See Spartan 4F and Spartan Charge label for rate determination and application methods. Early-season stunting may occur especially when incorporated. Rainfall or irrigation needed within 7 to 10 days of application for maximum weed control, particularly when surface applied. Observe rotational crop guidelines on label.*
		sulfentrazaone + carfentrazone MOA 14 (Spartan Charge)	*5.7 to 15.2 oz*	
TOBACCO, FLUE-CURED Field, after transplanting	*Most annual grasses and some broadleaf weeds*	*napropamide, MOA 17 (Devrinol) 50 DF*	*2 to 4 lb (broadcast, see label for band application)*	*Apply overtop immediately after transplanting tobacco. See remarks for Devrinol under "Before Transplanting." NOTE: Do not seed crops not specified on label for 12 months after application. Small grain seeded for cover crop in fall may be stunted. Do not use small grain for food or feed.*
	Annual grass and some broadleaf weeds	*clomazone, MOA 13 (Command 3 ME) 3 FME*	*2 to 2.67 pt*	*Excellent annual grass control plus control of certain broadleaf weeds, such as prickly sida, jimsonweed, tropic croton, smartweed, and common ragweed. Partial control of cocklebur; does not control pigweed, sicklepod, or morningglory. Make a single broadcast application in a minimum of 20 gal of water. Apply no more than once per season. Apply over the top of tobacco plants immediately, or up to 7 days after, transplanting but prior to emergence of weeds. Some whitening of lower leaves may occur, but plants should recover. Do not plant small grains or alfalfa in the fall or following spring after Command application.*

Table 6-3. (continued)

Crop	Weed	Herbicide, Mode of Action, and Formulation	Amount of Formulation Per Acre	Precautions and Remarks
TOBACCO, FLUE-CURED Field, after transplanting (continued)	*Postemergence control of annual grasses*	*sethoxydim, MOA 1 (Poast) 1.5 EC*	*1 to 1.5 pt*	*Apply to actively growing grass not under drought stress. Apply in 5 to 20 gal of spray at 40 to 60 psi. Add 2 pt of crop oil concentrate per acre. Do not apply within 42 days of harvest. Do not apply more than 4 pt per acre per season. Complete coverage of grass required for control.*
	Postemergence control of some broadleaf weeds	*carfentrazone, MOA 14 (Aim) 2 EC*	*0.8 to 1.5 oz*	*Apply using SHIELDED SPRAYER or HOODED SPRAYER to emerged, actively growing weeds PRIOR TO LAYBY. Do not apply when conditions favor drift. MUST PREVENT CONTACT OF SPRAY SOLUTION WITH TOBACCO PLANT. See label for further instruction.*
TOBACCO, FLUE-CURED Lay-by	*Most annual grasses and some broadleaf weeds*	*napropamide, MOA 17 (Devrinol) 50 DF*	*2 to 4 lb (band; see label for band application)*	*Apply in a band to row middles immediately after last cultivation. Lower rates usually adequate for most tobacco soils. Incorporate lightly or sprinkler irrigate, if no rainfall within 3 days after application. Do not apply more than a total of 4 lb of Devrinol per acre in a season. See remarks for Devrinol under "Before Transplanting" and "After Transplanting."*
		pendimethalin, MOA 3 (Prowl) 3.3 EC (Prowl) H_2O	*1.8 to 2.4 pt 1.6 to 2.1 pt*	*Apply to row middles immediately after last cultivation. Avoid contact with tobacco leaves. Use higher rate on medium- or fine-textured soils where grass infestation is heavy or if no herbicide was used previously. Rainfall or irrigation is needed within 7 days. Does not control emerged weeds.*
TOBACCO, FLUE-CURED After first harvest	*Postemergence control of some broadleaf weeds*	*carfentrazone, MOA 14 (Aim) 2 EC*	*0.8 to 1.5 oz*	*Apply AFTER FIRST HARVEST for control of actively growing, emerged weeds. Position nozzles 3 to 4 inches above the soil and directed underneath the crop canopy. Do not apply when conditions favor drift. MUST PREVENT CONTACT OF SPRAY SOLUTION WITH TOBACCO PLANT. See label for further instruction.*

7. Topping, Managing Suckers, and Using Ethephon

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Topping tobacco in the button stage (soon after the flower begins to appear) rather than later increases yield and body if suckers are controlled. When tobacco plants are not topped for three weeks after reaching the button stage, yields are reduced by 20 to 25 pounds per acre per day, or about 1 percent per acre per day when normal yields range from two thousand to 2,500 pounds per acre. Higher yields reduce per-pound production costs for acreage-related inputs such as chemicals, fertilizers, equipment, and some labor expenses. In addition to improved yield and quality, early topping has other advantages:

- It usually allows topping to be completed before harvest begins, helping spread the workload away from the peak harvest period.
- It reduces the possibility of plants blowing over in a windstorm.
- It stimulates earlier root development, which increases fertilizer efficiency, drought tolerance, and alkaloid production.
- It helps to reduce buildup of certain insects because eggs and larvae are removed with the floral parts.

These significant advantages of early topping far outweigh the disadvantage of earlier sucker growth, which can be controlled with proper use of contact chemicals. Also, sucker growth is often greater as a result of improved varieties and fertility programs, as well as better control of root diseases through the cultural practices of crop rotation, early stalk and root destruction, resistant varieties, and the use of soil-applied pesticides. As a result of these improved practices, plant roots normally have a greater ability to absorb water and nutrients throughout the growing season. The result is a higher yield as well as a greater potential for sucker growth, especially on plants topped in the button stage.

Cultural Practices to Reduce Sucker Pressure

No matter what sucker control method is used, sucker control is facilitated by (1) managing tobacco in such a way as to reduce sucker pressure and (2) maximizing the effectiveness of chemical applications. Using a reasonable nitrogen fertilizer rate and striving for a uniform crop are two of the most important things that tobacco producers can do to facilitate sucker control and management.

Using a Reasonable Nitrogen Rate

Excess nitrogen stimulates sucker growth and delays maturity, which increases the probability of troublesome sucker regrowth in prolonged harvest seasons. A base nitrogen rate of 50 to 80 pounds per acre is suggested, plus adjustment for leaching if needed. The lower portion of the rate range is suggested for finely textured, fertile soils, especially if legume crops were grown in the field the previous year. The higher portion of the rate range is suggested for coarsely textured soils with topsoils deeper than 15 inches to clay. The data in Table 7-1 illustrate the importance of nitrogen rate for sucker control. When the recommended nitrogen rate was exceeded, suckers were more difficult to control. See chapter 5 in this book, "Managing Nutrients," for more information on determining nitrogen rates.

Table 7-1. Sucker control with various rates of nitrogen at Kinston and Reidsville, 1993[a]

Nitrogen Rate	*Sucker Control (%)[a]*
Recommended – 16 lb/acre	*87*
Recommended	*80*
Recommended + 16 lb/acre	*66*
Recommended + 54 lb/acre	*55*

[a] Average of two locations. All treatments received two fatty alcohol applications followed by 1.5 gal/acre of maleic hydrazide.

Striving for a Uniform Crop

Good plant uniformity in the field improves the chance for consistently good chemical sucker control. Therefore, it is essential to produce and use healthy, uniform transplants. Also, it is important to maintain soil pH in the range of 5.8 to 6.0, use fertilizer application methods that minimize salts injury, and use only labeled rates and proper incorporation methods for soil-incorporated pesticides, especially herbicides. Always follow label instructions for pesticides or fertilizers added to the transplant water. These practices reduce early-season root injury and improve crop uniformity, which allows the crop to mature on a normal schedule. This reduces the time that good sucker control is needed, particularly if the nitrogen rate is not excessive.

Chemical Sucker Control

Two primary types of chemicals are available for sucker control: (1) contacts (fatty alcohols), which kill small suckers by touching (burning) them; and (2) systemics, which restrict sucker growth without killing. Contact alcohol chemicals desiccate (burn) tender sucker tissue, whereas systemic chemicals retard sucker growth by inhibiting cell division. Maleic hydrazide (MH) is the only true systemic suckericide because it is absorbed by leaves and translocated through the plant to small sucker buds. Flumetralin (Prime+, Flupro, and Drexalin Plus) is a contact-local systemic suckericide because it must touch the suckers to be effective, although it retards sucker growth by inhibiting cell division. Each of these is discussed in more detail below.

In 2011, one purchaser of U.S. flue-cured tobacco only accepted tobacco without any MH residues. Growers who produce "pesticide residue clean" tobacco do this without using MH and have received a premium for their cured leaf. Therefore, there are essentially two approaches to chemical sucker control that producers must take: conventional programs that include MH or alternative approaches that control suckers without MH. A discussion of each approach and options for producers follow.

Sucker Control Without MH

Successful sucker control that does not use MH relies on reaching the maximum potential from the remaining tools at our disposal. The following is a discussion of using contacts and flumetralin to control suckers without MH.

Contact Fatty Alcohols

The purpose of contact fatty alcohol applications is to provide sucker control between early topping and the time at which the upper leaves are large enough to be sprayed with flumetralin without causing leaf distortion. Another major advantage of contact alcohols, especially where multiple applications are made, is to shorten the period for flumetralin to control suckers after topping. Successful sucker control without MH starts with proper application concentration and timing of contacts. Poor control with contacts cannot be corrected by flumetralin. Applications of contacts and flumetralin should be made only to the rows where the crop was transplanted, to facilitate as accurate a delivery of the product as possible.

Timing. You should make the first contact application as soon as 50 to 60 percent of the plants have a visible button. Timing of chemical application is important because neither contacts nor flumetralin will adequately control suckers longer than 1 inch. Contacts are more effective if applied three to five days apart when humidity is low and leaf axils are fully exposed—that is, generally between 10 a.m. and 6 p.m. on sunny days, except when the plants are wilted and temperature exceeds 90ºF. Contacts should not be applied to plants that are wet with rain or heavy dew or that are severely stressed by drought.

Coverage of leaf axils and stalk rundown are essential for contact applications. Contacts should be applied with three nozzles per row (TG3-TG5-TG3 per row or equivalents), at a low pressure (20 to 25 pounds per square inch [psi]) and with a 50 gallons-per-acre delivery volume. Nozzle selection, pressure, and delivery volume are critical for proper droplet size, which leads to good stalk rundown and coverage.

Concentration. The degree of sucker control with contact alcohols is directly related to the ratio of chemical to water. Therefore, it is extremely important to mix a specific amount of contact chemical with an exact amount of water. The suggested ratio for the first application of C8–C10 contact alcohol products (Off-Shoot T, Fair 85, Kleen-Tac, Sucker Plucker, Royaltac-M, etc.) is two gallons in 48 gallons of water; this makes a 4 percent solution. A 5 percent solution is suggested for subsequent applications of C8–C10 contact alcohol products; this is 2.5 gallons in 47.5 gallons of water. The suggested ratio for the C10 products (Antak, Fair-Tac, Royaltac, Ten-Tac) is 1.5 gallons in 48.5 gallons of water; this makes a 3 percent solution. The mixtures should be strong enough to kill both of the tiny suckers in each leaf axil when the solution wets suckers less than one inch long. Using more than the suggested amount of water will weaken the mixture, and you will not obtain good control. Using less than the suggested amount of water will strengthen the mixture and may cause leaf burn on tender crops.

Weak contact solutions, those less than 4 percent for the C8–C10 products or less than 3 percent for the C10 products, often control only one of the two sucker buds in each leaf axil. A good general rule is to apply a contact solution that chemically tops 5 to 10 percent of the small, late plants in a field. If no chemical topping occurs during the first application, the solution is too weak to provide maximum sucker control, or the application took place too late. Some growers worry about leaf drop with contact alcohol solutions. This is not likely to be a problem unless the crop has been overfertilized with nitrogen and the season is unusually wet for several days after application. Generally, the benefits of increased sucker control from full-strength contact applications far outweigh any negative effects of leaf drop.

Flumetralin (Prime+, Flupro, and Drexalin Plus)

Mechanical application of flumetralin (over-top sprays). Flumetralin should be applied like a contact solution: only to the same rows to which the crop was transplanted. The objective is to apply flumetralin so that it touches the small suckers just like contact solutions because, unlike MH, flumetralin does not move to sucker buds through the leaves. Flumetralin must first wet the suckers like a fatty alcohol contact before it can stop cell division like a systemic. Therefore, flumetralin is referred to as a contact-local systemic. It has no true contact activity, and the controlled suckers do not turn brown or black but rather look yellow and deformed for several weeks after treatment.

Because flumetralin needs to run down the stalk and wet the suckers, it should be applied with contact nozzles (TG3-TG5-TG3 per row or equivalents), with a delivery volume of 50 gallons per acre and at a low pressure (20 to 25 psi). Flumetralin does not completely control suckers longer than one inch, so you should remove larger suckers before application. Full-season sucker control can be expected on small suckers wetted by the flumetralin solution, but missed suckers will continue to grow and should be removed by hand. Missed leaf axils with flumetralin are typically in the top of the plant and may result from leaning stalks, leaves covering the leaf axil, or both, preventing proper “rundown” of flumetralin into all the leaf axils.

Even though the flumetralin label allows for application of up to one gallon per acre, the general recommendation has been for application rates of two quarts per acre. Increasing flumetralin rates from two quarts per acre to three quarts or one gallon in a single mechanical application has not consistently improved sucker control, primarily because control is so dependent on coverage of all leaf axils, which is not improved by increasing flumetralin rates. However, application of two quarts of flumetralin followed by one quart of flumetralin seven days later improves sucker control compared to three quarts of flumetralin applied in a single application. This would indicate that increasing rates of flumetralin above two quarts per acre is only advantageous if the flumetralin is applied in a split application. It is likely that split applications reduce the number of missed leaf axils—the main cause of poor sucker control when MH is not used.

Soil residues of flumetralin applied to tobacco may contribute to stunted early-season growth of later crops, especially small grains and some vegetable crops, such as sweet potatoes and corn, but also nonrotated tobacco, particularly if excessive rates are used for sucker control on light, sandy soils. The carryover potential may be greater when a dinitroaniline is used for both weed and sucker control on sandy soils. (See product labels for comments on carryover residues and possible rotation crop injury.)

Dropline applications of flumetralin. Dropline applications are generally the most effective way to apply flumetralin because they allow for the most consistent ability to apply the flumetralin solution to each leaf axil. However, dropline applications require more labor, which is not always available on the farm depending on the scope of the farming operation or the degree of mechanization of other farming operations. Even though the best sucker control from flumetralin is achieved with dropline applications, growers must decide on a case-by-case basis whether such application methods are feasible and practical, depending on their individual situations.

A dropline application is made manually, with a single line per row, coming off of a powered sprayer (typically a high-clearance sprayer). Multiple lines can be used at one time, and each line has a valve (trigger) and a single TG nozzle. Flumetralin is then applied on a plant-by-plant basis by manually holding the nozzle over the center of the plant and opening the valve or "trigger" long enough to apply a desired amount of solution to each plant, which is enough for the solution to reach the soil line at the base of the plant.

Dropline applications should be initiated when approximately half of the plants are in the elongated bud to early flowering stage. Plants should be topped and then flumetralin applied within 24 hours. In many cases, both topping and applying flumetralin with a dropline can be accomplished at the same time. Where uniformity is a problem and some plants are later to mature, a second trip through the field to top and dropline flumetralin only on those plants may be needed. If a second trip is needed, it can usually be accomplished at a faster speed than the original dropline application. Only apply flumetralin with a dropline once per plant per season.

Another advantage of dropline applications is that they can reduce the need for contact applications because dropline applications of flumetralin can be made at topping. In many cases, contact applications, when used in conjunction with a dropline application of flumetralin, are used only to allow the crop to "even out" so that all plants are at the correct stage for flumetralin application and only one trip across the field with droplines is needed. Contacts may also be used in this scenario to delay flumetralin applications for better management of labor resources by controlling sucker growth until labor is available.

In a dropline application, flumetralin should be mixed the same as with mechanical applications: two or three quarts of flumetralin in 49.5 or 49.25 gallons of water, respectively. The flumetralin solutions should be applied alone to deliver one-half to two-thirds of a fluid ounce of solution per plant. The intent is for the solution to reach the soil line with no excess, to reduce residues in the soil. Workers who perform dropline applications of flumetralin must wear personal protective equipment. Read the label for each source of flumetralin carefully (Prime +, Flupro, Drexalin Plus) to determine the requirements for dropline applications.

Sucker Control with Programs That Use MH to Minimize MH Residues

MH has saved many hours of labor since its introduction in the early 1950s. It is widely used for sucker control because it is relatively inexpensive, easy to apply, and usually effective. But high residues can reduce demand by both domestic and export customers. No suitable alternative to MH has been developed, and many sucker control programs without this product have not given consistently good results.

Periodic droughts and the adoption of improved varieties and cultural practices that emphasize yield extend the harvest season, which extends the period needed for good sucker control. Unfortunately, longer harvest seasons and greater use of mechanical harvesters have sometimes led to excessive use of MH initially or in additional late-season applications. Consequently, MH residues on and in cured tobacco are often higher than acceptable to buyers.

Several members of the European Union, major importers of United States leaf tobacco, have adopted an MH tolerance level of 80 parts per million (ppm) for tobacco products. This tolerance may be established by other European countries in the near future. The major competitor for American-style flue-cured tobacco, Brazil, does not use MH and could capture a more significant share of the export market if MH residues on U.S. tobacco do not drop to and remain near the 80-ppm level.

Although an official MH tolerance has not been established in the United States, domestic cigarette manufacturers and all members of the industry are very concerned about poor public perception of any pesticide residues that could reduce tobacco use both here and abroad. Although domestic cigarette consumption is not increasing, the United States is a leading leaf exporter. Our continued success will depend partially on the domestic manufacturers' ability to provide cigarettes that meet current or potential pesticide tolerances in other countries.

MH is very water-soluble, and residues vary substantially among years and regions. Residues are generally lower when both rainfall and yields are relatively high. Also, don't forget that the Farm Services Agency certification you sign annually states that all pesticides you used for flue-cured tobacco production were applied according to label directions. In addition to possible loss of domestic and export markets, continued overuse of MH could result in greater use restrictions.

It is important for the entire tobacco industry, including producers and farm supply dealers, to understand the significance of the pesticide residue issue to our industry, particularly to our export market. Also, it would be wise to assume that all pesticides that leave residues on tobacco (not just MH) will very likely undergo even greater scrutiny and regulation soon.

Early sucker control can be maximized with fatty alcohol contacts and flumetralin. This is essential if good sucker control is to be maintained with one application of MH at the labeled rate. Because contacts and flumetralin must touch the suckers to be effective, uniform row spacing, proper application speed, correct boom height, precise nozzle size and arrangement, and suitable pump pressure are all important for good sucker control. (See product labels for instructions.)

Proper Use of Contacts (Fatty Alcohols)

The degree of sucker kill with contact alcohols is directly related to the ratio of chemical to water. Therefore, it is extremely important to mix a specific amount of contact chemical with an exact amount of water. Most other chemicals used to control insects, weeds, and diseases do not share this requirement because growers need to add only enough water to uniformly distribute the chemicals.

The suggested ratio for the first application of C8–C10 contact alcohol products (Off-Shoot T, Fair 85, Kleen-Tac, Sucker Plucker, Royaltac-M, etc.) is two gallons in 48 gallons of water; this makes a 4 percent solution. A 5 percent solution is suggested for the second or third application; this is 2.5 gallons in 47.5 gallons of water. The suggested ratio for the C10 products (Antak, Fair-Tac, Royaltac, Ten-Tac) is 1.5 gallons in 48.5 gallons of water; this makes a 3 percent solution. The mixtures should be strong enough to kill both of the tiny suckers in each leaf axil when the solution wets suckers less than one inch long. Using more than the suggested amount of water will weaken the mixture, and you will not obtain good control. Using less than the suggested amount of water will strengthen the mixture and may cause leaf burn on tender crops.

Sucker control data (Table 7-2) show the great difference in sucker growth at final harvest when three different concentrations of a contact alcohol solution were applied. Suckers appeared to be under control for several weeks but then grew rapidly as the harvest season progressed, especially where the 2 and 3 percent solutions were applied.

Table 7-2. Sucker growth with three different concentrations of C8–C10 contact alcohol sprays

Contact + Water (gallons)	*Percentage Solution*	*Suckers per Acre*	
		(number)	*(lb)*
1 + 49	*2*	*29,900*	*6,256*
1.5 + 48.5	*3*	*15,600*	*4,794*
2 + 48	*4[a]*	*7,800*	*1,950*

[a] Normal suggested rate of 2 gallons of contact chemical in 48 gallons of water.

Weak contact solutions, those less than 4 percent for the C8–C10 products or less than 3 percent for the C-10 products, often control only one of the two sucker buds in each leaf axil. Then the suggested rates of the systemic chemicals cannot control sucker growth on vigorously growing tobacco. Therefore, applying weak contact solutions may contribute to the use of excessive late-season applications of MH, which significantly increase MH residues on and in our cured tobacco. A good general rule is to apply a contact solution that chemically tops 5 to 10 percent of the small, late plants in a field. If no chemical topping occurs during the first application, the solution is too weak to provide maximum sucker control, or the application took place too late.

Some growers worry about leaf drop with contact alcohol solutions. This is not likely to be a problem unless the crop has been overfertilized with nitrogen and the season is unusually wet for several days after application. Generally, the benefits of increased sucker control from full-strength contact applications far outweigh any negative effects of leaf drop. Using a contact alcohol allows for earlier topping, which increases yields. Its purpose is to provide sucker control between early topping and the time when the upper leaves are large enough to be sprayed with a systemic chemical without causing distortion.

Timing of chemical application is also important because none of the chemicals, including MH, will adequately control suckers that are longer than one inch. You should make the first contact application as soon as 50 to 60 percent of the plants have a visible button. Contacts usually are more effective if applied three to five days apart when humidity is low and leaf axils are fully exposed—that is, generally between 10 a.m. and 6 p.m. on sunny days, except when the plants are wilted and temperature exceeds 90ºF. Also, none of the products should be applied to plants that are wet with rain or heavy dew or that are severely stressed by drought.

Another major advantage of contact alcohols, especially where two or three applications are made, is that they shorten the period for the systemic chemical to control suckers after topping. Systemic chemicals containing only MH tend to “give out” six to seven weeks after application. When the harvest season lasts for 10 or more weeks, sucker regrowth often occurs. Flumetralin, another systemic-acting chemical, controls suckers longer than MH does, but its control is further extended when preceded by one or two applications of alcohol contact.

Proper Use of Flumetralin (Prime+, Flupro, Drexalin Plus)

Flumetralin should be applied like a contact solution but not until the plants are in the elongated button to early flower stage. This is a few days before MH application is suggested. The objective is to apply flumetralin so that it touches the small suckers like contact solutions do because, unlike MH, flumetralin does not move to sucker buds through the leaves. Flumetralin must first wet the suckers like a fatty alcohol contact before it can stop cell division like a systemic.

Therefore, flumetralin is referred to as a contact-local systemic. It has no true contact activity, and the controlled suckers do not turn brown or black but rather look yellow and deformed for several weeks after treatment.

Because flumetralin needs to run down the stalk and wet the suckers, it should be applied with contact nozzles (TG3-TG5-TG3 per row or equivalents) at a low pump pressure (20 to 25 psi). And because it is not absorbed and moved through the plant, it performs better than MH in dry weather. Applying flumetralin by hand (down-stalk application) is likely to wet more suckers than mechanical spraying (overtop), but hand application requires more labor. Like other sucker control chemicals, flumetralin does not completely control suckers longer than one inch, so you should remove larger suckers before application.

Full-season sucker control can be expected on small suckers wetted by the flumetralin solution, but missed suckers will continue to grow and should be removed by hand. Missed suckers are likely to occur on leaning plants, whether treated with flumetralin or fatty alcohol contacts. Therefore, using MH in a tank mix with flumetralin or within a day or two after flumetralin application will control the missed suckers. This is why the most effective chemical sucker control programs include the use of both MH and flumetralin.

Soil residues of flumetralin applied to tobacco may contribute to stunted early-season growth of later crops, especially small grains, corn, and sweet potatoes, but also nonrotated tobacco, particularly if excessive rates are used for sucker control on light, sandy soils. The carryover potential may be greater when a dinitroaniline is used for both weed and sucker control on sandy soils. (See product labels for comments on carryover residues and possible rotation crop injury.) To minimize possible injury to crops planted in the fall or following spring, follow label mixing and rate instructions and do not apply any more spray volume than required to run down to the bottom of the stalks. Rainfall within two hours after application could reduce effectiveness of flumetralin, but reapplication will also increase the potential for soil residue carryover. Therefore, do not reapply if flumetralin washoff occurs. Also, destroy stalks and roots after the last priming and bury them two weeks later with a moldboard plow set at a depth of five to six inches. Disk once or twice before planting a small grain cover crop.

Growers are advised not to exceed labeled rates of flumetralin whether used alone or in tank mixes with MH. Higher rates will not significantly improve sucker control but may make soil residue levels high enough to stunt crops planted in the fall or spring.

Sucker control from flumetralin can be improved by making split applications, essentially dividing the desired total amount per acre into two applications made five to seven days apart, instead of all in one application. This is especially advantageous when reduced rates of MH are used or when sucker control without using MH is necessary. (See the discussion of MH-free tobacco earlier in this chapter.)

Apply the Labeled Rate of MH Properly

Unlike fatty alcohol contacts and flumetralin, MH is absorbed by leaves and moves within the plant to small sucker buds. Good absorption and systemic movement depend on having good crop growing conditions. Therefore, MH should never be applied on drought-stressed crops or on those wilted by too much rain, high temperatures, or both. It is best to apply MH one to three days after a good rain or irrigation. When irrigation is not available, many growers use flumetralin or one extra contact application to control suckers until enough rain comes for good MH absorption. This should be viewed as "buying time" until rainfall occurs. If soil moisture is adequate but afternoon temperatures will be high enough to cause partial wilting, MH should be applied only during the morning, starting when the leaves are just slightly wet with dew. Afternoon spraying generally is not suggested except on cool, cloudy days when soil moisture is good. It is extremely difficult for growers with large acreages and only one sprayer to take advantage of the best weather conditions for MH application; some should consider buying another sprayer or using larger nozzles to allow faster application.

The labeled rate of MH application on flue-cured tobacco is one quart per one thousand plants. Most tobacco in North Carolina is planted at approximately six thousand plants per acre. The correct rate for six thousand plants is 1.5 gallons per acre. (This rate is suitable for most formulations available in North Carolina, which contain 1.5 pounds of ai per gallon of product; some products contain 2.25 pounds of ai per gallon and should be applied at one gallon per acre for six thousand plants per acre.) Only one application is permitted unless the first application is washed off by rain. Even then, research indicates that reapplication of the full MH rate is not needed unless a substantial rain occurs within four hours after the first application. Only a half-rate application (0.75 gallon of MH per acre) is needed if rain occurs between four and 10 hours after the first application. No reapplication is needed if rain occurs more than 10 to 12 hours after the first application. Following these important guidelines will ensure good sucker control with only minimal increases in MH residues.

MH is absorbed more effectively by younger, upper leaves than by older, lower leaves. Therefore, MH should be applied to the upper third of the plant using the three-nozzles-per-row arrangement. Some growers use drop nozzles with high pressure, as they do when spraying for aphids or flea beetles. This will not substantially improve sucker control but will increase MH residues because more of the spray is deposited on the undersides of leaves, where rainfall is less apt to wash it off. Therefore, the use of drop nozzles for MH application is strongly discouraged. MH residues are often higher on lower leaves than on upper leaves because the lower leaves are harvested sooner after MH application.

MH is very water-soluble but is not substantially degraded by sunlight or the high temperatures used during curing. The data in Table 7-3 illustrate the importance of rainfall in reducing MH residues. In these tests, MH application was followed 24 hours later by various amounts of irrigation to simulate rainfall. Lower and upper green leaves were sampled for MH residues immediately after irrigation. As little as 0.05 to 0.1 inch of irrigation significantly reduced MH residues on leaves from both stalk positions.

Timing of MH Application

MH is the most widely used chemical on tobacco grown in the United States. More recently, flumetralin—also a systemic suckercide, as MH is—has become popular among flue-cured growers, particularly in tank mixes with MH. Each product controls sucker growth by inhibiting cell division. Most MH labels stipulate that it must not be applied before the upper leaves are eight inches long to reduce possible stunting, a discoloration called “bronzing,” or both. However, these abnormalities are sometimes observed when MH is applied on leaves longer than eight inches. Growth distortion of upper leaves treated with flumetralin also occurs, but less frequently than that associated with MH. Research suggests that the likelihood of discoloration and stunting from MH applications is greatly reduced when applications are delayed until upper leaves are 16 inches long.

MH residues can also be reduced when the interval between application and harvest is maximized. The MH label states that you should wait at least seven days between MH application and harvest, with the anticipation that rainfall during this period will wash off some residues. If tobacco is ready for MH application and harvest, make every attempt to harvest first, then apply MH. It will most likely be at least seven days before the crop will be ready for another harvest. This will ensure MH-free first primings.

Once the rainfast period has passed following application of MH (10 to 12 hours), irrigation or rainfall can reduce MH residues without adversely affecting sucker control. After 10 to 12 hours, essentially all of the leaf absorption of MH that will occur has taken place. The residual MH left on the leaf surface contributes greatly to MH residues in cured leaf. Therefore, the washing off of MH through irrigation or rainfall has the effect of reducing overall residues. Table 7-3 illustrates the reduction of MH residues with various levels of irrigation applied 24 hours after application in research trials in 1992 and 1993.

Table 7-3. MH residues on lower and upper green leaves following various amounts of irrigation, 1992–1993

	MH Residues[a] (ppm)	
Irrigation Applied (inches)	***Lower***	***Upper***
None	*61*	*181*
0.005	*53*	*125*
0.01	*51*	*96*
0.05	*32*	*85*
0.1	*27*	*84*
0.2	*22*	*76*
0.5	*24*	*70*

[a] All treatments received 1.5 gal/acre of MH. MH residues are averages of four experiments.

Consider Using an Alternative Sucker Control Program

The most effective sucker control programs include proper use of the fatty alcohol contacts, flumetralin, and the labeled rate of MH. All of the newer programs provide better control than the traditional treatment of two contact applications followed by MH application (Table 7-4). These programs offer excellent, season-long sucker control without using more than the recommended rate of MH. The MH-flumetralin tank mix was used on more than 60 percent of the flue-cured acreage in 2002. The delayed use of flumetralin or another fatty alcohol application two to three weeks after MH involves an additional trip over the field but provides excellent late-season sucker control if applied before sucker buds exceed one inch in length. Apply the

Table 7-4. Sucker number and weight reductions with sucker control programs including Prime+, 1991–1994

Application[a]		Suckers per Acre (Average/25 On-Farm Tests)	
Third	Fourth	(number)	(lb)
MH alone	None	13,644	1,697
(MH & Prime+) tank mix	None	1,575	380
MH alone	Prime+ (2 to 3 wk after MH)	557	165

[a] Third applications preceded by 4 percent and 5 percent fatty alcohol contact applications. Rates were 1.5 gal/acre for MH and 2 qts/acre for Prime+.

tank mix like a fatty alcohol contact, i.e., as a coarse spray (20 to 25 psi) using 50 gallons of spray volume per acre. Do not use the delayed flumetralin application if flumetralin was used for sucker control earlier in the season.

Topping and Sucker Control Programs That Include MH

Recommendations in this section for the use of MH are primarily related to achieving acceptable sucker control with minimal MH residues. Most recommendations in this section include 1.5 gallons of MH (2.25 lb ai). MH residues with 1.5 gallons of MH vary greatly across seasons and depend upon rainfall, irrigation, and harvest intervals. Generally, MH residues are lower in years with higher rainfall amounts. Irrigation and extending harvest intervals to wait on rainfall can lower residues in both dry and wet years. Because MH residues vary so greatly across growing seasons, it is not possible to recommend a rate that guarantees residue levels that are acceptable to all customers. However, reducing MH rates below the recommended rate of 1.5 gallons per acre can further reduce MH residues on a relative basis.

Acceptable sucker control can be achieved with rates below 1.5 gallons (2.25 lb ai) but require using contacts wisely (see section on use of contacts) and potentially splitting applications of flumetralin (see section on using flumetralin). Research has shown that if maximum sucker control is achieved with contact applications and application of flumetralin is split (two quarts of flumetralin followed by a second application of flumetralin at one quart five to seven days later), rates of MH can be reduced to one gallon per acre (1.5 lb ai). In this scenario, MH is applied with the second application of flumetralin and after the first harvest.

Several topping and chemical sucker control programs have been developed. Each is based on application of the correct rate of nitrogen (50 to 80 pounds per acre), depending upon soil type, with adjustments for leaching. Excessive nitrogen availability promotes excessive sucker growth as well as leaf drop and breakage. Proper sprayer calibration is important. See the sprayer calibration section in chapter 6, "Managing Weeds," for information on how to properly calibrate a spray boom with multiple nozzles per row.

Pay particular attention to label instructions regarding worker protection standards (see chapter 11, "Protecting People and the Environment When Using Pesticides"). This information provides specific requirements for personal protective clothing, restricted field reentry intervals, and other restrictions.

Overtop Application

Step 1. Apply an alcohol contact spray before topping when about 50 to 60 percent of the plants reach the button stage. The floral parts help to intercept sprays to increase sucker kill in the upper leaf axils. Use a 4 percent concentration for C8-C10 products or a 3 percent concentration for C10 products. Using higher concentrations or application pressures than those suggested on the product labels may cause substantial leaf burn, particularly for C10 products applied on tender tobacco when temperatures are unusually high.

Step 2. Top plants that are ready for topping 24 to 48 hours after the first contact alcohol application, making sure to follow label instructions regarding reentry into pesticide-treated fields.

Step 3. Make a second alcohol contact application three to five days after the first contact application. Use a 5 percent concentration for C8-C10 alcohols (2.5 gallons in 47.5 gallons of water per acre) or a 3 percent concentration for C10 alcohols (1.5 gallons in 48.5 gallons of water per acre). Note: Drought-stressed plants or those with irregular growth and flowering may need a third alcohol contact application several days after the second, applied at the same concentration as the second application. An alternative for reasonably uniform plants with tip leaves at least 10 to 12 inches long is 0.5 gallon of flumetralin in 49.5 gallons of water per acre.

Step 4. Top any plants that were not topped during the first topping.

Step 5. Use one of these alternatives:

- *Alternative A*. Apply a tank mix of 1.5 gallons of MH (for products containing 1.5 pounds active MH per gallon) and two quarts of flumetralin per acre at the normal stage of leaf development for MH application. Apply as a coarse spray in 50 gallons of total solution per acre, as with contact alcohols (three nozzles per row: TG3-TG5-TG3 or equivalents; see "Nozzle Sizes, Arrangements, and Application Speeds" below). Use no more than three quarts of flumetralin per season to reduce the risk of soil residue carryover to following crops. Allow at least one week between MH application and harvest to minimize MH residues on and in cured leaves.

- *Alternative B*. Apply three gallons of FST-7 or Leven-38 in 47 gallons of water per acre about five to seven days after the second or third alcohol contact. Higher concentrations may cause leaf burn. Allow at least one week between MH application and harvest to minimize MH residues on and in cured tobacco. These products are a combination of a C10 contact alcohol and MH but contain 11 percent less MH than other MH products when used at labeled rates.

- *Alternative C*. Apply 1.5 gallons of MH per acre (for products containing 1.5 pounds active MH per gallon) about five to seven days after the second or third contact alcohol application. Allow at least one week between application and harvest to minimize MH residues on and in cured tobacco. MH alone usually does not provide adequate season-long sucker control compared to the tank mix described in Alternative A, and a fourth application of one of the products in step 6 below is often required to control late-season sucker regrowth.

- *Alternative D*. Instead of the second or third (if applicable) contact alcohol application, apply two quarts of flumetralin per acre mixed in 49.5 gallons of water, as mentioned in step 3, when the crop is at the elongated button to early flower stage. Apply by the dropline method or by tractor-mounted sprayer. With a tractor-mounted sprayer, apply as a coarse spray with low pressure just as you would for a contact application. About five to seven days after this application, apply the labeled rate of MH. Use flumetralin only once per season to reduce the risk of soil residue carryover to following crops. Allow at least one week between MH application and harvest to minimize MH residues on and in cured tobacco.

Step 6. Use if sucker regrowth is anticipated late in the season:

- *Alternative A*. Apply a 5 percent C8-C10 contact solution (2.5 gallons in 47.5 gallons of water) using the standard application procedure for contact sprays. Do this about three weeks after MH application, when suckers are small and susceptible to contact burn. Remove suckers longer than one inch by hand before application.

- *Alternative B*. Apply two quarts of flumetralin per acre using the standard application procedure for fatty alcohol contacts (50 gallons of total solution per acre, three nozzles per row, low pressure). Apply about three weeks after MH application. Remove suckers longer than one inch by hand before application. Do not use this option if you applied flumetralin earlier in the season. Allow one week between MH application and harvest.

Nozzle Sizes, Arrangements, and Application Speeds

Except for MH applied alone, all currently labeled suckericides and mixes must be applied by methods that encourage stalk rundown in order to be most effective. When using the standard three-nozzle arrangement (TG3-TG5-TG3), application speed is limited to 2.5 to 3 mph to maintain the spray volume over the center of the row. Application of fatty alcohols and contact-local systemics, including tank mixes of these products with MH, is one of the slowest mechanical operations in tobacco production except for transplanting and perhaps mechanical harvesting of first primings. The ability to apply these products faster without lowering sucker control reduces manual and machine labor, improves timeliness of suckericide application, and allows more acreage to be sprayed when the weather is favorable. The increasing use of more precise application equipment, such as “high-boy” sprayers, may allow many growers to apply suckericides faster without reducing sucker control.

In 10 field tests conducted in 1997 through 1999, a “high-boy” sprayer operated at 2.8 or 4.6 mph was used to apply each of several sucker control treatments. All applications at 2.8 mph were made with standard TG3-TG5-TG3 nozzles, and all applications at 4.6 mph were made with TG6-TG8-TG6 nozzles. Each combination of nozzle sizes and speeds delivered 50 gallons-per-acre spray volume per application on 48-inch rows. Sucker number and weight per acre did not increase with any of the sucker control treatments when applied at the faster speed.

In trials conducted in 2001 and 2002, sprayer modifications were made that allowed the same treatments to be applied at 3 and 6 mph. In addition, a number of field experiments were conducted to determine if several other "straight" or "cross" nozzle arrangements with four or five nozzles per row would improve sucker control at the 6 mph application speed. Several of the arrangements are illustrated below. An additional purpose of the 5-8 • 8-5 and both of the five-nozzle-per-row arrangements was to concentrate relatively more of the total spray volume over the row centers as compared to the three-nozzles-per-row arrangements.

```
3 Nozzles/Row      4 Nozzles/Row       5 Nozzles/Row
   3—5—3             5—6•6—5              5         6
   6—8—6             5—8•8—5              |         |
                                      3—8—3     3—6—3
                                          |         |
                                          5
```

The arrangements shown in Table 7-5 provided the best sucker control in these trials. The differences in sucker number and weight among the three arrangements were not statistically significant. The poorest performers on average were the five-nozzle-per-row arrangements, which concentrated a relatively higher percentage of the total spray volume over the row centers (data not shown). This implies that failure to keep these nozzle arrangements directly over the row may reduce sucker control relatively more than arrangements that supply more of the total spray to the sides of the row.

These results indicate that growers who wish to apply stalk rundown suckericides at faster speeds can do so with confidence if they have uniform row widths, good sprayer equipment, and relatively level land, and if they treat only the number of rows that were transplanted. However, relatively simple three- or four-nozzle-per-row arrangements appear to provide sucker control as good as or better

Table 7-5. Sucker numbers and weights per acre in nine experiments for a good sucker control program applied with three nozzle arrangements or sizes, 2001–2002

TG Nozzle Sizes (per row)	Gauge Pressure (psi)	Application Speed[a] (mph)	Suckers per Acre[b]	
			(number)	(lb)
Treatment: Contact (4%) + Contact (5%) + (MH & Prime+)[c]				
3—5—3	20	3	1,089	288
6—8—6	18	6	1,480	395
5—6•6—5	18	6	1,477	346

[a] Each speed delivers 50 gal/acre of spray volume for the nozzle sizes and gauge pressures shown.
[b] Averages of nine research and on-farm tests.
[c] Rates were 2 qt/acre Prime+ and 1.5 gal/acre MH.

than the more elaborate five-nozzle arrangements tested to date.

No matter what arrangement you choose, be sure to calibrate your own application equipment for the row width, pressure, hose diameter, and strainer sizes to be used. Instructions for calibrating a sucker control boom are given in chapter 6, "Managing Weeds." After determining the output in gallons per minute (gpm), the speed needed to deliver the appropriate number of gallons of spray volume per acre (e.g., gpa = 50 gal/a) can be calculated by using the following formula:

$$mph = (gpm \times 5{,}940) / (gpa \times \text{row width (inches)})$$

Use of Ethephon

Ethephon (Prep, Ethephon 6, Mature XL, Oskie, or Super Boll) is the only chemical approved for yellowing tobacco in the field. To use any other chemical for this purpose is illegal. Growers who do so—whether selling by contract or at auction—could cause considerable problems for themselves and for our industry.

Before spraying whole fields of tobacco with ethephon, test-spray some plants uniformly with hand kits available from agricultural chemical dealers, or prepare your own test spray by mixing one teaspoon of product in one quart of water. The purpose of test-spraying is to determine whether the leaves are mature enough to be induced to yellow. Test-spraying a few representative plants at several locations in each field and observing them two to three days later will help you decide if the tobacco will yellow as desired. This may be especially important in fields planted at different times, planted with different varieties, fertilized differently, topped at different heights, or otherwise managed differently. Ethephon should be used on the entire field only if plants respond well to test-spraying; if test leaves do not yellow within 72 hours, the crop is not mature enough to be sprayed or harvested.

Good spray coverage, especially of the leaf butts and uppermost leaves, is essential to achieve uniform yellowing. For over-top applications, apply the chemical in 50 gallons of spray per acre using a three-nozzle arrangement at a pressure of 40 to 60 psi. The finer the spray, the better the chance of it drifting inward toward the stalk and covering the leaf butts; consequently, 60 psi may give better coverage than 40 psi. Be sure to adjust the nozzles to ensure adequate coverage of all remaining leaves. Ethephon works more consistently when applied on warm, sunny days. Treat only the acreage that can be harvested in one day, and guard against leaf drop by not allowing treated tobacco to become overyellow before harvesting. Prep, Ethephon 6, Mature XL, and Super Boll contain six pounds of ethephon per gallon and are labeled to be used at $1^1/_3$ to $2^2/_3$ pints per acre. Oskie contains three pounds of ethephon per gallon and is labeled to be used at $2^2/_3$ to $5^1/_3$ pints per acre. Use the lower rate for normal crops and the higher rate for rank crops, particularly when temperatures are lower than normal at application time.

The field reentry time restriction for ethephon is 48 hours after application. Also, allowing 48 hours between spraying of ethephon and harvesting results in larger and more consistent reductions in curing time compared to earlier harvesting.

Precautionary Statement on Pesticides

Pesticides must be used carefully to protect against human injury and harm to the environment. Diagnose your pest problem, and select the proper pesticide if one is needed. Follow label use directions, and obey all federal, state, and local pesticide laws and regulations.

Table 7-6. Yellowing agents for flue-cured tobacco

Purpose	Chemical	Amount of Formulation per Acre	Pounds Active Ingredient per Acre	Precautions and Remarks
Increase the rate of yellowing	*Ethephon (Prep) (Super Boll) (Mature XL) (Ethephon 6)*	*1.33 to 2.67 pt*	*1 to 2 lb*	*Use after second or third priming when remaining leaves are physiologically mature. Determine if tobacco is ready to spray by treating several representative plants at several locations with test kit. If test leaves begin to yellow in 24 to 72 hr, apply product to tobacco in 40 to 60 gal water per acre as a fine spray mist (40 to 60 psi). Effectiveness may be reduced by application on cool, cloudy days, poor spray coverage, or rain within 4 hr after application. Harvest leaves as soon as possible after REI on label or when they reach the desired degree of yellowness; prolonged delay in harvest may result in yield and quality loss or leaf drop. Therefore, do not spray more acreage than can be harvested before major rain is expected. DO NOT USE SURFACTANTS!*
	(Oskie)	*2.67 to 5.33 pt*	*1 to 2 lb*	

Table 7-7. Chemical control of sucker growth

Chemical and Formulation	Purpose	Amount of Formulation per Acre	Precautions and Remarks
CONTACT TYPE			
C_8–C_{10} fatty alcohol (various brands) 6.01 lb/gal	Normal sucker control	2 or 2.5 gal (4% or 5%)	Apply in 48 gal of water per acre (4% solution) to plants in button stage with second application 3 to 5 days later at any time of the day, except when plants are wet or temperature exceeds 90°F or plants are wilted. Use two TG-3 nozzle tips plus a TG-5 in the center or equivalents per row with approximately 20 psi operated from 12 to 16 in. above the top of the button or stalk at 2.5 to 3 mph. Rate of second application may be increased to 2.5 gal in 47.5 gal of water (5% solution) unless crop is tender. Will not control suckers more than 1 in. long. Excess nitrogen increases the chance of leaf drop.
C_{10} fatty alcohol 5.72 lb/gal	Normal sucker control	1.5 gal (3%)	Apply in 48.5 gal water per acre (3% solution) for both applications. Follow application instructions above for C_8–C_{10} alcohol.
C_8–C_{10} fatty alcohol 6 .01 lb/gal	Control of late-season sucker regrowth	2.5 gal (5%)	Apply 3 to 4 weeks after MH application if suckers begin to grow. Apply in 47.5 gal of water per acre. Follow same directions as above. Will not control suckers more than 1 in. long. Do not make more than three applications of a contact per crop per season.
SYSTEMIC TYPE			
Maleic hydrazide (MH) Liquids, various brands 1.5 lb/gal	Normal sucker control	1.5 gal (1 qt/1,000 plants)	Rate varies with plant population. 1.5 gal of the 1.5 lb per gal material assumes 6,000 plants per acre. For plant populations other than 6,000, adjust rate accordingly. Apply to plants 5 to 7 days after the last contact application. Apply in the morning, using 30 to 50 gal of water per acre, two to three cone nozzle tips per row, and 40 to 60 psi. Effectiveness will be reduced if applied to wet plants or those that are drought stressed or wilted from too much rainfall or high temperatures. Do not make more than one application per season. Should wash-off occur within 6 hr, a single repeat application may be made. DO NOT APPLY AT HIGHER THAN SUGGESTED RATES OR WITHIN 7 DAYS BEFORE HARVEST IN ORDER TO MINIMIZE MH RESIDUES.
Maleic hydrazide (MH) Liquids, various brands 2.25 lb/gal	Normal sucker control	1 gal (1 qt/1,500 plants)	

Table 7-7. *(continued)*

Chemical and Formulation	***Purpose***	***Amount of Formulation per Acre***	***Precautions and Remarks***
SYSTEMIC TYPE (continued)			
60% water-soluble products Fair 80 SP or Sucker Stuff 60 WS	*Normal sucker control*	*3.75 lb*	*Rate for 6,000 plants per acre. Adjust rate accordingly for other plant populations.*
Royal MH-30 SG	*Normal sucker control*	*4 to 5 lb*	
CONTACT-LOCAL SYSTEMIC TYPE			
Flumetralin (Prime+, Flupro, or Drexalin Plus) 1.2 lb/gal	*Normal sucker control, power sprayer*	*2 qt*	*Mix in 49 gal of water per acre and apply as a contact at elongated button to early flower stage with three nozzles per row (TG-3, TG-5, TG-3). Remove suckers longer than 1 in. within 24 hr before application and remove missed suckers as observed later. Excess spray to the point of rundown on the soil increases the risk of carryover residues, which may stunt early growth of next crop, including tobacco if a dinitroaniline herbicide is also used.* ***Do not apply these products through any type of irrigation system, and apply only once per season.*** *Rainfall within 2 hr after application may reduce effectiveness. Follow WPS requirements and other precautions and restrictions listed on product labels.*
Flumetralin (Prime+, Flupro, or Drexalin Plus) 1.2 lb/gal	*Hand application*	*1.2 to 2.4 qt (2.5 oz/gal water)*	*Mix in desired amount of water at rates shown in parentheses and apply mixture as a coarse spray or drench to top of stalk. Apply about 0.5 oz of mixture per plant after topping and removing suckers longer than 1 in., but do not exceed 25 to 30 gal per acre. See remarks above for power sprayer application and follow precautions, restrictions, and WPS requirements shown on product labels.*
Flumetralin (Prime+, Flupro, or Drexalin Plus) 1.2 lb/gal	*Control of late-season sucker regrowth*	*2 qt*	*Apply only if control with MH is beginning to break down. Mix in 49 gal water per acre and apply as a contact at 20 to 25 psi 3 to 4 weeks after MH application; will not control suckers longer than 1 in. TO REDUCE THE RISK OF SOIL RESIDUE CARRYOVER, DO NOT USE FOR LATE-SEASON CONTROL IF USED EARLIER IN THE SEASON.*

Table 7-7. *(continued)*

Chemical and Formulation	Purpose	Amount of Formulation per Acre	Precautions and Remarks
SYSTEMIC + CONTACT-LOCAL SYSTEMIC			
Maleic hydrazide (MH) + Flumetralin (Prime+, Flupro, or Drexalin Plus)	*Normal sucker control*	*Full rate MH + 2 qt*	*See precautions and remarks for MH to determine "full rate" of MH. Mix in sufficient water to total 50 gal per acre, and apply 5 to 7 days after the last contact or when MH alone is normally applied. Apply as a contact, using three nozzles (TG-3, TG-5, TG-3) per row at approximately 20 psi. Follow precautions and restrictions on labels. DO NOT APPLY AT HIGHER THAN LABELED RATES OR WITHIN 7 DAYS BEFORE HARVEST IN ORDER TO REDUCE MH RESIDUES.*
CONTACT + SYSTEMIC			
C_{10} fatty alcohol + MH (FST-7 or Leven-38) 4 lb/gal	*Normal sucker control*	*3 gal*	*Apply in 47 gal water to plants in early flower stage (1 week after button) any time during the day except when plants are wet or temperatures exceed 90°F or plants are wilted. Use three nozzles per row with tips that deliver a coarse spray and desired rate when operated at 20 psi. Operate sprayer at a speed of 2.5 to 3 miles per hour and spray 50 gal of diluted emulsion per acre. Use a semi-coarse spray covering the top 1/3 to 1/2 of the plant and allowing the liquid to run down the stalk to the bottom of each plant. DO NOT APPLY AT HIGHER THAN SUGGESTED RATES OR WITHIN 7 DAYS BEFORE HARVEST IN ORDER TO MINIMIZE MH RESIDUES. Effectiveness will be reduced if applied to plants that are drought-stressed or wilted from too much rainfall or high temperatures.*

8. Managing Diseases

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The Tobacco Disease Situation in 2013

The percentage of crop value lost in Figure 8-1 is based on reports from county agents for 48% of the acreage planted with tobacco in 2013.

In 2013 precipitation during winter was close to normal, but temperature was cooler than normal. March brought less rainfall across the state compared to February; however, temperatures remained cool. Some storms in late March forced tobacco growers to keep curtains up for a prolonged time. Soon after, outbreaks of collar rot and Rhizoctonia diseases were reported in several greenhouses. Overall, greenhouse season was very quiet, with few disease problems.

Cool weather continued into April with dry conditions persisting in the eastern part of the state. May was one of the coolest months on record. On the other hand, precipitation in May was split between areas that got or did not get rain, with many localized storms. Temperatures across the state in June were much cooler than those observed at the same time last year. Tropical Storm Andrea passed through North Carolina on June 7, eliminating dry conditions in the eastern part of the state. After Andrea passed through, several storms brought substantial rainfall all across the state, making June 2013 the second-wettest June on record. These prolonged wet conditions may be responsible for several extensive target spot epidemics observed during 2013. Field work was next to impossible at times, making foliar applications of fungicides difficult.,July was also unusually cool. The wet pattern from earlier continued, and most of the state received above normal precipitation. August in North Carolina was a continuation of the cool, wet conditions experienced in previous months. It did not rain quite as much, but temperatures continued to be below normal.

These cool conditions kept diseases overall at low levels. For instance, only 54 tobacco samples were submitted to the Plant Disease and Insect Clinic in 2013. This compares to 95 samples submitted in 2010 and 135 in 2008, years when disease pressure on tobacco was much higher. Some cases of Granville wilt were reported, whereas black shank incidence was close to zero. Target spot seemed like the

(Continued on page 126)

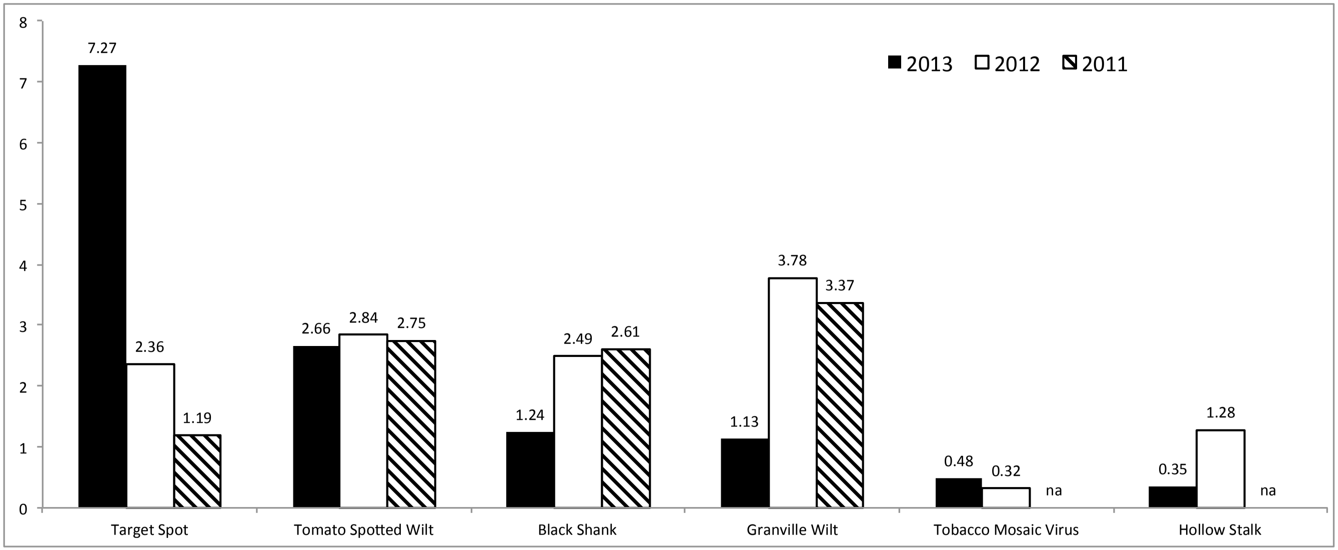

Figure 8-1. Tobacco losses caused by the six major diseases (2011–2013).

(Continued from page 124)

one disease that prevailed in 2013 across the tobacco production areas of North Carolina, due to the prolonged wet conditions.

Disease Management Practices

An effective disease management program always integrates a combination of tested and approved practices. No practice alone can be relied upon to manage diseases. Disease management strategies must be developed before the crop is planted. In making crop management decisions, carefully consider the disease problems present, disease severity, and environmental impact.

Crop Rotation

Most of the important diseases that occur every year are caused by organisms that persist in the soil and can reproduce only on tobacco

Table 8-1. The value of various rotation crops in helping to manage selected diseases

Crop	Black Shank	Black Root Rot	Granville Wilt	Tobacco Mosaic Virus	Root-Knot
Corn	High	High	Mod.	High	Low
Cotton	High	Low	Mod.	High	None
Fescue	High	High	High	High	High
Lespedeza "Rowan"	High	Low	High	High	High
Milo	High	High	Mod.	High	Low
Peanuts	High	Low	Low	High	None
Pepper	High	High	None	None	None[a]
Potato, white	High	High	None	High	Low
Small grain	High	High	High	High	High
Soybean	High	Low	High	High	Low[b]
Sweetpotato	High	High	Mod.	High	Low[c]
Tomato	High	Mod.	None	None	None[b]

Note: These ratings are based on the assumption that weeds are well-managed in these crops. Ratings range from high to none. High = highly valuable as a rotation crop for this disease; none = no value as a rotation crop, may be worse than continuous tobacco.

[a] Rating may be high for certain root-knot species or races.

[b] Rating is high if a root-knot resistant variety of soybean or tomato is used.

[c] Rating is moderate if a root-knot resistant variety of sweetpotato is used.

Table 8-2. Stalk and root destruction

Step	*Description*
1	*Cut stalks in small pieces with a bush hog or similar equipment the day harvest is complete.*
2	*Plow out stubble the day stalks are cut. Be sure to remove the root system entirely from the soil.*
3	*Re-disk or harrow the field about 2 weeks after steps 1 and 2 are completed. This provides additional root kill and exposes different areas of the root to the drying action of sun and wind.*
4	*Seed a cover crop where needed to prevent water and wind erosion. Postpone this seeding until roots are dead.*

and a few other plants. Without tobacco or one of the other host plants, populations of the disease-causing organisms are reduced. Therefore, crop rotation must be emphasized in planning any disease management program. Although growers may have valid reasons for having difficulty in rotating crops, the benefits they can derive in disease control are great enough to merit careful planning and consideration. Many North Carolina crops are good rotation crops to help control tobacco diseases (Table 8-1).

Length of rotation. The longer the rotation, the more beneficial it will be. Thus, a four-year rotation (three alternate crops between tobacco) is more effective than a two- or three-year rotation. Similarly, a three-year rotation is superior to a two-year rotation. Nevertheless, a two-year rotation (one alternate crop between crops of tobacco) significantly reduces disease and is far better than continuous culture. Where tobacco is grown continuously, farmers are “feeding” populations of pests, thereby contributing to their buildup and the probability of severe disease problems in the future.

Stalk and Root Destruction

Roots and stalks from the previous year’s crop must be destroyed, regardless of whether diseases have been observed (Table 8-2). To be effective, this must be accomplished as soon after harvest as possible. Completing these tasks quickly and thoroughly reduces populations of several tobacco diseases, including black shank, Granville wilt, root-knot, mosaic, brown spot, and vein banding, as well as certain insects, grasses, and weeds.

Furthermore, destroying old tissue exposes pests living there to adverse environmental elements. For example, root-knot nematodes are very sensitive to drying; if root tissue surrounding them decays, they are exposed to the drying action of the wind and sun. Tobacco mosaic virus (TMV) particles lose their ability to infect after they are freed from tobacco tissue. TMV carryover may be reduced from 5 percent of plants to less than 0.1 percent by destroying tobacco roots and stalks.

Resistant Varieties

Growers should not depend solely on resistant varieties for disease management. Even resistant varieties are sometimes severely damaged by disease, especially where rotation, stalk and root destruction, and other management tools are not used. Some varieties are highly resistant to only certain races or species of a particular pathogen. For example, root-knot-resistant varieties are only resistant against *Meloidogyne incognita*, races 1 and 3. Some of the varieties listed in Table 8-3 are highly resistant to race 0 of the black shank fungus but quite susceptible to race 1. See the section on black shank for a more complete discussion of resistance to that disease, and see Table 8-4.

Table 8-3. Resistance ratings of certain varieties to Black shank, Granville wilt, and tobacco mosaic virus. The LOWER the rating, the MORE RESISTANT a variety is.

Variety	*Ph gene*	*Black Shank*	*Granville wilt*	*TMV*
CC 13	-[c]	*18*	*28*	*S*[b]
CC 27	+	*32*	*17*	*R*[a]
CC 304	+	*14*	*22*	*R*
CC 33	-	*10*	*22*	*S*
CC 35	-	*21*	*43*	*S*
CC 37	+	*18*	*14*	*R*
CC 65	-	*15*	*44*	*S*
CC 67	+[c]	*15*	*16*	*R*
CC 700	+	*20*	*31*	*S*
GF 318	+	*20*	*27*	*S*
GF 52	+	*31*	*27*	*R*
GL 338	+	*28*	*28*	*S*
GL 395	-	*11*	*18*	*S*
GL 368	+	*13*	*26*	*S*
GL 939	-	*20*	*15*	*S*
K 149	-	*24*	*11*	*S*
K 326	-	*27*	*36*	*S*
K 346	-	*6*	*19*	*S*
K 394	-	*20*	*43*	*S*

Table 8-3. *(continued)*

Variety	*Ph gene*	*Black Shank*	*Granville wilt*	*TMV*
K 399	-	8	11	S
K 730	-	11	11	S
NC 102	+	32	27	R
NC 196	+	11	23	S
NC 291	+	28	31	S
NC 297	+	31	22	R
NC 299	+	28	23	S
NC 471	+	9	15	R
NC 55	-	35	27	S
NC 606	-	12	14	S
NC 71	+	25	30	S
NC 72	+	30	18	S
NC 810	+	9	13	S
NC 92	**+**	**29**	**26**	**S**
NC 925	-	9	26	S
PVH 1118	+	16	34	S
PVH 1452	+	10	13	S
PVH 2110	-	19	27	S
PVH 2275	+	41	25	R
RG 17	-	32	20	S
RG H4	-	29	24	R
RG H51	+	30	24	S
SP 168	+	11	9	S
SP 179	+	22	20	S
SP 210	-	19	13	S
SP 220	+	14	10	S
SP 225	+	4	7	S
SP 227	+	5	5	S
SP 234	+	17	14	S
SP 236	-	3	18	S
SP H20	+	13	17	R
SP NF3	-	13	16	S
Ratings for these varieties may change as more data become available:				
CC 143	-	5	21	S
CC 1063	-	10	15	S

[a]*Resistant*

[b]*Susceptible*

[c] *- no ph gene; +: ph gene present.*

Fumigants, Fungicides, and Nematicides

Fumigants, fungicides, and nematicides give growers an additional tool to manage diseases. Fumigants primarily help manage Granville wilt and nematodes. More narrow-spectrum chemicals are also available to help control nematodes, black shank, and some other diseases. Protectant foliar fungicides are also available for Ridomil-insensitive blue mold management. All disease management chemicals must be applied before the disease is established.

- Pesticides should be used only when cultural practices alone cannot manage the disease satisfactorily.
- For optimum benefit, it is essential to know the disease and its severity.
- It is important to select the appropriate chemical for the disease. It is both useless and expensive to expect effective control of a disease from a material designed for a different problem.
- For soil application, the soil must be in good tilth—not too dry or too wet. Poor soil preparation lessens effectiveness. Soil temperatures must also be within a favorable range.
- The risk of injury to tobacco becomes much greater when soil or climatic conditions are unfavorable.

New Regulations for Fumigant Applications

Phase I: 2010 Labels—2011 Implementation

- Handler respiratory protection
    - New labels will require handlers to stop work or use respirators if air concentrations exceed acceptable limits.
    - For most activities, sensory detection triggers respiratory protection requirements.
    - PPE or cease work and leave application block.
    - At least one to two handlers (depending on product) must have air-purifying respirator available.
    - Fit-tested, trained, and medical clearance
    - At least one SCBA on-site and ready for emergency
- Reentry restrictions
- Tarp perforation and removal restrictions
- Good Agricultural Practices
- Fumigant Management Plans
    - More than 20 Good Agricultural Practice items
    - Site-specific details

    — Posting and monitoring procedures
    — Personnel data and training records
    — Safety procedures, PPE, and emergency plans
    — Postapplication summary
    — Buffer, notification zone, and DTE information (will be included in phase II)
- RUP classification
- Registrant-provided handler information

Phase II: 2011–2012 Labels—2013 Implementation

- Buffers and buffer posting
    — The area around the application block where bystanders must be excluded during the buffer zone period, except for people in transit (bicycles and motorized vehicles).
    — The "buffer zone period" starts when a fumigant is first delivered to the soil and is in effect for 48 hours after the fumigant has stopped being delivered to the soil.
- Restrictions near sites that are difficult to evacuate
- Emergency preparedness and response
- Registrant-provided training for applicators and community outreach programs

Additional Helpful Cultural Practices

The following practices give the plant every possible advantage to enable it to withstand attack by disease-causing agents. Growers will be rewarded by considering carefully the impact of each practice on disease development and by operating in ways that favor the tobacco plant, thereby working to the disadvantage of disease-causing agents.

Formation of a high, wide bed (row). Developing a high, wide bed in the field helps provide proper conditions for tobacco roots to develop. This practice conserves soil moisture during dry periods and helps provide drainage for root systems in areas of fields that tend to become waterlogged. Most causal agents that affect the root systems of plants are favored by poor drainage or high moisture.

Spacing. Tobacco plants that are spaced too closely often suffer more disease than those planted farther apart in the row. In particular, spacing influences diseases, such as brown spot, target spot, and blue mold. Wider spacing provides for more sunlight, better aeration, and better drying conditions for the foliage on the bottom of the plant.

Balanced fertilization. Disease-causing agents are generally favored by imbalanced fertilizer application. Some pests, such as root-knot nematodes, are favored by deficiencies in nutrients such as potassium. Other causal agents, including the black shank fungus, are favored by excessive nitrogen. Usually, a healthy crop is one that has received balanced fertilization—neither excessive nor deficient.

Order of cultivation when disease is present. If disease appears in only some fields or certain parts of a field, cultivate these areas last to reduce the chance of spreading the disease organisms to "clean" areas. After cultivation, wash equipment with a detergent at the same strength used to wash clothes.

Managing the Major Diseases

Transplant Diseases

General information on the successful production of good tobacco transplants is found in chapter 4, "Producing Healthy Transplants in a Float System." The following section addresses only certain disease problems that may occur in plant beds and greenhouses in North Carolina. Also see the condensed management guide for seedlings at the end of this chapter (Table 8-10).

Diseases in greenhouses. The most common diseases in greenhouses are caused by rhizoctonia, sclerotinia (collar rot), pythium, and bacterial soft rot (*Erwinia* spp.). Rhizoctonia causes most of the damping-off observed before clipping begins, and sclerotinia causes the most after clipping. Damping-off caused by pythium is preceded by extensive yellowing of the plants. TMV is rare, but it is devastating where it occurs.

Sanitation practices. Mowers can spread mosaic virus and bacteria. Wash and sanitize blades and the underside of the deck with 50 percent household bleach before each clipping of each greenhouse. Furthermore, be sure the mower thoroughly removes clipping debris (usually by vacuum). Clipping too much of the plant in one pass or allowing mower bags to fill too full causes more debris to fall back into the trays. Leaf debris in the trays or on the plants is usually the starting point for collar rot and bacterial soft rot.

Before using trays that have been used before, thoroughly wash them and allow them to dry. Then fumigate the trays with methyl bromide at three pounds per 1,000 cubic feet. *Do not fumigate inside a greenhouse.* Trays may be stacked, criss-crossed up to five feet high, tarped and sealed on concrete or on a tarp, and then fumigated. See the product label, and follow the instructions for space fumigation. Allow at least 48 hours of aeration before filling with media. Do not depend on dipping trays in any sanitation product, including bleach, to kill pathogens satisfactorily. Steaming trays at 160°F to 175°F for 30 minutes is an excellent alternative to fumigation. Growers who know greenhouse transplants were a source of mosaic should dispose of the trays and purchase new ones.

Environmental conditions. Greenhouses should be fully ventilated when temperatures are not cold enough to damage the plants. Furthermore, to remove humidity from the greenhouse, place fans just above the plant canopy to circulate air around the structure. Polytubes or other power ventilators can also be used to remove humidity. Ventilation will help to reduce leaf moisture and subsequent disease. Pythium is most damaging at pH levels above 6.1 and at float water temperatures above 68°F. To keep water temperatures cool as long as possible, do not fill the bays with water until it is time to float the trays. Closing greenhouses during July or August to allow temperatures to reach 140°F for eight hours per day for seven days helps kill pathogens. Heat-sensitive items should be removed, and adequate moisture should be maintained in the house.

Other precautions: *Never dump plants or used media within 100 yards of a greenhouse.* Once diseased plants have been dumped, they may serve as a source for collar rot for up to five years. Walkways and entryways should be made of gravel, asphalt, concrete, or other material that can be easily washed. Boots worn outside the structure should not be worn inside unless they have been sanitized with a 10 percent bleach solution. Use special care in preventing field soil from contaminating water beds in float systems. Also, do not recycle pond water among beds because it can be a source of disease inoculum. Excessive and sloppy watering, poor drainage, plant injury, overcrowding, and excessive humidity most often lead to disease problems in greenhouses. Use only media produced for tobacco transplants. Do not introduce tobacco products into the greenhouse. Do not allow weeds, especially horsenettle, to grow in the greenhouse.

Tobacco should not be grown for any reason during a three-month period between October and February to ensure that blue mold, especially a Ridomil-resistant strain, does not overwinter. Spray Dithane

Rainshield weekly after plants reach the size of a quarter to help prevent blue mold.

Field Diseases

The following sections present general information about some of the most common or recently discovered diseases. Diseases are listed in alphabetical order. A condensed disease-management field guide begins at the end of this chapter (Table 8-11).

Black shank. Black shank is caused by a soil-inhabiting fungus (*Phytophthora nicotianae*) that belongs to a group of the most destructive fungi that attack plants. These fungi thrive in high-moisture areas. The black shank fungus produces three types of spores, including a swimming spore that infects tobacco roots and sometimes infects stalk stems at leaf scars (where leaves fall off). Some leaf infection can be observed after rains that splash soil onto the leaves.

The symptoms of black shank are well-known to tobacco growers. Once infection occurs, death usually follows quickly. In highly resistant varieties, the symptoms on the stalks are usually confined to near-ground level. When stalks are split, the pith often appears blackened and separated into discrete discs. Discing can occur because of other factors; likewise, not all plants suffering from this disease exhibit this symptom. Rotation, varietal resistance, and chemicals are usually integrated into a management program (Table 8-4).

There are two sources of resistance used in available varieties. The FL 301 resistance has been the predominant form of resistance for many years. It is effective to varying degrees against both race 0 and race 1 of black shank fungus. All commercial flue-cured varieties have some level of FL 301 resistance. For example, K 346 has a high level, while K 326 has a low level. A more recently incorporated form of resistance imparts complete resistance (immunity) to race 0 of the pathogen but is susceptible to race 1. This complete resistance is controlled by a single gene (ph). Any tobacco variety containing this gene will be completely resistant to race 0. However, varieties with the ph gene may vary in their resistance to race 1, depending on how much FL 301 resistance is in their heritage. Currently, most varieties with the ph gene have little FL 301 resistance, which means they will be more susceptible to race 1 than older varieties, such as K 346, that have high levels of FL 301 resistance. Most new varieties released over the past five to 10 years have the ph gene, similar to the proportion of varieties that currently have the MI gene for races 1 and 3 of the southern root-knot nematode. Therefore, over time, the ph gene has become a less effective tool. Whenever varieties with the ph gene are planted crop after crop, race 1 becomes very aggressive, even if it was not the predominant race at first.

Table 8-4. Chemical recommendations for fields with recurring economic losses to black shank caused by race 0 of Phytophthora nicotianea

Variety Rating[1]	*2-Year Rotation*	*1-Year Rotation*	*Continuous Tobacco (not recommended)*
0–10	*No chemical[2] or Ridomil Gold[3] 1+0+0[4] or Ultra Flourish 2+0+0*	*Ridomil Gold 1+0+0 or 1+0+.5 or Ultra Flourish 2+0+0 or 2+0+1*	*Ridomil Gold 1+0+0 or 1+0+.5 or Ultra Flourish 2+0+0 or 2+0+1*
11–21	*Ridomil Gold 1+0+.5 or Ultra Flourish 2+0+1*	*Ridomil Gold 1+0+1 or Ultra Flourish 2+0+2 or Telone C-17, 10.5 gal + Ridomil Gold 0+1+0 or Ultra Flourish 0+2+0 or Chloropicrin, 3 gal + Ridomil Gold 0+1+0 or Ultra Flourish 0+2+0*	*Ridomil Gold 1+0+1 or Ultra Flourish 2+0+2 or Telone C-17, 10.5 gal + Ridomil Gold 0+1+0 or Ultra Flourish 0+2+0 or Chloropicrin, 3 gal + Ridomil Gold 0+1+0 or Ultra Flourish 0+2+0*
22+	*Ridomil Gold 1+0+1 or Ultra Flourish 2+0+2 or Telone C-17, 10.5 gal + Ridomil Gold 0+1+0 or Ultra Flourish 0+2+0 or Chloropicrin, 3 gal + Ridomil Gold 0+1+0 or Ultra Flourish 0+2+0*	*Ridomil Gold 1+1+1 or Ultra Flourish 2+2+2 or Telone C-17, 10.5 gal + Ridomil Gold 0+1+0 or Ultra Flourish 0+2+0 or Chloropicrin, 3 gal + Ridomil Gold 0+1+0 or Ultra Flourish 0+2+0*	***Losses likely even with:*** *Ridomil Gold 1+1+1 or Ultra Flourish 2+2+2 or Telone C-17, 10.5 gal + Ridomil Gold 0+1+1 or Ultra Flourish 0+2+2 or Chloropicrin, 3 gal + Ridomil Gold 0+1+1 or Ultra Flourish 0+2+2*

Note: Within each box, choose lower rates and lower-cost treatments for fields where losses to black shank have been minimal.

[1] From Table 8-3. If a variety with the ph gene is planted where a variety with the ph gene was planted in the previous tobacco crop, use the center row of the table rather than the top row.

[2] Where disease levels are consistently below 6 percent.

[3] If field has a root-knot history, select an option that includes a fumigant (see Table 8-7).

[4] Ridomil Gold and Ultra Flourish rates are lb for 50 WSP and pt for EC and SL in the format: preplant + first cultivation + four weeks after transplanting. Preplant is within four days of transplanting.

Use of a variety with the ph gene for two or more tobacco crops results in the black shank population changing progressively, or in some cases rapidly, from race 0 to race 1. When this occurs, varieties with ph gene will appear to have little resistance, and fungicides, such as mefenoxam (Ridomil Gold), will be needed (Table 8-5). When applying Ridomil Gold, keep in mind the following:

- Timing is very important for mefenoxam (Ridomil Gold) application.
- Early applications (i.e., within the first seven to 10 days after transplant) are the most critical for effective control.
- Do not wait to see plants with black shank symptoms to apply Ridomil. Most likely there are several infected plants that have not shown symptoms yet, and Ridomil Gold will not provide the best possible control at that point.
- Ridomil Gold should be incorporated in the soil by cultivation. The tobacco plant absorbs it only through the root system.

Additional factors, such as irrigation, damage from nematodes, and number and depth of cultivations may influence the severity of black shank in a field.

Table 8-5. Percentages of surviving plants and percentages of surviving plants required to pay the cost of Ridomil Gold application. Data are based on 25 farm tests (1997–2004, NC State University) with K-326.

Application (1 pint Ridomil Gold per application)	*Surviving Plants (% per acre)*	*Surviving Plants Required to Pay Cost Difference (% per acre)**
Preplant + 1st cultivation + layby vs. nothing	*50–75*	*6*
Preplant + 1st cultivation vs. nothing	*30–50*	*4*
Preplant + layby vs. nothing	*31–50*	*4*
1st cultivation vs. nothing	*31–50*	*2*
1st cultivation + layby vs. nothing	*50–75*	*4*
Preplant + layby vs. layby	*10–30*	*2*
Preplant + 1st cultivation + layby vs. layby	*10–30*	*4*
1st cultivation + layby vs. 1st cultivation	*10–30*	*2*

** Percentages were calculated under the assumptions that a tobacco plant yields 0.5 pound, six thousand plants are planted per acre, and average price/pound is $1.65.*

Blue mold. Blue mold is caused by an airborne fungus (*Peronospora tabacina*), and it caused widespread losses in North Carolina during

1979 and 1980. During those years, the disease occurred in fields as well as in plant beds. The fungus also spreads when infected seedlings are shipped. Its occurrence was sporadic until 1995, when it became widespread again. Ridomil-insensitive strains were first identified in North Carolina flue-cured tobacco in 1995. All greenhouses should be treated with Dithane Rainshield (0.5 lb/100 gal. spray) every week after plants are the size of a quarter.

The foliar infection is characterized by the development of round, yellow spots with gray or bluish-gray mold on the undersides of the leaves. These spots rapidly multiply in a favorable environment and coalesce to kill entire leaves. Old spots are tan to white. When systemic, the fungus penetrates the plant, interfering with normal plant growth and resulting in stunting, distortion, and eventual death. Either type of infection can cause severe losses under certain environmental conditions (usually high moisture and cool temperatures).

Because air currents disperse this fungus, crop rotation and stalk and root destruction do not affect this disease in North Carolina. The fungus does not overwinter in North Carolina, so we do not know if future infestations will be sensitive to Ridomil Gold or Ultra Flourish. It is likely that some blue mold will be sensitive, and Ridomil Gold application will be of some benefit. Acrobat MZ, foliar-applied protectant fungicides, or Actigard are needed for Ridomil-insensitive blue mold. Acrobat MZ is no longer manufactured and has been replaced with Acrobat 50WP. Acrobat 50WP has also been replaced with a liquid formulation of dimethomorph (Forum). The label requires application of Forum only in tank mixtures with Dithane DF Rainshield (mancozeb).

Forecasting blue mold. Blue mold causes sudden, widespread, and fast-moving epidemics that usually spread from south to north. The disease is spread by airborne spores blowing from infected fields and plant beds. During cool, wet, and cloudy weather, the disease can double in an infected field every four days.

Blue mold is not known to survive through the winter north of Florida. Initial outbreaks in the United States originate from airborne spores from winter tobacco crops in Cuba, Mexico, or Latin America. Wild tobacco plants (*Nicotiana spp.*) growing as weeds in the southwestern United States can also serve as a source of airborne inoculum.

The North American Plant Disease Forecast Center at NC State operated for 15 years issuing forecasts two or three times per week, and more often if necessary, from March through August. The forecasts were based upon daily occurrence reports from blue mold cooperators in tobacco-producing states in the United States, Mexico, and Canada. Meteorological surface wind models were used to generate reports of favorable weather conditions and of regional weather, as well as the outlook for new outbreaks (high, medium, or low risk). Once spores arrive and infect the leaves, yellow lesions appear seven to 10 days later during the latent period. Blue mold forecast maps of spore trajectories showed the source of spores, the pathway the spores would follow in the wind, and the risk of infection, all based upon true forecasts for the next 48 hours. This provided growers with two days' warning should they decide to apply protectant fungicides, which must be applied before the spores germinate on the leaves.

The forecasts were suspended at the end of 2011; however, additional information on the disease and control recommendations are available on the Blue Mold Forecast website: http://www.ces.ncsu.edu/depts/pp/bluemold.

Brown spot. Brown spot is caused by an airborne fungus (*Alternaria spp.*). It may be considered an "opportunistic" disease-causing agent. It does not usually become a problem in varieties tolerant to this disease if good cultural practices are followed. However, during periods of extended rainfall late in the harvest season, it can become destructive. Brown spot is a disease of senescent (old) tissue.

Fusarium wilt. Fusarium wilt, although not destructive in all parts of the state, is significant in certain areas. It is caused by a fungus that lives in the soil (*Fusarium oxysporum f. sp. nicotianae*) and is well adapted for survival there. It can live well on decaying organic matter in the soil and can form spores that are very resistant to adverse conditions. Fusarium wilt is not as aggressive as some other diseases, such as Granville wilt or black shank, but it might also be considered an "opportunistic" disease. If tobacco plants are stressed in certain ways, such as by root wounding or nematode infection, significant fusarium wilt may develop. Although crop rotation and stalk and root destruction are beneficial to some extent, these practices do not drastically reduce fusarium wilt development because of the fungus's ability to live on organic matter and form resistant spores.

Granville wilt. Granville wilt appears first as a wilting on one side of the plant. As the disease progresses, the entire plant wilts and dies. When plants survive they are usually stunted, and their leaves may be twisted and distorted. The stalk usually becomes dark, especially at the ground level. At this stage, Granville wilt may be easily confused with other diseases, such as black shank. A diagnostic characteristic of Granville wilt is the streaks that extend up the stalk just beneath the outer bark.

Granville wilt is caused by a tiny bacterium (*Ralstonia solanacearum*) that inhabits the soil. Infection occurs when these microscopic bacteria enter wounds or openings in the root system. Hence, cultivation and nematode damage can increase the incidence of this disease. Also, roots may "wound" themselves as they grow through the soil. Therefore, Granville wilt bacteria usually have no difficulty locating a suitable entry point into the plant.

It is important to remember that Granville wilt bacteria are soil inhabitors. In fact, anything that moves soil containing the bacteria will spread them from place to place. This can happen in many ways: by moving soil on machinery and other equipment, by water washing soil from one part of the field to another, by moving transplants with infested soil around the roots, and by any other means by which infested soil is moved.

Relatively high soil temperatures and adequate to high moisture levels in soil favor Granville wilt bacteria. In fact, wet seasons greatly increase infection by these organisms. Infection may not be noticed immediately because wilting symptoms may not appear until plants

Table 8-6. Granville wilt management

Cultural

1. Rotate with fescue, small grains, or soybeans. Control weeds.
2. Use varieties with high levels of resistance.
3. Destroy stalks and roots immediately after harvest.
4. Avoid root wounding.
5. Manage nematodes.
6. Fumigate in the fall or spring with one of the following treatments.

Fumigants—Allow three weeks from application to transplanting

Chemical	***Rate (gal/acre)***	***Method***	***Relative Control Rating****
Chloropicrin	*5–6*	*Broadcast*	*Very Good*
Chloropicrin	*3*	*Row*	*Good*
Pic +	*4*	*Row*	*Good*
Telone C-17	*10.5*	*Row*	*Good*
Telone C-17	*13–15*	*Broadcast*	*Good*

** Actual control varies depending on other control practices and environmental conditions.*

undergo a moisture stress. Thus, it is not unusual to observe symptoms of Granville wilt several weeks after infection actually occurs.

Granville wilt bacteria also can infect tomatoes, white potatoes, peppers, eggplants, and peanuts. Ragweed, common to most of North Carolina, can also be infected and should be controlled. See Table 8-6 for management recommendations.

Hollow stalk (soft rot). Hollow stalk or soft rot (caused by *Erwinia spp.*) usually appears first near topping and suckering time. It may begin at any stem wound and is often seen in the pith at the break made by topping. Soon after infection, a rapid browning of the pith develops, followed by general soft rot and collapse of the tissue. Top leaves often wilt, and the infection spreads downward; the leaves droop and hang down or fall off, leaving the stalk bare. Diseased areas may appear as black bands or stripes that may girdle the stalk. In another phase of the disease, a soft decay appears at the junction where leaf petioles are attached to the stalk.

Causal bacteria are usually present in soil and on plant surfaces. They may also be present on workers' hands as they top, sucker, or harvest the crop. These bacteria are often unimportant unless there is frequent rainfall and high humidity. These conditions favor their infection and subsequent development. The use of some contact sucker control agents may lead to an increase in hollow stalk, especially if leaf axil tissue is damaged.

Remember that if affected leaves are harvested when wet and carried to the barn, they often develop barn rot during curing. Infection is most likely if ventilation is inadequate.

Pythium stem rot. This disease is caused by a group of pythium species that include *Pythium aphanidermatum* as the most important and aggressive species, followed by *P. ultimun* var. *ultimun* and *P. myriotylum*. Pythium was believed to affect only tobacco seedlings in the early stages of growth after being transplanted in the field, causing damping-off, root and stem rot, and feeder root necrosis. In the last several years, pythium was also detected affecting tobacco at different growth stages in the field (stages 4 to 8). Symptoms of pythium stem rot are very similar to those caused by black shank, making loss estimates difficult. In most cases, pythium stem rot affects some roots at the soil line level and most of the lower stem, causing a sunken black lesion that will continue to grow upward in the stem. Wilting of plants and chlorosis are also observed in plants affected by pythium.

The predominant pythium species (*P. aphanidermatum*) has not been detected on tobacco transplants produced in greenhouses in North Carolina; thus, the potential of carrying pythium-infected transplants with this pathogen from greenhouses is minimal. However, other *Pythium* species can be carried on infected transplants from the greenhouse and cause seedling blight. Spores of *P. aphanidermatum* can survive in the soil and plant debris in the field. *P. aphanidermatum* can infect a large number of host plants, including peppers, tomatoes, corn, cucumbers, and peanuts, among others.

Since 1997, pythium stem rot has been more frequently detected in tobacco cultivars with resistance to race 0 of black shank, especially in fields where cultivars with this resistance have not been used before. In recent studies it was demonstrated that cultivars carrying the ph gene are not more susceptible to pythium root rot. Therefore, the increase in incidence may be due to a reduction in competition from the black shank fungus or a reduction in application of mefenoxam in fields planted with cultivars carrying the ph gene. High temperatures and soil moisture favor the development of pythium stem rot. Other pythium species that only cause root rot have been detected, including *P. dissotocum* and *P. Group Hs*. Because the incidence of this disease depends on environmental conditions, the development of control strategies is very difficult to generalize. Management of this disease may be similar to that for black shank, although resistance to this disease has not been identified.

Root-knot nematodes (and other nematode problems). Nematodes are microscopic roundworms that live as "obligate parasites," which means they require living plant tissue to survive and complete their life cycle. Nematodes that attack tobacco live in the soil and are spread when infested soil is moved. Because nematodes are highly specialized organisms, knowledge of their biology and of how plants respond to them is necessary to develop a profitable management plan. The key to nematode control is to keep populations at nondestructive levels. Although a single nematode is not harmful, high populations have a devastating effect. Root-knot nematodes complete their life cycle, under favorable conditions, in only three weeks. Thus, in North Carolina they can produce as many as seven generations during one tobacco-growing season.

The most important nematode on tobacco in North Carolina is the root-knot nematode, *Meloidogyne incognita*. However, other *Meloidogyne* species are increasing in this state, especially *M. arenaria, M. javanica,* and *M. hapla*. Both of these latter species are severely damaging. The spread of these two species is a threat to root-knot control in the state because of the lack of resistance to them and the possibility that some nonfumigant nematicides may not effectively control them. Also, certain races of *M. incognita* that can attack root-knot resistant varieties appear to be increasing in the state.

To determine the infestation level of root-knot nematodes, examine the roots and have soil assays completed. A combination of these techniques provides excellent insight. First, observe the roots at random just after fall stalk and root destruction (immediately after harvest). You can estimate the infestation level by observing the area galled and using the following index:

- Low infestation—0 to 10 percent of root area covered with galls
- Moderate infestation—11 to 25 percent of root area covered with galls
- High infestation—26 to 50 percent of root area covered with galls
- Very high infestation—51 to 100 percent of root area covered with galls

The risk posed by moderate to high infestations is often equal to or greater than the risk posed by very high infestations. Even low to moderate infestations on a nematode-resistant variety warrant rotation to a nonhost crop. The higher the gall index, the higher the infestation level. You can learn much about the root-knot population in each field by systematically assessing such indices. This information will prove valuable when making decisions about soil nematicide treatments or the use of a root-knot resistant variety.

To obtain nematode assays, take soil samples from the field and send them to the Agronomic Division, Nematode Assay Section, North Carolina Department of Agriculture and Consumer Services, 4300 Reedy Creek Road, Raleigh, NC 27607-6465. Contact your county Cooperative Extension Service agent for help. These samples must be taken in the fall (before December 1) to provide reliable information. No more than four acres should be represented by one sample, which should consist of at least 20 cores or subsamples from six to eight inches deep. Samples must not be allowed to dry or heat above 80°F. The counts obtained from samples taken in the spring are usually much lower and are therefore not nearly as reliable.

As with other tobacco diseases, control of root-knot and other nematodes must be based on a combination of suitable practices; no one approach can provide adequate, long-term control. Recommendations for nematicides are presented in Table 8-7.

Table 8-7. Nematicides for root-knot nematode control on flue-cured tobacco

Material[a]	Rate/Acre	Method of Application	Waiting Period	Control Rating
Telone C-17 (1,3-d+chloropicrin)	7–10.5 gal	Fumigant—row[b]	21 days	Excellent
Chloropicrin 100 (chloropicrin)	3 gal	Fumigant—row[b]	21 days	Excellent[c]
Chlor-O-Pic 100 (chloropicrin)	3 gal	Fumigant—row[b]	21 days	Excellent[c]
Pic + (chloropicrin 86%)	4 gal	Fumigant—row[b]	21 days	Excellent[c]
Telone II (l,3-d)	6 gal	Fumigant—row[b]	21 days	Excellent

[a] *Most nematicides can damage plants under certain conditions. Greenhouse-produced plants may be more sensitive to this type of injury.*
[b] *Apply six to eight inches deep. Fumigants work best and cause the least injury when applied at soil temperatures above 50°F and when the soil is moist but not wet. Form a high, wide bed immediately after application.*
[c] *Control may be variable, and numerous galls may be found on roots later in the season.*

Target spot. Target spot (*Rhizoctonia spp.*) has been prevalent in North Carolina since 1984, especially in plant beds and greenhouses. In 1995, it caused the greatest losses of any disease since 1959. The fungus that causes target spot lives in many North Carolina soils. Saturated soils and leaf moisture favor sporulation of the fungus and germination of the spores into the tobacco leaves.

Target spot symptoms are quite similar to those of brown spot. With target spot, the centers of the lesions rapidly become very thin and papery and shatter if only slight pressure is applied. The concentric rings that characterize brown spot lesions may look similar to those caused by target spot. Because target spot lesions are so fragile, the necrotic areas usually drop from the leaf, leaving a ragged appearance. Target spot may occur on leaves at any plant position and, where conditions favor the problem, may cause considerable destruction. Target spot, like brown spot, is favored by frequent rainfall and high humidity.

Removing the lower leaves and ensuring adequate nitrogen are recommended management tactics. In 2006 Quadris (Azoxystrobin) was registered for control of target spot. Quadris is a "locally systemic" product (i.e., it can move only a short distance from the point where a drop lands on a leaf). Therefore, drop nozzles are highly recommended for Quadris application in the field to ensure uniform coverage of the foliage.

Tobacco mosaic virus. Tobacco mosaic is the most contagious tobacco disease that growers encounter in North Carolina. The virus that causes it is a large, complex chemical molecule that, like all other viruses, requires living tissue to multiply. Once a tobacco mosaic particle enters the plant, it becomes a part of that plant and will persist until the plant dies. The tobacco mosaic virus is spread in the sap of diseased plants. Anything that moves sap or juice from a diseased plant to a healthy plant will move the virus. That includes machinery used during cultivation and the hands or clothing of workers. It is not spread through air currents or by other carriers associated with most other diseases.

Mosaic is not as sensitive to weather conditions as most other tobacco diseases. However, it is easier for plants to become infected when there is moisture on them and when they are succulent and growing rapidly. Damage is most severe when infected plants suffer during hot, dry conditions.

The symptoms of tobacco mosaic are well-known to most producers. The most common is leaf mottling, which is alternating areas of light and dark green tissue. This symptom is especially noted in the top of the plant or in younger tissue. During periods of high temperatures and high light intensity, affected portions of leaves may die, resulting in "mosaic burn."

Because of the virus's unique nature, control of tobacco mosaic must be approached differently from that of other diseases. No chemicals are labeled for mosaic control, although the milk-dip treatment is beneficial as workers perform tasks within the crop. New resistant varieties are very valuable control tools (see Table 8-3).

Also, you should rotate fields, clean equipment, and discard seedling trays (if tobacco mosaic virus was at least 20 percent by layby in any field). In addition, you should wash greenhouse clippers, transplanters, tractor bottoms and tool bars, and any other equipment that came in direct contact with the foliage and sanitize them with a 25 to 50 percent bleach solution.

Tomato spotted wilt virus. Tomato spotted wilt (TSW) is a potentially devastating disease of tobacco in North Carolina caused by tomato spotted wilt virus (TSWV). This virus also causes disease in North Carolina tomatoes, peppers, peanuts, and white potatoes. The host range is large, including many weeds and ornamentals. TSWV is moved from plant to plant by tiny insects called thrips. In most years, the tobacco thrips is apparently the most important vector of TSWV in the early season. However, the western flower thrips was abundant early in the season in 2002. TSWV was first detected in North Carolina tobacco in 1989. Because the virus can infect more

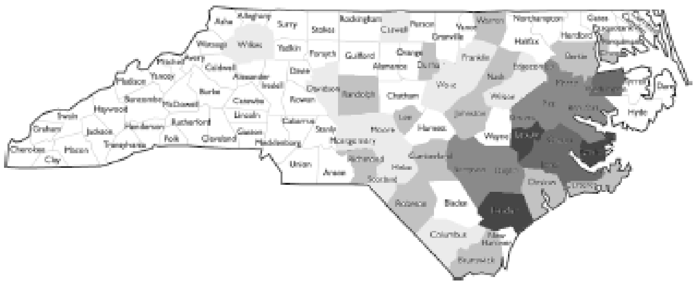

Figure 8-2. Distribution of tomato spotted wilt virus in North Carolina (based on county reports 1993–2008). *The darker colors represent counties where tomato spotted wilt incidence may be high (>10%–15%) in several fields every year.*

than four hundred species of plants, including many native and introduced plants found in North Carolina, it is entrenched in our agricultural landscapes and is unlikely to disappear. Planning for TSWV management is crucial for growers in areas where the virus is firmly established; growers in other areas must remain vigilant against this disease (Figure 8-2).

Symptoms of TSWV vary with plant age, virus strain, and environmental conditions. Newly transplanted seedlings die rapidly, then swiftly decay. Therefore, seedling infections are often misdiagnosed as other seedling diseases or transplanting problems. Plants that are ankle-high and taller will show some characteristic foliar symptoms. On small plants, dark reddish-brown specks and leaf distortion are common on the youngest leaves. Slightly older plants will show classic reddish-brown necrotic spots or ringspots, often with star-like projections into the green leaf tissue. Necrosis of tissue running adjacent to leaf veins is common and characteristic. Despite the term wilt in the name, older plants only appear wilted because of the twisting and distortion the virus causes. Symptoms are usually most severe on one side of the plant and in the bud. Infected plants near flowering may have black streaks running down one side of the stem, often resembling burn from contact suckercides. Streaks also occur within the pith. Plants that get infected near, during, or after flowering suffer little loss. Symptoms on these plants are generally local, being restricted to the leaf or leaves that were initially infected.

Although TSWV symptoms are somewhat characteristic, the disease can be confused with other seedling diseases, as mentioned earlier.

It also can be confused with other viruses, especially tobacco streak virus (TSV). TSWV is usually randomly distributed throughout a field, whereas TSV is usually very concentrated near a particular field border. The only way to be sure which virus or viruses are present is to use a reliable assay procedure to identify the virus.

Many plant species can be infected by TSWV. However, some are much better hosts than others. Research indicates that the most important sources for infection of tobacco are several species of winter weeds. Some of these include the annual smallflower buttercup, mousear chickweed, common chickweed, and spiny sowthistle, as well as the perennials dandelion and Rugel's plantain. As the winter annuals begin to die in the spring, adult thrips are forced to move to alternative plants, including tobacco. If the plant on which they developed was infected, they carry the virus with them. The virus can also move back and forth between winter annuals and summer annuals and perennials.

The movement of TSWV into tobacco is complex and, in a sense, difficult. Several things must go just right (or just wrong, from the farmer's point of view) for transmission to occur. First, there must be infected plant hosts in the area that harbor the disease. Second, these plants must also be hosts of one of the thrips species that can carry the disease. Third, these thrips must be one of the species that attack tobacco. Fourth, there must be some reason for the adult thrips to move from the host to tobacco. Finally, this movement must take place when the tobacco is in the field and in a susceptible stage.

Why, then, do we see so much TSWV in tobacco in some years (such as 2002) and so little in others? We can only speculate. However, we think several factors are at work:

- TSWV has gradually built up in weed hosts in North Carolina, especially in certain areas. This allows movement of the virus over short distances.
- A relatively warm winter before the field season allows thrips to be active during much of the winter, spreading the disease among weed hosts. This weather may also help thrips survive and build up in higher numbers than usual. Colder winters may suppress thrips numbers and the spread of the disease among weeds, resulting in a smaller source in the spring.
- An early, dry spring causes winter hosts to yellow and die earlier than usual. Thrips begin moving off these dying weeds at just the time tobacco is being transplanted. Generally, tobacco seems to be most susceptible to infection at transplanting. As the crop ages, it

is progressively less likely to be infected by a virus-carrying thrips. If winter weeds remain green and healthy until well after tobacco is in the field, thrips have less need to move to newly set tobacco.
- Most winters and springs will fall between these extremes.

While no current management practices will completely control the effects of TSWV on tobacco crops, some tools that can help moderate the disease have emerged in the last few years. Proper application of these strategies can significantly reduce TSWV incidence in tobacco fields, but they may not provide adequate suppression under extremely high virus pressure. See chapter 9, “Tobacco Insect Management,” for more information.

Thrips are able to transmit TSWV very quickly, and most of these virus-carrying thrips come from outside the tobacco field. Over-the-top insecticides do not kill these thrips quickly enough to stop the spread of the virus. This type of spraying has not been successful in reducing disease incidence. However, some disease suppression has been noted on Admire-treated plants in Georgia and North Carolina. Therefore, applying Admire in the greenhouse to control aphids and other insect pests may help suppress TSWV. The suppression varies from year to year and is related to the timing of thrips flight and amount of available virus (Table 8-8).

Table 8-8. Suppression of TSWV with Actigard and Admire Pro, North Carolina

	Percentages of Plants Infected by Tomato Spotted Wilt Virus			
County, Year	Untreated Control	Admire Pro 0.8 oz/ 1,000 Plants	Admire Pro 0.8 oz/1,000 Plants + Actigard 10 ppm float water	Admire Pro 0.8 oz/1,000 Plants + Actigard 1 oz/50,000 Plants
Duplin, 2008	38	10	4	4
Craven, 2008	20	11	5	3
Duplin, 2005	54	36	22	36
Onslow, 2005	29	20	9	12
Average	35.3	19	10	14

Note: The Actigard and Admire Pro treatments were applied in the greenhouse seven to 14 days before transplanting. Actigard was applied to trays as a foliar spray and then drenched with a sufficient amount of water to move the material to the root zone, or it was applied in the water bed followed by thorough circulation of the water in the bed to ensure uniform distribution of the material.

The application of Actigard, alone or in combination with Admire or Platinum, to seedlings in the greenhouse shows promise for being an effective and economical management tactic. Most economically important TSWV infections apparently occur within the first week or two after transplanting; many may occur during the first few days. Thus, protection should be in place before transplanting. Application of any chemicals after the virus has infected the plant will be of little, if any, benefit. The best treatment in our studies (examples in Table 8-8) averaged about 50 to 70 percent control. This level of control is comparable to the control levels obtained with pesticides for other tobacco diseases.

Use of pesticides of any type usually comes at a price. Our tests have shown that treatment in the greenhouse with Actigard and higher rates of Admire may result in early-season leaf damage and stunting and that this effect is greatest when both materials are used. This is usually a temporary effect and has not resulted in significant loss of yield in our tests. However, such losses are possible. For that reason, we recommend that growers use both chemicals only when they have had at least 10 percent losses from TSWV in the past. Where TSWV levels have been significant but lower, Admire alone is recommended at 0.8 to 1.2 ounces per thousand plants (Admire 2F at 1.8 oz/thousand plants) in the greenhouse. Lower rates of Admire are adequate if only insect control is needed. If you use a generic version of imidacloprid instead of Admire Pro or Admire 2F, make sure you read the label to determine the appropriate rate before treating. Injury is most likely when the plants are stressed. If Actigard is used, take great care in ensuring that the product is precisely measured and applied according to label directions. Actigard can be applied as a foliar spray and then drenched to the root zone with water or applied in the float bed water. If application in the float bed water is chosen, use Table 8-9 to calculate the quantity needed. In our tests, Platinum used alone in the greenhouse at 1.3 ounces per thousand plants has not reduced TSWV significantly. However, the combination of Platinum and Actigard has been as effective as the combination of Admire and Actigard.

Weather fleck. Weather fleck is not an infectious disease, but it causes dark, metallic-like, sunken leaf spots (flecks) that gradually fade to white with age. Symptoms are most obvious on older leaves of young plants or on middle-aged leaves of older plants. Spots are often more common near leaf tips. Damage can be severe enough to blight bottom leaves. Weather fleck is an injury caused by the common air pollutant ozone. Ozone is heavy oxygen (O_3) and is produced by internal combustion engines and by certain manufacturing processes. During periods of

Table 8-9. Conversion of ppm to grams of Actigard based on float bed size

Gallons per Bed	Actigard Rate (ppm)			
	10.0	15.0	20.0	25.0
3,000	4.0	6.0	7.9	9.9
3,200	4.2	6.4	8.5	10.6
3,400	4.5	6.8	9.0	11.3
3,600	4.8	7.2	9.5	11.9
3,800	5.0	7.6	10.1	12.6
4,000	5.3	7.9	10.6	13.2
4,200	5.6	8.3	11.1	13.9

Note: ppm = parts per million.
HOW TO READ THE TABLE: If a bed has 3,000 gal of water and you wish to apply 15 ppm of Actigard, then this is equivalent to 6 grams of the product.
This table shows the rate of Actigard product (IN OUNCES) to add to obtain the desired ppm rate. Use the lower rate (10 ppm) in areas of moderate TSWV risk and the highest rate (25 ppm) in areas of severe TSWV risk.
A waiver of liability must be signed to obtain an Actigard label. To obtain this waiver and label, growers must visit www.farmassist.com and register (email address required).
Apply Actigard three to five days before transplanting. For best results, dilute the Actigard in a small volume of water, and then add this volume to the float water. Ensure adequate and uniform circulation of the product within the bed.

cloudy, overcast, or rainy weather, the concentrations of ozone that would normally escape into the stratosphere are held closer to ground level. Most important, it is during these conditions that leaf pores (stomata) remain open the longest and the leaves absorb the most ozone. Some varieties are much less sensitive to weather fleck than others, and growers who experience chronic difficulty should select a variety that is more tolerant.

Some Tips on Planning Disease Management

No single practice can be expected to provide protection from every disease, much less from the many different diseases that might attack tobacco during a growing season. Tobacco growers urgently need to assess the disease problems within each of their fields and plan management strategies well before the crop year. A "tobacco disease map" of each field is of great benefit. To develop such a map, sketch the field and mark areas of disease infestation. Update the map each time tobacco is in the field, noting any change in location and in level of infestation. Over time, growers who do this can plan control practices that should benefit them immensely as they develop production plans from season to season. For black shank and Granville wilt, the average percentage of plants diseased within a field gives a good indication of the level of that disease in the field.

Other References

Tobacco disease information notes on collar rot, control of tobacco mosaic virus on flue-cured tobacco, Granville wilt, brown spot, black shank, blue mold, Pythium root rot in greenhouses, Pythium root rot in the field, Rhizoctonia diseases in the greenhouse, tomato spotted wilt virus, and tobacco disease management in greenhouses are available from http://www.cals.ncsu.edu/plantpath/extension/clinic/fact_sheets/index.php?do=plant&id=3.

Compendium of Tobacco Diseases, 68 pp., is available from the American Phytopathological Society. Call (800) 328-7560 to order.

A Precautionary Statement on Pesticides

Pesticides must be used carefully to protect against human injury and harm to the environment. Diagnose your pest problem, and select the proper pesticide if one is needed. Follow label-use directions, and obey all federal, state, and local pesticide laws and regulations.

Acknowledgments

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Table 8-10. Condensed management guide for seedlings (for more information, contact your county Cooperative Extension center)

Disease	Cultural Management	Chemicals (read and follow the label)	Comments
Anthracnose (Collectotricum gloeosporioides)	Clip beds frequently to allow foliage to dry.	Dithane Rainshield (mancozeb) **Greenhouse** 0.5 lb/100 gal (sprayed)	Spray foliage to runoff, and maintain thorough coverage with fungicide when weather is cool and damp. Fungicide may be sprayed twice a week.
Blue Mold (Peronospora tabacina)	Clip beds frequently to allow foliage to dry.	See Anthracnose Aliette WDG 0.5lb/50 gal water	Spray Dithane Rainshield weekly from the time plants are the size of a quarter. Apply preventively or at the first sign of blue mold. Do not exceed 2 applications.
Collar rot (Sclerotinia sclerotiorum)	Don't seed more than 60 days before plants are needed. Thoroughly ventilate and use air-circulating fans. Do not dump soil or plants near greenhouses. Reduce the amount of debris left on seedling beds after clipping.	None	
Damping-off (Pythium spp.)	Plant bed: Select warm, well-drained site. In greenhouses, keep pH below 6.2. Place trays in float beds as soon after filling with water as possible.	Terramaster (etridiazole) 35W 2 oz/100 gal float water Terramaster (etridiazole) 4E 1.4 fl oz/100 gal float water	Thoroughly mix into float water 2 to 3 weeks after seeding.
Soilborne diseases (Root-knot, Granville wilt, black shank, some damping-off)	Plant bed: Select warm, well-drained site. Greenhouse trays: Wash trays. Steam at 160 °F–175°F for 30 min.	Methyl bromide 98% 9 lb/100 sq yd Methyl bromide 98% 3 lb/1,000 cu ft	Thoroughly prepare bed. Fumigate if temperature is higher than 50° F and soil is moist but not wet. Wait 24 to 48 hours after cover removal before seeding. Stack trays criss-cross up to 5 ft. Tarp and seal over airtight surface. Fumigate for 24 hours. Aerate for 48 hours.

Table. 8-10. *(continued)*

Disease	*Cultural Management*	*Chemicals (read and follow the label)*	*Comments*
Target spot (Rhizoctonia *sp.)*	*Clip plants frequently to allow foliage to dry.*	*Quadris* *0.14 ml/100 sq ft*	*See blue mold.* *Make only one application prior to transplant.*
Tobacco Mosaic Virus	*Do not touch plants. Use new trays if previous seedlings were infected. Control horsenettle around seedlings. Keep tomato and pepper plants and fruits out of area.*	*Household bleach*	*Wash and sanitize mower with 25 to 50 percent household bleach and/or steam clean mower.*
		Milk (any type) *5 gal/1,000 sq ft of bed* *or* *5 lb dry skim milk in 5 gal water/1,000 sq ft*	*Spray plants within 24 hours of transplanting.*

Table. 8-11. Condensed management guide for field diseases *(for more information, contact your county Cooperative Extension center)*

Disease	*Cultural Management*	*Chemicals (read and follow the label)*	*Comments*
Angular leafspot (Pseudomonas syringae)	*If disease is severe, avoid working in fields when foliage is wet.*	*None*	*Control is not usually necessary.*
Barn rot (Erwinia *sp.)*	*Harvest tobacco dry. For wet tobacco, run fans for 24 hours with vents open to dry tobacco before increasing temperature.*	*None*	
Black root rot (Thielaviopsis basicola)	*Rotate (Table 8-1). Maintain soil pH near 6.0.*	*Chloropicrin at 3 gal/acre* *Pic + at 4 gal/a* *Telone C-17 at 10.5 gal/acre*	*Observe 21-day waiting period between application and transplanting.*
Black shank (Phytophthora nicotianae)	*Rotate (Table 8-1).* *Use resistant varieties (Table 8-3). Destroy stalks and roots (Table 8-2). Plant on high, wide bed. Cultivate infested fields last. Manage nematodes.*	*Ridomil Gold EC , LS (WSP) at* *1+.5 pt (lb)/acre* *1+1 pt (lb)/acre* *1+1+1 pt (lb)/acre* *Ultra Flourish* *(2x Ridomil Gold rates)* *Ridomil Gold, 1 pt (lb)/acre + Telone C-17 at 7 gal/acre* *Ridomil Gold, 1 pt (lb)/acre + Chloropicrin at 3 gal/acre* *Ridomil Gold, 1 pt (lb)/acre + Pic + at 4 gal/acre*	*In fields with histories of black shank, use all cultural practices. Use Ridomil just before transplanting. Apply again at first cultivation and/or lay-by if risk of disease is high. Ultra Flourish 2E brand of mefenoxam used at 2 times the rates of Ridomil may be used in place of Ridomil Gold 4EC brand of mefenoxam. When using a fumigant apply mefenoxam at first cultivation, not preplant. See Table 8-4.*

Table 8-11. *(continued)*

Disease	**Cultural Management**	**Chemicals (read and follow the label)**	**Comments**
Blue mold (Peronospora tabacina)	*Destroy unused seedlings as soon as possible. Avoid planting in shaded areas. Avoid close plant spacings.*	*Acrobat 50WP at 2.5 lb/100 gal*	*Spray at first threat of blue mold and every 7–10 days. See label for spray volumes.*
		Actigard 50W at 0.5 oz/a in 20 gal water	*Apply after plants are 18 in. tall. Repeat in 10 days. See label for precautions.*
		Dithane Rainshield at 1.5–2 lb/100 gal	*Spray foliage weekly for complete coverage. Stop spraying all products 21 days before harvest.*
		Aliette WDP at 2.5–4 lb/acre	*Apply preventively or at first sign of blue mold. Apply until 3 days before harvest*
		Quadris at 6–12 fluid oz/acre	*See label for spray volumes.*
		Revus at 8 fluid oz/acre	*Do not apply within 7 days before harvest.*
Brown spot (Alternaria alternata)	*Avoid close plant spacing. Control suckers. Do not apply excess nitrogen. Manage nematodes. Use tolerant varieties.*	*None*	*Harvest as often as necessary to save tobacco.*
Charcoal rot (Macrophomina phaseolina)	*Avoid overapplication of contact sucker chemicals.*	*None*	*Rare, but occurs during hot and dry periods.*
Etch *Tobacco Etch Virus*		*None*	*No control available.*
Fusarium wilt (Fusarium oxysporum *f. sp.* nicotianae)	*Rotate. Destroy stalks and roots (Table 8-2). Avoid root wounding. Use resistant varieties. Manage nematodes.*	*None*	*Significant problem only when root-knot or root injury is present.*

Table 8-11. *(continued)*

Disease	Cultural Management	Chemicals (read and follow the label)	Comments
Granville wilt (Ralstonia solanacearum)	*Rotate (Table 8-1). Destroy stalks and roots (Table 8-2). Use resistant varieties (Table 8-3). (All varieties may be severely damaged.) Avoid root wounding. Plant on high, wide bed. Manage nematodes.*	*Chloropicrin at 3 gal/acre* *Pic + at 4 gal/acre* *Telone C-17 at 10.5 gal/acre* *See Table 8-6.*	*Use all cultural practices and a fumigant (fall or spring) where Granville wilt has recently occurred. Observe 21-day waiting period for fumigants. Use higher rates for broadcast application.*
Hollow stalk *(Bacterial soft rot)* (Erwinia *sp.)*	*Avoid getting soil on hands or stalks while topping and suckering.*	*None*	
Lesion nematodes (Pratylenchlus *spp.)*	*Destroy stalks and roots (Table 8-2). Rotate with fescue.*	*None usually required. See Table 8-7.*	*Not a problem year after year.*
PVY (vein-banding) *(Potato Virus Y)*	*Avoid transplants from areas with high incidence of PVY.*	*None*	*No practical control.*
Ringspot *(Tobacco ringspot virus)*	*Avoid problem fields.*	*None*	*No remedial control.*
Root-knot (Meloidogyne incognita) (M. arenaria) (M. javanica) (M. hapla)	*Destroy stalks and roots (Table 8-2).* *Rotate (Table 8-1).* *Use resistant varieties (Table 8-3).* *Take and submit fall nematode samples.*	*For nematicides see Table 8-7.*	*Rotation usually requires two or more years. Resistant varieties are resistant only to Races I and 3 of* M. incognita. *Other species and races are now common in North Carolina. Observe 21-day waiting period for fumigants.*
Soreshin (Rhizoctonia *sp.)*	*Pull and handle plants carefully to avoid wounding or bruising.*	*None*	*Plant on high, wide bed to provide adequate drainage. Avoid placing nitrogen too close to stalk.*
Southern stem rot (Sclerotium rolfsii)	*Avoid wounding stalk.*	*None*	

Table 8-11. *(continued)*

Disease	Cultural Management	Chemicals (read and follow the label)	Comments
Target spot (Rhizoctonia sp.)	*Harvest or remove bottom leaves as soon after disease begins as possible. Maintain recommended nitrogen levels. Maintain sucker and weed control.*	*Quadris at 6–12 fluid oz/acre (8 fl oz/acre has given consistently good results)*	*Easily confused with brown spot.*
Tobacco cyst *(Osborne's cyst)* (Globodera tabacum)	*Rotate (avoid tomato and pepper). Destroy stalks and roots (Table 8-2).*	*Temik at 20 lb/acre* *Telone C-17 at 10.5 gal/acre*	
Tobacco mosaic virus *(Field)*	*Do not plant infected seedlings. Rotate (Table 8-1). Destroy stalks and roots (Table 8-2). Use resistant varieties (Table 8-3). Practice good sanitation. Manage horsenettle. Irrigate during dry periods.*	*None*	*Wash hands with soap or milk after handling tobacco. Disinfect equipment with 25 to 50 percent household bleach.*
Tomato spotted wilt virus	*Check with county Extension centers for extensive publications and recommendations.*		
Weather fleck *(Ozone air pollution)*	*None*	*None*	*No practical control.*

9. Tobacco Insect Management

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Tobacco insect pressure was lower than normal in 2013, with late tobacco budworm flights and low tobacco hornworm pressure. No usual insect populations were observed. The most notable aspect of the 2013 growing season was the increased awareness of good agricultural practices (GAPs). Nearly all tobacco purchasers required or encouraged their growers to attend GAP training sessions, coordinated through NC State University Cooperative Extension. In total, More than 2,100 growers were certified to have attended a GAP training in North Carolina. An important component of these trainings was educating growers about economic thresholds for key tobacco insect pests and preparing them to make decisions based on insect populations observed through scouting rather than applying pesticides on a prescheduled basis.

Economic thresholds for the key tobacco pests are described in this chapter and may serve as a valuable resource for growers in making treatment decisions. Additional information on insect pest biology, along with images of pests and their damage, can be found at tobacco.ces.ncsu.edu.

Protecting Seedlings in Greenhouses

Insects seldom threaten to destroy all the plants in a greenhouse, but they can reduce the number of usable plants produced. Insect pests may also be carried on transplants to the field, where they are more challenging to control. The most common greenhouse pests are crickets and aphids, but ants, slugs, and others can infest greenhouses as well. Managing insect pests in greenhouses requires a systematic approach that starts with careful planning and close observation.

Sanitation

Sanitation in and around greenhouses is essential. Keep houses free of trash, supplies, equipment, or any other items that are not absolutely necessary. Insects and other pests can be supported or protected by materials in the greenhouse. Keep the area surrounding the greenhouse clear of such debris as well. A strip of bare ground, sand, or gravel around the house may help reduce the number of insect pests entering the house. Once transplanting is complete, remove and destroy excess plants in the greenhouse as soon as practical. Otherwise they can serve as a nursery for pests moving into fields.

Fallow Periods

If possible, use greenhouses only for tobacco production. Growing other plants, such as ornamentals or vegetable seedlings, may be a good way to help recover the cost of the house, but these plants can introduce or sustain insect pests. Some of these may be uncommon tobacco pests for which no labeled pesticides are available or that are very difficult to control. If greenhouses are used for other purposes, they should be kept empty (fallow) whenever possible. A long empty period just before introduction of tobacco is especially important in breaking the life cycle of pests. Growing other plants in the greenhouse from seed is preferable to bringing in seedlings from another location. The latter practice increases the chance of introducing pest problems.

Cold

Keeping the empty greenhouse open during cold periods helps reduce populations of insects wintering inside. Do not leave any materials (such as trays) in the greenhouse to provide pests insulation.

Solarization

Closing the greenhouse during the summer and bringing the temperature up to 140°F (but not higher) for several days may also help reduce insect numbers. Again, you should remove any insulating material (such as trays) that protect insects. Also remove any materials that can be damaged by high temperatures.

Insecticides

Watch plants carefully and treat with an insecticide if insects threaten an adequate supply of healthy plants. Few insecticides are labeled for use in tobacco greenhouses. Acephate is a broad-spectrum material labeled for the control of several pests. Acephate 97UP can be used at ¾ tablespoon per 3 gallons of water for each 1,000 square feet (Acephate 75 EP at 1 tablespoon). Uniform coverage is important. Check your nozzle spacing and be sure the nozzles are not worn or damaged. A spray table should be used to check for unevenness in your spray pattern on an annual basis. A metaldehyde bait (Deadline Bullets) is labeled for control of slugs in tobacco greenhouses, and Sluggo (iron phosphate) baits are an organically acceptable (i.e., Organic Materials Review Institute listed) slug treatment. To avoid injury, do not put baits directly on plants.

Several other insecticides are labeled for use around the outside of structures or within the greenhouse on crops other than tobacco. Check with your county agent or the North Carolina Agricultural Chemicals Manual for specific recommendations. Fire ants, where they occur, can carry off seeds and germinating plants from large areas of a house. These pests should be controlled before seeding by using an insecticide bait. Baits may act more slowly than other pesticides, so start bait use early. Extinguish is a fire ant bait that is also labeled for use on cropland. Bait treatments typically provide longer-acting control than mound drenches with insecticides like acephate, although these two methods can be combined by first treating with a bait and then applying a drench treatment a few days later.

Protecting Tobacco in the Field

Management of Soil Insects

Wireworms. Wireworms are already present in the soil at transplanting (eggs are laid on the soil in the summer and early fall of the previous year, and larvae can live in soil for several years). They damage tobacco by tunneling into the stalk below the soil surface. This may kill or stunt plants and may open even resistant varieties to soilborne diseases. Stunting and the need to reset plants can result in an uneven crop that is costly and difficult to manage. Under good growing conditions, tobacco usually recovers from wireworm damage with no yield loss. However, if conditions are less favorable or if certain diseases are present, yield may be reduced.

It is not possible to control wireworms in tobacco with post transplant rescue treatments; you must decide in advance whether you need to use soil-applied insecticides (Table 9-1). If there is a history of wireworms, if the field was weedy or fallow, or if the field is heavily infested with soilborne diseases such as black shank and Granville wilt, a preventive treatment may be justified. In other cases, the decision is less obvious. Insurance treatments for wireworms add to the costs of production and add pesticides to the environment.

Either contact insecticides (Lorsban, Capture) or systemic insecticides (Admire, Platinum, Brigadier) can be used for wireworm control. Both types have provided good control in tests, but systemic materials also provide control of aphids and flea beetles. Use either a contact or a systemic insecticide for wireworms, not both. Whether you choose a contact or a systemic, the following application techniques are important:

- Broadcast materials should be thoroughly incorporated into the soil (this usually requires two passes with incorporation equipment). It is also important to give broadcast insecticides time to work before transplanting; at least two weeks are recommended, unless the label says otherwise.
- For systemics applied in the greenhouse, apply materials evenly and wash them off thoroughly, to move the insecticide to the potting soil.
- Transplant water treatments should only be applied if application equipment can be accurately calibrated. Pressurized tanks fitted with nozzles to apply transplant water treatments are advised, and growers are cautioned not to apply transplant water treatments using gravity flow tanks.

When choosing soil-applied insecticides, always consider the possible effect on groundwater and surface water. See Chapter 11,

Table 9-1. Soil-applied insecticides for wireworm control

Insecticide and Formulation	*Amount/Acre*	*Remarks*
Lorsban Advanced	*2 qt*	
Capture LFR[a]	*3.4–6.8 fl oz*	*Apply at transplant in transplant water or incorporate pretransplant into the top 6 in. of soil.*
Brigadier[a,b]	*3.8–6.8 fl oz.*	*Apply in transplant water.*
Admire Pro	*1.2 fl oz per 1,000 plants*	*Apply to plants in greenhouse followed by immediate wash-off, OR apply in transplant water. Note that wireworm rates are higher than aphid & flea beetle rates. Only use wireworm rates in fields with history of wireworm injury.*
Platinum	*1.3 fl oz per 1,000 plants*	

[a] *Capture LFR and Brigadier wireworm control data are limited.*

[b] *Brigadier is a combination of bifenthrin, a pyrethroid, and imidacloprid.*

“Protecting People and the Environ-ment When Using Pesticides,” for information on leaching and runoff potentials.

Cutworms. Cutworms are occasionally a problem post transplant, but most fields do not require cutworm treatment. In addition, an effective rescue treatment for cutworms is available; for these reasons, preventive chemical control is not recommended. You can, however, reduce the likelihood of cutworm problems by preparing the soil four to six weeks before transplanting. Whether you use preventive control or not, you should check fields regularly during the first three to four weeks after transplanting. Cutworm feeding first presents as small, webless holes on young leaves. As the larvae grow, they begin their typical cutting behavior. Cutworm larvae can be distinguished from other caterpillars because they curl into a circle when disturbed. Treat with a foliar spray (Table 9-5) if 5 percent or more of the plants are damaged; stand losses below 5 percent will not reduce yields. Fields are more likely to be infested if they were weedy the previous fall and winter or if they are low-lying with heavier soils. Because most cutworm species are active only at night, scouting should be done in the evening, and treatments are most effective if made late in the day.

Other pests. Occasionally growers may have problems with sod webworms. These caterpillars tunnel in the underground stem much like wireworms, but they are almost always found in the stem, and they line the cavity with silk. These strands of silk, covered by dirt particles, often hang out of the entry hole. Problems with webworms are rare but do sometimes occur in fields recently converted from sod. Other uncommon soil pests are white-fringed beetles and vegetable weevils. The white-fringed beetle is an introduced pest whose larvae (grubs) are white or cream colored and C shaped. The grub has no legs, but it does have a distinct head capsule. Damage is similar to that of wireworms but may be more extensive and intense. None of these pests can be controlled after transplanting, but growers should talk to their local agent about future management options.

General Steps in Managing Leaf-Feeding Insects

The real goal of insect management is not to kill insects but to reduce damage and maximize profits. Thus, it is not only necessary to protect the crop but also to keep the costs of protection as low as is practical. The decision to use pesticides and selection of the appropriate pesticide should also include considerations of environmental impact, worker health, and residue minimization. Growers stand the best chance of meeting these goals by combining a variety of tools in an efficient system. There are four basic types of control that may be used against insects: (1) cultural control, (2) biological control through conservation of beneficial insects, (3) preventive chemical treatments applied to the soil, and (4) insecticides applied after a problem develops (remedial treatment). Biological control is important and should be allowed to reduce pest populations whenever possible. Calendar-based, over-the-top spray schedules add costs and often lead to more problems than they control. They should be avoided.

1. Cultural control. Several production practices can reduce the risk and extent of insect problems. These practices work to reduce the numbers of an insect pest in a wide area, make individual fields less attractive to insects, or help the plant tolerate insect attack with less loss. Most of these practices (listed below) are also important in good crop management, and most add little or nothing to the cost of production:

- Destroy overwintering sites and hosts of aphids and flea beetles near greenhouses or plant beds (garden greens, wild mustard, dock).
- Destroy unused plants as soon as transplanting is complete. Undestroyed plants may become breeding sites for several insect pests and sources for diseases such as blue mold.
- Practicing weed control reduces sources of tobacco thrips, the main vector of tomato spotted wilt virus (TSWV), but weed control should be initiated at least two weeks prior to transplant to prevent flushing thrips into a susceptible tobacco crop. Encouraging grassy vegetation surrounding fields can also minimize thrips habitat. Grasses are poor hosts for TSWV and do not support vector species of thrips.
- If cutworms are a regular pest, prepare fields as early as is practical.
- Choose a transplanting time to minimize your most important (or difficult-to-control) insect pests. Early planting reduces the chance of hornworm problems, early or late planting helps manage aphids, and late planting reduces budworm numbers. However, late-planted tobacco usually yields less.
- To reduce the attractiveness of the crop to aphids, budworms, and hornworms, do not use nitrogen at rates higher than those recommended. This allows the crop to be harvested sooner.

- Practice timely topping and good sucker control to reduce the attractiveness of the crop and to deny a source of food to budworms, hornworms, and aphids.
- To reduce grasshopper and cricket invasion, keep borders clean and avoid haying grasshopper-infested grass strips near tobacco.
- Destroy stalks and roots immediately after harvest to reduce pest overwintering sites. This is important in management of budworms, hornworms, tobacco splitworms, and flea beetles. It is also very important in control of diseases.
- Use good production practices to give the crop a good start, keep it healthy, and get it out of the field (where it is exposed to pests) quickly.

2. Biological control. Biological control is the use of a living organism to control another living organism. In general this includes nematodes, pathogens, predators, and parasites. In tobacco specifically, naturally occurring predators and parasites comprise our biological control agents. The importance of these beneficial organisms in controlling insect pests is hard to exaggerate. For example, as a group, they often kill 80 or 90 percent of budworms and hornworms in a field. To make the most use of this free, natural control, follow these guidelines:

- Minimize or avoid using systemic insecticides that may reduce the populations of beneficial insects. Stilt bugs (which feed on budworm and hornworm eggs) are especially sensitive to some systemic insecticides.
- Do not use insecticides after transplanting unless pest populations are at economic threshold. Many insecticides reduce the number of predators and parasites in a field. This can result in more pests later on. Even a few untreated areas can provide a refuge for beneficial insects. Beneficials can leave untreated areas to reinvade treated fields once the pesticide is no longer active.
- If insecticide is necessary, choose the one most likely to target the pest and not harm beneficial insects. One way to tell if a pesticide is likely to harm beneficial insects is to compare the number of pest groups on the label. An insecticide that kills beetles, caterpillars, and flies is more likely to be harmful to beneficial insects than one that only kills caterpillars. Avoid IRAC (Insecticide Resistance Action Committee) modes of

action (MOAs) 1 and 3, when possible; these are broad-spectrum materials.

3. Preventive chemical treatments applied to the soil. Systemic insecticides are applied to the soil and taken up by the plant to control leaf-feeding insects. Several systemics that control aphids and flea beetles and suppress TSWV are available (Table 9-2). There are several reasons you might use one of these materials:

- They offer some insurance against loss to insect pests and against the need to apply rescue treatments.
- They may slow the development of aphid populations and provide more time to detect and react to this pest.
- They may do other things besides control leaf-feeding insects—for example, they may control nematodes or wireworms or reduce tomato spotted wilt infection—and this may increase yield or quality even when leaf-feeding insects are absent.

On the other hand, there are disadvantages to using systemic insecticides:

- Most offer protection against only one or two pests (usually aphids and early-season flea beetles). Use of a systemic seldom reduces budworm and hornworm numbers and sometimes actually increases them.
- Protection is not always season-long, and it may not be adequate to keep pests from reaching damaging levels.
- Systemics may reduce the numbers of beneficial insects (e.g., stilt bugs) in the field and may actually increase pest pressures.

Table 9-2. Effectiveness of soil-incorporated insecticides

Material	*Wireworm*	*Aphid*	*Flea Beetle*[a]	*TSWV Suppression*[b]
Admire and generic imidacloprids	*Intermediate*	*Best*	*Best*	*Best*
Lorsban	*Intermediate*	*No*	*No*	*No*
Orthene (TPW)	*No*	*Inconsistent*	*Best*	*No*
Platinum	*Intermediate*	*Best*	*Best*	*Low*

Note: No = Not recommended.

[a] *Ratings for flea beetle control are for early-season populations.*

[b] *Imidacloprid suppresses TSWV by altering thrips feeding behavior.*

- Each year many untreated fields never reach threshold for the pests controlled by a systemic insecticide (e.g., aphids and flea beetles). In those cases, treatment would have been an unneeded expense.
- All pesticides pose some risk to humans and the environment.
- The public is concerned about pesticide use in their communities and on the commodities they buy.
- There is always a risk that a systemic will injure tobacco and reduce yield or quality (Tables 9-3, 9-4).
- As with any pesticide, widespread use of systemics over time may result in the development of resistance.

Be cautious about combining systemics. There is no advantage in using two chemicals that do similar jobs. You will get little or no additional control for your extra expense, and the likelihood of crop damage is increased.

Growers may consider using a systemic insecticide for early-season tobacco budworms and hornworms. Coragen, a recently registered tobacco insecticide, is labeled for application in transplant water against pretopping caterpillar pests. This primarily refers to tobacco budworms, but hornworms can also occur pre-topping. Current NC State trials show that transplant water applications can have some efficacy against tobacco budworms very early in the season (four to

Table 9-3. Preplant systemic insecticides for control of foliar feeding insects

Insects	*Insecticides and Formulations*	*Amount per Acre*	*Remarks*
Flea beetles	*Acephate (Acephate 97UP)*	*¾ lb*	*Transplant water treatment. Higher rates than shown may injure plants. Use 100+ gal water/acre.*
Aphids and flea beetles	*Imidacloprid (Admire Pro)*	*0.6 fluid oz per 1,000 plants*	*Apply in transplant water, OR apply in a water spray over top of greenhouse plants in trays and wash off immediately. Transplant within three days. Do not add wetting agents or de-foamers or use in combina-tion with other pesticides.*
	Thiamethoxam (Platinum)	*0.5–1.3 fl oz per 1,000 plants*	
Aphids (suppression only)	*Acephate (Acephate 97UP)*	*¾ lb*	*Transplant water treatment. Higher rates than shown may injure plants. Use 100+ gal water/acre.*

six weeks post transplant), although long activity has been observed against hornworms. Hornworms are infrequent pre-topping pests and are easily controlled with other materials, so a preventive treatment targeted toward them is not advised. If growers are interested in using Coragen in a transplant water application, they should carefully follow the label, use at least one hundred gallons of water per acre, and use equipment that ensures that each plant receives the correct rate of pesticide in the appropriate amount of water.

4. Remedial control. To determine if any insect pest population requires remedial treatment, you must know the pest level in each field. To get this information, scout fields weekly. To scout a field, walk through it (being sure to cover all areas) and stop at several representative locations to check for insects. Make eight stops in a small field (one to three acres) and 10 in an average-size field (four to eight acres). At each stop, check five plants in a row for insects. In larger fields, add two stops for each additional four acres, or split the field into smaller areas and make a separate decision for each area. The exact pattern of stops is not critical, but be sure your path covers all parts of the field. You should not

Table 9-4. Posttransplant impacts of systemic neonicotinoid insecticides, summarized data from field trials, 2009. Values followed by the same letter are not significantly different. Plant stunting effects of systemic insecticides are often transient, as illustrated by the increase in plant height relative to the untreated control 6 weeks after transplant.

				Plant height (inches)	
Insecticide	Rate	Phytoxicity rating (0-4)	% plants stunted (3 weeks after transplant)	5 weeks after transplant	6 weeks after transplant
	0.6 fl oz/ 1000 plants	0.25 b	6 b	8.49 ab	28.11 ab
Imidacloprid (Admire Pro)	1.2 fl oz/ 1000 plants	0.78 a	23 a	6.43 c	28.76 a
Thiamethoxam (Platinum)	0.8 oz/ 1000 plants	0.61 a	8 b	7.70 b	27.26 b
Untreated control		0.05 b	1 c	8.96 a	27.24 b

Table 9-5. Economic thresholds for key tobacco insect pests. Based on a minimum of 40 plants randomly sampled per field (for fields less than 3 acres).

Insect Pest	Scouting Period	Economic Threshold
Tobacco budworms	Before button	10% infested plants. Do not count damaged plants as infested!
Tobacco/tomato hornworms	All season	1 or more larvae at least 1 inch long per 10 plants; parasitized larvae count as 1/5 of larva
Flea beetles	Posttransplant	4 or more beetles per plant
	Preharvest and harvest	60 or more beetles per plant
Aphids	Pretopping	10% of plants with 50 or more aphids on upper leaves
Japanese beetles, loopers, grasshoppers	All season	10% damaged plants with live insects active in fields (note that this threshold is a suggestion and is not based on research)
Cutworms, vegetable weevils, mole crickets, slugs	Posttransplant	5% or more small plants are killed or injured
Tobacco splitworm	Posttopping	10% or more of plants with greater than 10 mines per plant (note that this threshold is under development)

take samples near field borders (within 30 feet) because pests are often more numerous there. It is a good idea to look along borders, however, and you might want to consider a spot treatment there.

Do not bias your sample by stopping to count when you see a damaged plant. Instead, determine where you will stop before you get there. Count the number of hornworms, budworms, and aphid-infested plants, and estimate the number of flea beetles per plant. Also note any other insects or damage. It is possible to reduce profits by applying insecticides that are not needed. The point at which it pays to treat is called an economic threshold (Table 9-5). When you leave the field, compare your results with the treatment thresholds that have been established for each pest (Table 9-5) to determine whether you should initiate remedial treatment.

Consider each field independently, as pest populations will differ between fields. Do not treat all fields based on the pest population in one or two locations.

Scouting is your insurance against pest damage; it must be done on a regular basis. If you think a field may soon reach the threshold level for a pest (for example, if you find many hornworms less than 1 inch long or many small aphid colonies), check the field again in two to three days. It is better to check again than to treat below threshold because beneficial insects and weather may eliminate the problem. Remember that these thresholds were developed as guidelines for average conditions. In unusual situations (drought stress or multiple pests), use your judgment in applying thresholds. Also keep in mind that these thresholds were developed based on relatively high-priced tobacco. When the value of the crop goes down, the point at which it pays you to begin control goes up. Thus, these thresholds are now even more conservative than in the past.

When choosing an insecticide, remember than no single insecticide is best for all pests or even for a single pest under every condition. Choose an insecticide that fits your conditions and needs when the pest problem occurs. To make this choice, ask yourself the following questions:

What insect pest or pests need to be controlled? To do a good job of management, you must know which pests are in your fields. This is achieved through regular scouting and correct pest identification.

What are the most effective insecticides to use against the pest or pests you are trying to control? If two or more insects are damaging a field, the best choice would be an insecticide providing good control of all the pest insects. (This does not mean you should always look for broad-spectrum insecticides. Narrowly targeted materials, which are usually less detrimental to beneficials and the environment, often are the best choice.) Table 9-6 shows the effectiveness of insecticide sprays against major leaf-feeding insects, and Table 9-7 shows general insecticide recommendations.

What are the hazards to the applicator and other workers? When choosing pesticides, consider the hazard presented by each and the abilities of the person doing the application. It is best to use less hazardous materials when workers will be entering fields frequently. Labeling regulations require that all pesticides bear signal words to indicate relative hazards of use. Products bearing the words Danger—Poison are highly hazardous, those bearing Warning are moderately hazardous, and those bearing Caution range from slightly hazardous to relatively hazardless. You also need to consider the protective equipment requirements imposed by worker protection standards (see chapter 11, "Protecting People and the Environment When Using Pesticides").

What are the hazards to groundwater and surface water? Insecticides vary in their potential for leaching into groundwater or running off in surface water. If you farm leachable soils or fields with high

(Continued on page 174)

Table 9-6. Effectiveness of foliar insecticides against insect pests

	Insect Pest Control Levels			
Insecticide	***Aphid[a]***	***Budworm***	***Flea Beetle***	***Hornworm***
Actara	*Excellent*	*No*	*Excellent*	*No*
Admire Pro	*Excellent*	*No*	*Excellent*	*No*
Assail[b]	*Excellent*	*No*	*Excellent*	*NR*
Belt	*No*	*Good*	*No*	*Excellent*
Brigade	*No*	*Good*	*No*	*NR*
B. thuringiensis *spray[c]*	*No*	*Moderate[c,d]*	*No*	*Excellent*
Coragen	*No*	*Good*	*No*	*Excellent*
Denim	*No*	*Good*	*No*	*Excellent*
Fulfill	*Excellent*	*No*	*No*	*No*
Lannate	*Fair*	*Moderate[e]*	*Good*	*Excellent*
Pyganic	*Fair*	*No*	*Good*	*No*
Orthene	*Good*	*Moderate[e]*	*Good*	*Excellent*
Tracer	*No*	*Good*	*No*	*Excellent*
Warrior	*Fair*	*Good[e]*	*No*	*Excellent*

Note. Moderate *also means the insecticide may be less consistent.*
NR = Not recommended; limited data.
[a] *Aphid control ratings are based on maximum labeled rates.*
[b] *Aphid rating for Assail is based on limited data. Assail acts an ovicide for tobacco budworm.*
[c] B. thuringiensis *is sold under a variety of trade names.*
[d] B. thuringiensis *products seem to be more effective against budworms as the season progresses.*

Table 9-7. Remedial treatments for insect control in the field

Insect	Insecticide and Formulation	Rate per Acre	Reentry Interval (hrs)	Remarks
Aphids	Acephate (Acephate 97UP)	¾ lb	24	Good coverage is essential with any product.
	Imidacloprid (Admire Pro)	0.6 fl oz	12	
	Lambda-cyhalothrin (Warrior) (Karate Xeon)	2.5–3 oz 0.96–1.92 fl oz	24	Note long preharvest interval.
	Thiamethoxam (Actara 25WDG)	2 oz	12	
	Pymetrozine (Fulfill 50WG)	2¾ oz	12	
	Acetamiprid (Assail 30SG)	1.5–4 oz	12	
	Methomyl (Lannate 90SP) (Lannate 2.4LV)	½ lb 1½ pt	48 48	Initial control is fair to good, but numbers rebound quickly.
Budworms	Spinosad (Blackhawk)	1.6 oz	4	Use one or three solid cone nozzles no more than 12 inches above the bud. Apply 25–50 gal water/acre with at least 40–60 lb pressure.
	Emamectin benzoate (Denim 0.16EC)	8 oz	48	
	Methomyl (Lannate 90SP) (Lannate 2.4 LV)	½ lb 1½ pt	48 48	
	Acephate (Acephate 97UP)	¾ lb	24	

Table 9-7. Remedial treatments for insect control in the field

Insect	Insecticide and Formulation	Rate per Acre	Reentry Interval (hrs)	Remarks
Budworms (cont.)	Bacillus thuringiensis *(Agree)* *(Biobit HP)* *(Crymax)* *(Deliver)* *(DiPel ES)* *(DiPel DF)* *(Javelin WG)* *(Lepinox WDG)*	 *2 lb* *1 lb* *1–1½ lb* *1–1½ lb* *2 pt* *½–1 lb* *1–1¼ lb* *1–2 lb*	 *4* *4* *4* *4* *4* *4* *4* *12*	
	Chlorantroniliprole (rynaxypyr) (Coragen)	*5 fl oz*	*4*	
	Flubendiamide (Belt SC)	*3 fl oz*	*12*	*14-day preharvest interval.*
Cutworms	*Acephate (Acephate 97UP)*	*¾ lb*	*24*	*In late afternoon, apply in 25–50 gal water.*
	Flubendiamide (Belt SC)	*3 fl oz*	*12*	
	Chlorantroniliprole (rynaxypyr) (Coragen)	*5 fl oz*	*4*	
Flea beetles	*Acephate (Acephate 97UP)*	*½ lb*	*24*	*For best control with any product, spray entire plant.*
	Imidacloprid (Admire Pro and many generics)	*0.6 fl oz*	*12*	
	Thiamethoxam (Actara 25WDG)	*2–3 oz*	*12*	
	Methomyl *(Lannate 90SP)* *(Lannate 2.4LV)*	 *¼–½ lb* *1½ pt*	 *48* *48*	
Grasshoppers	*acephate (Acephate 97UP)*	*½ lb*	*24*	

Table 9-7. Remedial treatments for insect control in the field

Insect	Insecticide and Formulation	Rate per Acre	Reentry Interval (hrs)	Remarks
Hornworms	Acephate (Acephate 97UP)	½ lb	24	If applications are necessary during harvest, make them immediately after priming rather than before.
	Spinosad (Blackhawk)	1.6 oz	4	
	Methomyl (Lannate 90SP) (Lannate 2.4LV)	 ¼–½ lb ¾–1½ pt	 48 48	
	Bacillus thuringiensis (Agree) (Biobit HP) (Crymax) (Deliver) (DiPel DF) (DiPel ES) (Javelin WG) (Lepinox WDG)	 1–2 lb ¼–½ lb ½–1 lb ½–1 lb ¼–½ lb ½–1 pt 1/8–¼ lb 1 lb	 4 4 4 4 4 4 4 12	
	Emamectin benzoate (Denim 0.16EC)	8 oz	48	Denim has a 14-day preharvest interval.
	Flubendiamide (Belt SC)	3 fl oz	12	14-day preharvest interval.
	chlorantroniliprole (rynaxypyr) (Coragen)	5 fl oz	4	
Japanese beetles	Lambda-cyhalothrin (Warrior) (Karate Xeon)	 2.5–3 oz 0.96–1.92 fl oz	24	Do not use Warrior within 40 days of harvest.
	Thiamethoxam (Actara 25WDG)	2–3 oz	12	
	Acephate (Acephate 97UP)	½ lb	24	

Table 9-7. Remedial treatments for insect control in the field

Insect	Insecticide and Formulation	Rate per Acre	Reentry Interval (hrs)	Remarks
Loopers	Bacillus thuringiensis (Agree) (Biobit HP) (Condor OF) (Crymax) (Deliver) (Dipel DF) (Dipel ES) (Javelin WG) (Lepinox WDG)	 2 lb 1 lb 1²/³ qt 1–1½ lb 1–1½ lb ½–1 lb 1–2 pt 1 lb 2 lb	 4 4 4 4 4 4 4 4 12	Good coverage, especially of lower leaves, is essential.
	Flubendiamide (Belt SC)	2–3 fl oz	12	
	Chlorantroniliprole (rynaxypyr) (Coragen)	3.5–7.5 fl oz	4	
Slugs	Metaldehyde (Deadline Bullets)	12–40 lb	12	Apply at dusk. Do not put bait on plants.
	Iron phosphate (Sluggo)	0.54-1 lb	0	Do not put bait on plants. Organically acceptable.
Splitworms	Flubendiamide (Belt SC)	2–3 fl oz	12	14-day preharvest interval.
	Chlorantroniliprole (rynaxypyr) (Coragen)	3.5–7.5 fl oz	4	
Stink bugs	Bifenthrin (Capture LFR)	3.4–6.8 fl oz	12	Do not apply after layby.
	Bifenthrin + imidacloprid (Brigadier 2SC)	6.4 fl oz	12	Do not apply after layby.
	Lambda-cyhalothrin (Warrior 1CS) (Karate Xeon)	 2.5–3 oz 0.96–1.92 fl oz	24	Do not use Warrior within 40 days of harvest.

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runoff potentials, you should choose remedial (and soil-applied) chemicals carefully (see chapter 11, "Protecting People and the Environment When Using Pesticides").

What restrictions on field work will there be? Worker protection standards prohibit workers from entering treated areas for a period of time after treatment. The length of time depends on the chemical used and is given on the label. Restricted entry periods generally range from four to 48 hours.

Do tobacco buyers have concerns about insecticide residues? Yes. Because of concerns about residues of certain materials, such as carbaryl (Sevin), we no longer suggest using them in tobacco. Communicate with your intended buyer to ensure that you are using only acceptable materials. Also, take care to prevent drift of any unregistered pesticides onto tobacco when they are being applied to an adjacent crop, such as cotton.

Will use of the insecticide restrict time of harvest? Regulations require a waiting period between application of insecticides and harvest. The length of time varies with the insecticide and is given on the label. For example, the pyrethriod lambda-cyhalothrin (Warrior) has a 40-day preharvest interval restriction, and bifenthrin (Brigade 2EC, etc.) cannot be applied after layby.

What effect will various insecticides have on beneficial insects? Some insecticides are more detrimental to beneficial insects than others. The *Bacillus thuringiensis* products (DiPel, etc.) do no direct harm to predators and parasites of tobacco pests. Fulfill is very specific to aphids and should have very little effect on beneficials. Tests in cotton indicate that Tracer is only somewhat detrimental to beneficials, but few data are available in tobacco. Ongoing research on imidacloprid indicates that foliar applications may affect wasp parasitoids of caterpillars.

Is rotation between chemical classes an option? The answer to this is almost always yes. To prevent the buildup of insecticide resistance and minimize residues, it is best to avoid using the same insecticide over and over. Codes assigned by the Insecticide Resistance Action Committee (IRAC) allow growers to determine which insecticides have different modes of action and therefore can be used for rotation. See Chapter 11 for an explanation of IRAC codes.

How much does the material cost? Cost is always a consideration. Remember, though, that the cost of the insecticide is not the only cost associated with insecticide use. An inexpensive but poorly chosen insecticide can actually increase pest problems and control costs. Other long-term costs, such as environmental damage and human health risks, should also be considered.

Tobacco splitworm biology

The tobacco splitworm, more accurately known as the potato tuberworm, has been a minor pest of tobacco for many years. Splitworm moths are small (their wingspan is about half an inch) and grayish brown, and the back edges of their wings are heavily fringed; but you are much more likely to see the larvae and their damage. The larvae mine or tunnel between the upper and lower surfaces of tobacco leaves, creating a thin, irregular window in the leaf and destroying the leaf tissue in the mined area. If you hold a damaged leaf up to the light, you may be able to see the silhouette of the caterpillar moving within the window in the leaf. When infestations begin early in the

Table 9-8. Reductions in budworm damage in North Carolina tests, 1998–2010

Insecticide[a]	*Percentage Reduction in Leaf Loss*[b]	*Number of Trials*[c]
Belt SC, 3–4 fl oz	*87*	*5*
Coragen, 3–7 fl oz foliar applications	*80*	*5*
DiPel 10G, bait	*87*	*11*
Denim 0.16EC, 6–8 oz	*84*	*9*
DiPel ES, 2 pt	*51*	*9*
Lannate LV, 1.5 pt	*52*	*5*
Orthene 97, 0.77 lb	*56*	*18*
Tracer, 1.4–2.0 oz	*79*	*20*
Warrior, 1CS, 2.5 oz[d]	*73*	*7*

[a] Rates are in units of formulated product per acre. All treatments were over-the-top sprays except for hand-applied DiPel 10G. All insecticides were not included in all tests.
[b] Percentage reductions in the leaf area lost are in comparison to the untreated check in each test in which the treatment was included and averaged over these tests. Control in general was poor in most tests including Lannate and good in most tests including Denim. Thus, these comparisons may underrate Lannate somewhat and slightly overrate Denim.
[c] Numbers indicate the number of trials in which the treatment was included.
[d] Lambda-cyhalothrin, tested as Warrior 1CS in five tests and as Karate Z in two others.

growing season, splitworms may affect all leaves of the plants nearly at once. If the infestation begins after topping, as has been the case in recent years, it more typically starts on the lower leaves and moves up the stalk.

The splitworm threshold is still under development, but if 10% or more of plants are heavily infested (10 or more mines per plant), control is probably justified because populations of this insect can increase rapidly (Table 9-5). There are few good options for control. Plants should be scouted for any mines just after topping. If no mines are present midseason, it is unlikely that tobacco splitworm populations will be economically significant in that field. However, if mines are present midseason, this field should be carefully scouted for new mines on a weekly basis by examining the lower leaves of at least 40 plants per acre. If new mines with live larvae are developing, treat the infested plants to prevent a late-season infesation.

Limited testing with Warrior has provided good results in North Carolina and Virginia, but its very long preharvest restriction (40 days) limits its use to the first few weeks of the season. Denim is also somewhat effective but also has a long preharvest restriction (14 days). Belt and Coragen are registered for tobacco splitworm, but efficacy data are limited. If a splitworm infestation occurs during the harvest period, growers may be able reduce populations by harvesting leaves with mines and following with insecticide sprays. This is not a recommendation to harvest unripe tobacco.

Impact of Budworms on Tobacco

Budworms (actually a complex of tobacco budworms and corn earworms) are among our most difficult insect pests to control because they spend much of their time in the tightly rolled leaves of the bud. On the other hand, because tobacco can compensate for budworm damage, budworms may cause less loss than many growers may expect. Tests on North Carolina flue-cured tobacco in 1998 and 1999 examined the effect of budworm infestation on yield. Infestation levels of 40 percent (1998) and 100 percent (1999) did not significantly reduce yields compared to tobacco kept budworm free. Tests in 2002 and 2003 looked at the impact of budworm feeding on a plant-by-plant basis. In only one of six trials did a 100 percent budworm infestation significantly reduce yield, and then only when the infestation occurred early and there was an unusually high incidence of topping. It is clear that the treatment threshold (10 percent of plants budworm-infested) is a very conservative and safe threshold. Do not rush into making a treatment. Also, think carefully before making repeated applications that do not seem to be working. In many cases, using cultural practices (choosing a resistant variety, avoiding excessive nitrogen, timely topping, practicing good sucker control and stalk and root destruction) and encouraging natural biological control may be adequate to protect your crop from loss to budworms.

Apply insecticides carefully. Budworms are often hidden in the bud; as a result, sprays are sometimes not very effective. It is very important to treat when the bud is most open (usually in the early morning or at night). Direct the spray into the bud and onto the upper one-third of the plant, and use a high volume (25 to 50 gallons per acre). The spray nozzles should be as low over the bud as practical, no more than 12 inches above the bud (or about six inches above the uppermost leaf tips). Do not treat after topping except in very unusual cases.

Thrips and Tomato Spotted Wilt Virus

TSWV is moved from plant to plant by tiny insects called thrips. Tobacco thrips, the main vector in tobacco, are usually brown or black as adults and have delicate fringed wings that look a bit like an individual feather. Thrips are thin, much longer than broad, but are not more than an eighth of an inch long. Young thrips are smaller, wingless, and usually yellow. If you want to check for the presence of thrips, it's best to use a hand lens or other magnifying device. Alternatively, you may slap a leaf or flower head against a white surface. If some of the "dust" transferred to the white surface is elongated and moving around, your tobacco probably has thrips.

Thrips usually spend the winter as adults or as pupae in the soil. Adults may hibernate in sheltered areas, but in mild winters (or at least during mild periods) they may be active on host plants, such as winter weeds. In the spring, thrips begin to move more actively and can spread to other hosts, including tobacco. Most of this movement is over distances that may reach several hundred yards, but thrips can sometimes be carried hundreds of miles by the wind. Generations are short, about two weeks when the weather is warm, and there may be several generations during the growing season.

Not every thrips you see on your tobacco is spreading TSWV. (Yes, the word thrips is both singular and plural.) Although many species of thrips exist, most of them either cannot carry TSWV or do not feed on tobacco. Moreover, even thrips that are able to carry the disease may not have picked up the virus from a diseased plant. Two species that do carry the virus and do feed on tobacco are the tobacco thrips (Frankliniella fusca) and the western flower thrips (Frankliniella occidentalis). In most years, the tobacco thrips is apparently the most important vector of TSWV in the early season. However, the western flower thrips was abundant early in the season in 2002.

TSWV is carried from plant to plant inside the insect vector and not just on the outside of the insect's mouthparts. Thus, there is a delay between acquisition of the virus from one plant and transmission to another plant. The virus must be picked up by a very young thrips within a day or two of its hatching. The same thrips cannot move the disease to another plant until the thrips matures into an adult.

Pesticides. Thrips are able to transmit TSWV very quickly, and most of these virus-carrying thrips come from outside the tobacco field. Over-the-top insescticides do not kill these thrips quickly enough to stop the spread of the virus. This type of spraying has not been successful in reducing disease incidence. Imidacloprid (Admire Pro and others) is effective at reducing TSWV transmission by altering thrips' feeding behavior. The application of Actigard, alone or in combination with Admire or Platinum, as a foliar spray (drench) to seedlings in the greenhouse may also reduce TSWV in certain years. (See chapter 8, "Managing Diseases," for details.) In addition to greenhouse treatments, Actigard can also be appilied as a foliar treatment in the field. Tests in 2007, 2008, and 2009 using the Morsello-Kennedy thrips flight models (http://bit.ly/1dwSEgT) to time foliar Actigard applications reduced TSWV incidence.

Cultural practices. Field selection and the transplanting date affect disease, but the transplanting date's effect is not consistent enough from year to year to include in a management plan. TSWV is most severe in early-planted fields in most years, but in some years late-planted tobacco is most affected. Thrips flight timing is weather dependent.

Weed management. It is not clear whether vigorous early-spring weed control immediately around fields can be a cost-effective way to reduce the disease in tobacco. However, a few management tools appear promising:

- Weedy small grain fields and fallow fields destined for no-till soybeans or cotton may be important sources of virus-carrying thrips. Be careful not to disrupt these fields (for example, do not use a broad-spectrum herbicide) just before or during transplantation of tobacco. Thrips will be forced from the dying weeds into a very susceptible tobacco crop. Weeds in these fields should be dead for at least three weeks before transplanting.

- Movement of the virus from summer annuals back to winter annuals is an important step in the virus cycle. If summer annuals can be killed before the winter annuals emerge, the cycle might be disrupted. This is another argument for a vigorous, early stalk-and-root destruction program in tobacco (including cultivation) and for good general weed control in late summer and early fall. Pay particular attention to fields with substantial carpetweed populations because this plant generates large numbers of thrips and is a reservoir for the virus.
- Whenever possible, manage your field borders to favor grassy vegetation over broad-leaved weeds. Grasses don't generate vector species of thrips and are poor hosts for the virus.

Organic Insect Management

There is increasing grower and industry interest in organic and Pesticide Residue Clean tobacco production. Fortunately, we have many tools available for insect management in organic systems. Some of these insecticides are standbys from conventional production that are also organically acceptable (Bt for budworm and hornworm control). Others are materials not previously used in tobacco and about which we have little information. One material, Pyganic EC (1.4, 5.4; MGK Company), has been tested on a limited basis for aphid and flea beetle control in tobacco. The label rate range for Pyganic EC 1.4 is 16 to 64 fluid ounces, and we do not currently have information to narrow this range. Because organic materials may be costly and are often broad spectrum, it is in the best interest of growers and researchers to develop organic pest management strategies for North Carolina. Organically acceptable materials for insect control in tobacco are listed in the 2013 North Carolina Agricultural Chemicals Manual.

Protecting Stored Tobacco

Tobacco stored on the farm is subject to two insect pests: the cigarette beetle and the tobacco moth. Both of these pests are more active during warm weather, but they live through our winters in protected areas. Damage caused by the cigarette beetle resembles the small holes chewed by flea beetles in green tobacco. Cigarette beetles leave behind a powdery waste that can give tobacco an unpleasant flavor. Damage by tobacco moths ranges from irregular holes about the size of a quarter to leaves completely stripped except for major veins. Damage by moths may also reduce the grade of tobacco to NOG due to silk webbing, droppings, and insect skins and bodies in the tobacco.

Controlling an established insect infestation is difficult at best. The best strategy is to prevent it through good sanitation and vigilance. If the tobacco to be stored is from the final harvest, it is best to leave it in the barn because the barn will have been heat-sterilized and may be reasonably tight. Also, if an infestation occurs, the barn can be heated to kill the pests. The tobacco should be first dried at a low heat before the temperature is raised above 100°F. A temperature of 140°F maintained for two hours is sufficient to destroy any pests and has the added advantage of lowering the moisture content of the tobacco. A possible disadvantage to leaving the tobacco hanging is that it will likely come in and out of order with changing weather conditions. This tends to darken the tobacco over time.

If the tobacco is removed from the bulk barn for storage, be sure to thoroughly clean the storage area first. Move discarded tobacco and other organic refuse well away from the pack house and burn it. Treat tobacco and storage areas with Bacillus thuringiensis to help prevent tobacco moth infestation. Apply a fine spray to loose tobacco as it is being sheeted or baled. It is easy to apply this material as the tobacco is being handled but much more difficult later. Rates for treatment with DiPel are as follows:

- Tobacco: 2½ teaspoons DiPel DF or Biobit HP per quart of water per one hundred pounds of tobacco.
- Storage area: six teaspoons DiPel DF or Biobit HP per 2½ gallons of water. Use half a gallon per one thousand square feet of surface area.

Bulk barns, especially box barns, make good areas for storing sheeted tobacco if the barns and surrounding areas are free of tobacco trash. Although heating sheeted tobacco to kill pests may be effective, it is expensive, and the dried tobacco will be very difficult to bring back into order. Once tobacco is in storage, check it periodically for signs of insects and new damage. Both insect pests are active primarily from April through October. During this period, tobacco should be checked every week or two. Pests may also be active during warm spells in the winter, and tobacco should be checked then as well.

If tobacco moths are found, the tobacco should be treated with Bacillus thuringiensis as described above. Simply treating the outside of the bundles or bales may help but probably will not control an established infestation. Sheets should be opened and the tobacco treated as loose leaves as much as possible. The aim is to get as much coverage as possible. This will probably not be practical for tobacco in bales, making it even more important to treat the tobacco as loose leaves before it is compressed in a bale. If cigarette beetles are found, the only effective option is fumigation. Fumigation should be done by a professional because fumigants are very hazardous and must be carefully handled to be effective. Furthermore, regulations make it difficult for farmers to legally fumigate on their own. Fumigation controls both the cigarette beetle and the tobacco moth, but remember that it controls only those insects that are present in the fumigated area; it is not a preventive measure. Reinfestation can soon occur. Thus, sanitation in and around the storage area is essential.

Cigarette beetle and tobacco moth damage can greatly reduce the grade and desirability of tobacco. Thus, it is probably cost-effective (at least for loose or sheeted tobacco) to carefully sort out and discard damaged tobacco and other signs of damage before offering the tobacco for sale. If there has been a cigarette beetle infestation, even undamaged portions of a bundle should be shaken to remove any of the residues that impart off-flavors.

A Precautionary Statement on Pesticides

Pesticides must be used carefully to protect against human injury and harm to the environment. Diagnose your pest problem, and select the proper pesticide if one is needed. The information presented here is not a substitute for pesticide label information. Follow label use directions, and obey all federal, state, and local pesticide laws and regulations.

10. Curing and Mechanization

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A few guidelines are recommended for successful and efficient curing:

1. Load the racks or boxes uniformly with quality tobacco.
2. Maintain an adequate airflow through the tobacco.
3. Practice good curing management, especially ventilation control.
4. Make sure your heating equipment and barn are energy efficient and well maintained.

With the continued uncertainty in future energy costs, it is critical that growers apply all the recommended strategies to decrease energy usage and minimize production costs associated with curing. In addition, heat exchanger retrofit systems require annual adjustments and inspections. The information provided in this chapter can help you make the most efficient use of fuel and electricity while maintaining the highest cured leaf quality.

Load Uniformly and Maintain Adequate Airflow

Uniform loading is the key to adequate airflow, which is necessary for top-quality cures. Green leaf handling systems have become more common for multiple reasons. Mechanical loading systems improve the handling efficiency and incorporate a weighing system to load boxes with the same quantity of leaf. Overloaded boxes can result in scalded tobacco, particularly on lower-stalk tobacco. More often, however, improperly cured tobacco results from uneven loading that allows air to pass through less densely loaded areas while bypassing more densely loaded areas. This differential drying can occur within a given box and between adjacent boxes in the same barn. Uneven drying results in longer curing times, thus increasing the electricity and fuel consumed. Weighing the boxes allows the grower to load each with exactly the same amount of green tobacco and minimize the density variations. The bulk density—the pounds of green leaf per unit volume—significantly affects the airflow through the packed bed of tobacco. As the amount of green leaf per box (bulk density) increases, the resistance the fan must overcome to produce a desired airflow also increases. Thus, an accurate green weight measurement will assist with determining the optimum loading rates for your particular barn-retrofit combination.

Many growers increase the quantity of tobacco loaded per box as harvesting advances from the lower-stalk leaves to the upper-stalk leaves. Box loading varies from 1,800 to 2,000 pounds for lower-stalk leaves, 2,000 to 2,200 pounds for mid-stalk leaves, and 2,200 to 2,400 pounds for upper-stalk leaves. These loading rates are typical for Long, Powell, or Taylor barn size boxes. The loading rates for smaller boxes would be less for a given stalk position, but the resulting bulk density will be similar. Regardless of the box volume, typical bulk densities vary from approximately 9 pounds to 12.5 pounds per cubic feet. The barn airflow capacity and quality of the harvested tobacco are important factors that affect the quantity of tobacco loaded per box for any stalk position. As a result, the loading rate may also vary with each growing season. Good box-to-barn and box-to-box sealing should be obtained for maximum leaf ventilation and top-quality cures. Although good cures can be obtained with slight air leakage between containers that are provided adequate airflow, reduced cured leaf quality and increased energy use are likely when low airflow occurs with leakage, nonuniform loading, or both.

Practice Good Curing Management

Proper control of temperature and relative humidity are essential for efficient tobacco curing. For most growers, the relative humidity is indirectly monitored by measuring both the dry- and wet-bulb temperatures. However, many of the automated ventilation control systems are now using a relative humidity sensor (dry sensor) that has eliminated using a wet-bulb thermometer. Although relative humidity is measured directly with this sensor, the wet- and dry-bulb temperatures are still displayed. As a result, the ventilation schedule that growers are familiar with remains the same. A benefit of the dry sensor is the elimination of the routine maintenance required when using a wet-bulb thermometer to ensure accurate measurements. The feedback from growers using the relative humidity sensors continues to be positive.

Dry-Bulb Temperature, Wet-Bulb Temperature, and Relative Humidity

The dry-bulb temperature, which is the actual air temperature, is measured with a conventional thermometer or thermostat. The dry-bulb temperature is controlled by the thermostat, which cycles the heat on and off. A wet-bulb thermometer is simply a dry-bulb thermometer connected to a water reservoir by a wick that is wrapped around the thermometer bulb.

As a result of the evaporative cooling process, the wet-bulb temperature will be lower than the dry-bulb temperature. The amount of cooling depends on the relative humidity. The relative humidity is a ratio: the actual weight of the water vapor in the air relative to the maximum weight of water vapor the air can hold for a given dry-bulb temperature. The higher the relative humidity, the slower the evaporation rate, and vice versa. The difference between the dry-bulb and wet-bulb temperatures determines the relative humidity of the air. As the difference between the dry-bulb and wet-bulb temperatures increases, the relative humidity decreases. A smaller difference in temperature indicates an increase in the relative humidity. If the air were completely saturated, which means the relative humidity would be 100%, the dry-bulb and wet-bulb temperatures would be equal. Table 10-1 shows the relative humidity (%) for typical dry-bulb and wet-bulb temperatures during curing. The relative humidity is read at the intersection of the given wet-bulb temperature row and dry-bulb temperature column. For example, given a dry-bulb temperature of 144°F and a wet-bulb temperature of 112°F, the relative humidity is 37%.

Curing Phases

Typically the curing schedule is divided into three phases defined as yellowing, leaf drying, and stem drying. The actual curing schedule used will deviate due to factors such as tobacco ripeness and maturity, weather ture schedule based on your curing experience and the tobacco's response to the curing environment.

Yellowing involves a delicate balance between maintaining a high relative humidity and removing as much moisture as possible without excessive drying. The goal is twofold: to allow completion of the biological and physiological processes occurring in the leaf and to avoid overdrying. Removal of as much water as possible during yellowing

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Table 10-1. Relative humitity (%) for typical dry-bulb and wet-bulb temperatures during curing

	Dry-Bulb Temperature (°F)																											
Wet-Bulb Temperature (°F)	92	94	96	98	100	102	104	106	108	110	114	118	120	124	128	130	134	138	140	144	148	150	154	158	160	164	168	170
80	60	55	50	46	42	36	33	30	28	25																		
82	66	60	55	51	47	43	39	36	33	31																		
84	72	66	61	56	52	48	44	40	37	34	29																	
86	78	72	67	62	57	52	48	45	41	38	32																	
88	85	79	73	67	62	58	53	49	45	42	36	31																
90	92	86	79	73	68	63	58	54	50	46	40	34	32															
92	100	93	86	80	74	68	63	59	55	51	44	38	35															
94		100	93	86	80	74	69	64	59	55	48	41	38	33														
96			100	93	86	80	75	69	64	60	52	45	42	36	32	30	26	22	21	18	16	15	13	11	10	9	8	7
98				100	93	86	80	75	70	65	56	49	46	40	35	32	28	25	23	20	18	16	14	13	12	10	9	8
100					100	93	87	81	75	70	61	53	50	43	38	35	31	27	25	22	19	18	16	14	13	12	10	9
102						100	93	87	81	76	66	58	54	47	41	38	34	30	28	24	21	20	18	16	15	13	11	11
104							100	93	87	81	71	62	58	51	45	42	37	32	30	27	23	22	19	17	16	14	13	12
106								100	93	87	76	67	63	55	48	45	40	35	33	29	26	24	21	19	18	16	14	13
108									100	94	82	72	67	59	52	49	43	38	36	31	28	26	23	21	19	17	15	14
110										100	88	77	72	63	56	52	46	41	38	34	30	28	25	22	21	19	17	16
112											94	82	77	68	60	56	50	44	41	37	33	31	27	24	23	20	18	17
114											100	88	83	73	64	60	53	47	45	40	35	33	30	26	25	22	20	19
116												94	88	78	69	65	57	51	48	42	38	36	32	28	27	24	21	20
118												100	94	83	73	69	61	54	51	46	41	38	34	31	29	26	23	22
120													100	88	78	74	65	58	55	49	43	41	37	33	31	28	25	24
122														94	83	78	70	62	58	52	47	44	39	35	33	30	27	25

(Continued from page 184)

while maintaining the proper humidity can reduce fuel consumption, thus improving energy efficiency. Likewise, as sufficient moisture is removed during yellowing, drying will help to improve airflow through the containers.

As curing progresses, the difference between the dry-bulb and wet-bulb temperatures increases, and the relative humidity decreases. When air is heated without changing the moisture content, both the dry-bulb and wet-bulb temperatures will increase. The dry-bulb temperature will increase more than the wet-bulb temperature, thus decreasing the relative humidity. The maximum dry-bulb temperature advance rate recommended is 2°F per hour during leaf drying and no more than 3°F per hour during stem drying. This gradual increase allows sufficient time for the moisture removal to keep up with the temperature increase, therefore minimizing the possibility of leaf scalding.

As long as the leaf retains sufficient moisture, the wet-bulb temperature and leaf temperature are approximately the same. If the leaf temperature exceeds approximately 113°F, the cells die, which produces browning or scalding. This is a result of too high a wet-bulb temperature and a slow drying rate. Therefore, after yellowing, the wet-bulb temperature should never exceed 105°F until the leaf lamina is completely dry. Once the leaf is dry enough to advance the dry-bulb temperature above 135°F, maintaining a wet-bulb temperature of 110°F or higher will reduce fuel consumption. Many growers rely on experience to manage ventilation, but accurate control and minimizing fuel consumption requires monitoring the relative humidity in the curing environment. For more details concerning the curing schedule, contact your local county Extension center for assistance.

Controlling the Wet-Bulb Temperature—Ventilation

One of the most efficient energy-saving strategies is the proper use of a wet-bulb thermometer. Measuring the wet-bulb temperature also allows the grower to monitor the actual leaf temperature during early phases of the curing process. Monitoring the leaf temperature will help to avoid the curing problems mentioned previously in this chapter. To control the wet-bulb temperature and therefore the relative humidity, the fresh air intake damper is adjusted manually, typically in small increments. Opening the damper increases the fresh air intake or ventilation rate, which decreases the wet-bulb temperature and relative humidity. Closing the damper decreases the ventilation rate and increases the wet-bulb temperature and relative humidity.

Growers who do not measure or monitor the wet-bulb temperature are almost certain to overventilate to avoid browning or scalding the tobacco. Curing with a wet-bulb temperature that is lower than recommended will increase the quantity of wasted heat. Additionally, overventilation during yellowing may result in accelerated drying, setting the color green, especially on the bottom of the boxes or racks that are in contact with the air first. As the damper opening is widened, the ventilation rate and fuel consumption increase. Additionally, less air is recirculated inside the barn, and more air is exhausted out the vents. The air that exits the top of the boxes and goes out of the barn will seldom be saturated, which means that some of the available heat energy in the air will be lost to the outside. Additionally, the dry-bulb temperature of the air above the boxes or racks will be less than the air below the tobacco. The difference between the bottom and top dry-bulb temperatures is only a few degrees during yellowing, but the difference increases during leaf drying. Finally, during stem drying the difference decreases, and the two temperatures are approximately the same.

Excessive air leaks in the barn may make it difficult to maintain the desired wet-bulb temperature and thus the relative humidity as well. Excessive leaks increase the infiltration of fresh air pulled in by the fan to compensate for the air exhausted. This wastes fuel and energy because the air is exhausted out of the barn before it passes through the tobacco.

Automatic damper control provides continuous monitoring of the wet-bulb temperature or relative humidity, resulting in more accurate ventilation control, which can decrease fuel consumption during curing. Ambient conditions also change, and as a result, ventilation adjustments may be required more frequently later in the curing season to maintain the desired curing environment and improve fuel efficiency. The amount of fuel savings associated with using any automatic damper control will depend on how well a grower is currently managing the ventilation process.

During the 2007 season, multiple on-farm locations were used to compare automatic ventilation and manual ventilation control. At each location gas meters were installed on two identical curing barns to measure fuel consumption during each cure. An automatic ventilation control was installed on one barn at each location, and the second barn ventilation was controlled manually. For most locations, manual ventilation control did not include using a wet-bulb thermometer. The fuel savings and economic benefits associated with improved ventilation

Table 10-2. Annual fuel savings comparing ventilation control during the 2007 season

	Location						
	1*	***2***	***3***	***4***	***5***	***6***	***7****
Fuel savings (%)	*1.43*	*12.63*	*12.15*	*16.42*	*28.33*	*16.50*	*2.23*
Fuel savings (gals)	*43*	*349*	*400*	*456*	*947*	*366*	*36*
Savings per barn[1]	*$62*	*$506*	*$580*	*$661*	*$1,373*	*$531*	*$52*

** Grower used a wet-bulb thermometer with manual control*

[1] $1.45 per gallon LP gas

are summarized in Table 10-2. The fuel savings reported is the difference between the two barns at the end of the curing season (minimum of six cures) expressed as a percentage and gallons of LP gas. Averaged across all locations, the fuel savings was approximately 13%. Although it is possible for some growers to minimize fuel consumption without using a wet-bulb thermometer or automated system, many can benefit significantly from improved ventilation control. At a few locations the growers did use a wet-bulb thermometer to assist with manual ventilation; as a result, the fuel savings were marginal. Although the automatic ventilation controllers used a wet-bulb thermometer during this evaluation, many have eliminated the wet-bulb sensor and now measure relative humidity.

Many of the automatic control systems also have an optional feature to monitor the dry-bulb and wet-bulb temperatures and transmit this information to a web-based monitoring system. This allows the grower to observe the real-time curing conditions of each barn. The remote monitoring capability has a significant time management benefit. Additionally, alarm conditions can be established that will notify the grower if problems occur during curing. Although automatic curing control systems can help improve curing management, the desired curing conditions are inputs based on experience curing tobacco.

Wet-Bulb Thermometer Location

Regardless of whether damper control is manual or automatic, if a wet-bulb thermometer is used a few maintenance steps are required to ensure accurate measurements. Keeping the wet-bulb wick from becoming dry during curing is critical to proper ventilation control. Theoretically, the wet-bulb temperature should be the same below and above the tobacco. However, the closer the wet-bulb thermometer is located to the heating system output, the more likely it is that small differences in the wet-bulb temperature may be observed when comparing this location to others in the barn. To obtain the most accurate wet-bulb temperature, a few guidelines are suggested:

1. Place the wet-bulb thermometer far enough away from the burner output to ensure adequate mixing of the air but in a location with sufficient air movement across the wick. Typically, the wet-bulb thermometer is positioned on the floor below the curing containers, near the front of the curing barn. This allows easy access and is in an environment with sufficient airflow.
2. Monitor the wet-bulb thermometer reservoir, and maintain it with water to keep the wick wet at all times. Change or wash wicks frequently due to the decrease in water absorption that commonly occurs. Impurities in the water and the unforgiving curing environment contribute to the decreases in moisture absorption.
3. In some cases the airflow around the wick may be excessive, and at higher temperatures the increased evaporation rate will result in inaccurate measurements. Placing a piece of thin-gauge sheet metal on the floor beneath the wick and reservoir to shield the airflow has minimized this problem for some growers.

Make Sure Your Equipment and Barn Are Energy-Efficient and Well-Maintained

Top-quality tobacco is not likely to come out of a barn with an improperly adjusted burner, faulty or inaccurate curing controls, or multiple sources of air leaks. Not only will the quality of the tobacco be lower; it will cost significantly more to cure the tobacco if the heating equipment, barn, or both are poorly maintained.

It is important to follow any annual maintenance requirements recommended by the manufacturers of both the heat exchanger and the burner, to ensure that both units are functioning at their optimum levels. The burners should be annually inspected and adjusted to establish the correct amount of excess air, which will ensure complete burning of the fuel and minimize fuel consumption. Also, any electronic controls and temperature sensors should be inspected and recalibrated if needed to ensure proper operation. The U.S. Tobacco Good Agricultural Practices Program currently requires all tobacco curing barn heat exchangers to be tested for combustion product leaks every three years. Barn testing can be conducted by independent third-party companies or individual growers that have attended a Cooperative Extension training. The optimum time to check your heat exchangers for leaks would be immediately after the curing season, before the electrical and fuel supply are shut down during the off season. This would also allow sufficient time to correct any heat exchanger issues prior to next season. Additional information about the recommended barn testing equipment can be obtained from your county Extension center.

Burner Efficiency

The single greatest reason for burner inefficiency is too little or too much air. In theory, a precise quantity of air is required to completely burn a precise quantity of fuel. Because of incomplete mixing, a limited but very important amount of excess air is required to produce complete burning and the highest efficiency. When too little air is present, the burner will produce partially unburned fuel or smoke. Smoke not only wastes fuel but can deposit soot inside the heat exchanger, where it acts as insulation that can reduce the heat exchanger's efficiency.

Although an approximately correct burner air-fuel ratio may be set by eye (a blue flame instead of an orange one), the proper air-fuel ratio can best be achieved with a combustion analyzer. Refer to the burner manual or manufacturer for additional information on recommended excess air values. The manual may list the fan shutter setting for a given burner firing rate (BTUs/hour), but a combustion test should always be performed to verify the excess air percentage. Most fuel dealers or barn service technicians have some type of combustion analyzer and the experience to assist with adjusting the heat exchanger burner.

Adjusting the Burner

Most combustion analyzers have sensors that measure the carbon dioxide (CO_2) and oxygen (O_2) concentrations in the exhaust stack, which are expressed as percentages. These measurements are used to adjust the excess air level on the burner. Typically, a fresh air inlet vent or shutter on the burner fan is adjusted until the desired excess air level is obtained.

Thermal efficiency is a measurement of how well the heating system is converting the fuel into usable heat energy at a specific period of time in the operation of the heating system. The thermal efficiency is complicated by the performance of the burner and heat exchanger acting as a single unit. Because some of the heat will always be lost up the exhaust stack, a thermal efficiency of at least 80 percent should be targeted. An ideal stack temperature is in the range of 350°F to 450°F. A properly tuned burner can result in significant improvements in the heat exchanger performance. A barn service technician should be able to evaluate burner performance and make any necessary adjustments.

Heat Exchanger Efficiency

The energy efficiency of the heat exchanger is the percentage of the total heat entering from the burner that is extracted (exchanged) for practical use inside the barn. For the heat to be exchanged from the burning flue gases, it must pass through the walls of the heat exchanger. Many factors influence the exchange capacity and hence the efficiency of the heat exchanger. These include the shape and size of the heat exchanger, its material type and thickness, the rate of hot gases flowing inside the heat exchanger, and the rate of air flowing over the outside surfaces of the heat exchanger. Additionally, the rate of heat generation by the burner (BTUs/hour) can greatly influence the efficiency of a particular heat exchanger.

Growers should have their barn service technician check the burner-firing rate on every barn prior to each curing season. Typical burner-firing rates range from 325,000 to 450,000 BTUs/hour, depending on the amount of green tobacco loaded, heat exchanger design, fan output, and other factors. The burner/heat exchanger system will operate most efficiently when the burner is operating at the lowest capacity that will allow the barn to maintain the desired temperature. The most heat is required during leaf drying, when the barn temperature is typically between 130°F and 150°F. Adjust the heat output of the burner so that the burner is operating nearly continually during this time. At a minimum, you should know the approximate burner firing rate on all your barns.

An Energy-Efficient Barn

A bulk curing barn is less of a structure than it is a piece of equipment. Like any piece of equipment, it requires (and deserves) periodic maintenance to keep it in good shape. A good barn maintenance plan should consider the whole barn.

Most bulk barns are situated on a 4-inch-thick pad of concrete. Some are insulated, but most are not. During the 2008 season fuel savings were compared at three on-farm locations with an insulated cement pad versus a cement pad without insulation. The insulated barn pad resulted in fuel savings of approximately 3.27%, 6.41%, and 14.77% at each loaction. At the location with the highest fuel savings, the barn without an insulated pad was also loaded with approximately 1,000 pounds more green tobacco, which will result in additional fuel consumption. Therefore, the fuel savings at this location is a combination of two factors: decreased quantity of green leaf loaded compared to the check barn, and insulation under the pad. However, even at 3% to 6% fuel savings, the payback for insulating the barn pad is typically three years or less, depending on the price of fuel. It may be too late to do much about an uninsulated pad now, but if you are thinking of putting in a new barn or moving an old one, you should consider placing an inch of foam insulation under the concrete to minimize heat losses through the ground.

After a few years, even the most well-constructed barn will develop cracks and gaps. The natural daily cycle of heating and cooling will loosen screws, nails, and staples that secure the roofing and siding. Doors are particularly noticeable sources of maintenance problems. Hinges work loose, and gaskets get hard and torn, causing them to need periodic replacement. It is also a good idea to reseal the foundation joint with a good grade of butyl caulking compound.

Curing Energy Efficiency

Curing energy efficiency is the system's energy efficiency (barn plus burner and heat exchanger) and bottom line that can be quantified in pounds of cured leaf (marketed leaf) per unit of fuel consumed. For example, if you are taking out three thousand pounds of cured leaf per barn and consuming three hundred gallons of LP gas for that amount of leaf, that would indicate a curing efficiency of ten pounds of cured leaf per gallon of LP gas (3,000 divided by 300). These numbers may vary considerably, even in the same barn over a curing season, because they are affected by such factors as barn loading rates, stalk position, ambient conditions, the quality of the tobacco, and curing management.

Over the past few seasons, on-farm fuel consumption data have been collected from multiple locations to determine energy usage and efficiencies. Most of the barns studied were insulated and were made of all-metal construction, but the heat exchanger manufacturers, burner firing rates, and curing management varied, which can have a significant effect on fuel consumption. The cured leaf weight was recorded, and the tobacco green weight was also recorded if possible. The season-averaged curing efficiencies ranged from approximately 7.34 to 13.98 pounds of cured leaf per gallon of LP gas. These are significant differences in curing energy efficiency and thus the cost per pound of cured leaf. Table 10-3 shows the estimated cost per pound cured for varying curing efficiency ratios and fuel costs. The fuel cost is expressed as dollars per unit and therefore can be used for natural gas, LP gas, and no. 2 diesel. The greater the curing energy efficiency, the lower the curing cost. As an example, if two growers were paying $1.00 per gallon for LP gas but their curing efficiencies averaged over the season were 8 pounds/gallon and 10 pounds/gallon respectively, the difference is approximately $0.0254 (0.125 minus 0.1) per pound cured. Multiplying this difference by the total pounds cured can run into thousands of dollars over a season.

Table 10-3. Estimated curing cost (fuel only) for varying barn energy efficiencies and fuel cost

	Fuel Cost ($/unit)									
	0.80	***1.00***	***1.20***	***1.40***	***1.60***	***1.80***	***2.00***	***2.20***	***2.30***	***2.40***
lb/gal	***$/lb Cured***									
7	*0.114*	*0.143*	*0.171*	*0.200*	*0.229*	*0.257*	*0.286*	*0.314*	*0.343*	*0.343*
8	*0.100*	*0.125*	*0.150*	*0.175*	*0.200*	*0.225*	*0.250*	*0.275*	*0.300*	*0.300*
9	*0.089*	*0.111*	*0.133*	*0.156*	*0.178*	*0.200*	*0.222*	*0.244*	*0.267*	*0.267*
10	*0.080*	*0.100*	*0.120*	*0.140*	*0.160*	*0.180*	*0.200*	*0.220*	*0.240*	*0.240*
11	*0.073*	*0.091*	*0.109*	*0.127*	*0.145*	*0.164*	*0.182*	*0.200*	*0.218*	*0.218*
12	*0.067*	*0.083*	*0.100*	*0.117*	*0.133*	*0.150*	*0.167*	*0.183*	*0.200*	*0.200*
13	*0.062*	*0.077*	*0.092*	*0.108*	*0.123*	*0.138*	*0.154*	*0.169*	*0.185*	*0.185*

Energy Content of Fuels

Although more than 80% of growers use LP gas, Table 10-4 shows the heating value of several fuels used to cure tobacco. Natural gas is typically sold in therms, and one therm is approximately the energy equivalent of burning 100 cubic feet of gas. A therm of natural gas has approximately 10% more energy than a gallon of LP gas. The heating value of wood reported is for seasoned or dried wood, which has a wet-basis moisture content of approximately 15 percent. Green wood is approximately 50% water, and the heating value is approximately half the value of seasoned wood. As a result of the differences in energy content, a grower using natural gas or fuel oil may consume fewer units of fuel in the same size of barn loaded with the same quantity of tobacco compared with a grower using LP gas.

Table 10-4. Heating value of fuels used for curing

Fuel (units)	*BTU/Unit*
LP gas (gal)	*91,500*
#2 fuel oil (gal)	*139,000*
Natural gas (therm)	*100,000*
**Wood (lb)*	*7,000*

** Seasoned wood*

Growers should target a seasonal average curing energy efficiency of 10 pounds of cured leaf per gallon of LP gas, especially if using box barns. Typically, curing efficiencies will be less with lower-stalk leaf and will increase with middle- and upper-stalk leaf. It takes significantly more fuel per pound of cured leaf to cure lower-stalk leaf compared to upper-stalk leaf. This is because lower-stalk tobacco has a higher moisture content than upper-stalk tobacco, and the box loading rate is typically less with lower-stalk tobacco, resulting in less cured weight. To obtain the targeted efficiency and significantly reduce curing costs, all the energy-saving guidelines for bulk curing need to be applied. Although many growers can estimate their seasonal fuel consumption, cured weights, and resulting curing energy efficiency, installing a gas meter on a single barn can provide accurate fuel consumption information to assist with evaluating your system performance and curing management. If you have more than one type of barn and heat exchanger, then you may be interested in multiple gas meters. A gas meter costs approximately $400 to $500 installed, but it might pay for itself in one season. Contact your local fuel supplier or barn service technician for more information on installing a gas meter.

New Curing Barn Energy Performance Assessment

Many growers are interested in upgrading their aging barn infrastructure or adding additional curing capacity for their existing acreage. A very unusual opportunity during the 2013 season resulted in the energy performance evaluation of three different makes of new curing barns (Long, World Tobacco, and Tytun) at the same on-farm location. Instrumentation was implemented to monitor the total energy consumption (fuel and electricity) for each cure for the new barns and for two existing barns for comparison. All the new barns were loaded the same day with similar qualities and quantities of tobacco. Automatic ventilation control was used on all the barns, new and existing, and as a result the curing management for each barn was easy to duplicate. The energy performance information is summarized in Table 10-5.

Averaged over eight cures, the fuel efficiency was 15.35, 14.94, and 17.26 pounds of cured leaf per gallon of LP gas for the World Tobacco, Long, and Tytun barns, respectively. The existing Long and DeCloet barns averaged 13.25 and 12.64 pounds of cured leaf per gallon of LP gas, respectively. The new curing barns are better insulated and have fewer structural air leaks, factors contributing to improved energy efficiency. Although the three new barns demonstrated a reduction in fuel consumption compared to the two existing barns, the existing barns at this location still operated efficiently. The average length of cure was 181, 172, and 156 hours for the three new barns compared to 206 hours and 184 hours for the two existing barns. There was also a difference in cure duration among the new barns for a similar quantity of green tobacco. Factors contributing to a decreased curing time include airflow, heat exchanger efficiency, and barn design. Reducing the length of cure decreases the total energy consumed and allows a grower to reload the barn faster, possibly reducing the number of barns needed for a given acreage. The grower observed no differences in the cured leaf quality from any of the new barns.

Although energy performance alone is not necessarily the justification for selecting a given barn make, it is an important factor because of the production costs associated with curing and the uncertainty of future energy prices. Other factors include the new barn cost, make and model of the existing barn infrastructure, and existing material handling system components. Performance-based comparisons and manufacturer competition can result in innovations and improvements in future barn designs.

Moisture Addition in Cured Tobacco

Green tobacco is approximately 80% to 90% water. At the end of the curing cycle, the tobacco is essentially 0% water. At this stage,

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Table 10-5. New barn on-farm energy performance summary

Cure	Loaded	UnLoaded	Cure (hrs)	LP Gas (gal)	Electrical Energy (kWh)	Green Wt. per Box (lb)	Bulk Density (lb/ft3)	Green Wt. (lb)	Cured Wt. (lb)	lb /gal LP
						World Tobacco (15 Box)				
1	19-Jul	26-Jul	168	319	1174	1300	10.2	19,500	2905	9.11
2	29-Jul	6-Aug	190	336	1381	1333	10.4	20,000	2888	8.60
3	7-Aug	14-Aug	168	275	1272	1536	12.0	23,000	4747	17.26
4	15-Aug	23-Aug	192	294	1294	1333	10.4	20,000	3729	12.67
5	24-Aug	2-Sep	213	223	1427	1536	12.0	23,000	5097	22.86
6	3-Sep	11-Sep	174	311	1294	1536	12.0	23,000	5425	17.44
7	12-Sep	19-Sep	162	325	1281	1600	12.5	24,000	5470	16.83
8	20-Sep	28-Sep	184	316	1360	1600	12.5	24,000	5691	18.01
		(Avg. or Sum)	181	2,399	10,483			176,500	35,952	15.35
						Long (10 Box)				
1	19-Jul	26-Jul	168	278	1272	1950	10.1	19,500	2908	10.46
2	29-Jul	6-Aug	180	333	1442	2000	10.4	20,000	2904	8.72
3	7-Aug	14-Aug	164	272	1364	2350	12.2	23,500	4811	17.69
4	15-Aug	23-Aug	192	311	1470	2000	10.4	20,000	3705	11.92
5	24-Aug	2-Sep	168	256	1443	2352	12.2	23,500	4993	19.50
6	3-Sep	11-Sep	174	314	1445	2352	12.2	23,500	5393	17.18
7	12-Sep	19-Sep	168	333	1403	2450	12.7	24,500	5483	16.47
8	20-Sep	28-Sep	160	325	1462	2450	12.7	24,500	5720	17.60
		(Avg. or Sum)	172	2,422	11,301			179,000	35,917	14.94
						Tytun (14 Box)				
1	19-Jul	26-Jul	156	267	1230	1300	9.1	18,200	2847	10.66
2	29-Jul	6-Aug	161	283	1240	1429	10.0	20,000	2937	10.38
3	7-Aug	14-Aug	163	247	1290	1716	12.0	24,000	5088	20.60
4	15-Aug	23-Aug	158	248	1273	1429	10.0	20,000	3790	15.31
5	24-Aug	2-Sep	168	248	1331	1788	12.5	25,000	5268	21.24
6	3-Sep	11-Sep	141	286	1079	1788	12.5	25,000	5828	20.38
7	12-Sep	19-Sep	146	300	1163	1859	13.0	26,000	5875	19.58
8	20-Sep	28-Sep	157	292	1256	1800	12.6	25,200	5825	19.95
		(Avg. or Sum)	156	2,171	9,862			183,400	37,458	17.26

(Continued from page 195)

tobacco is much too brittle to handle without shattering. Therefore, moisture must be added back into the tobacco at the end of the cure to enable handling and market preparation. Too much moisture, however, can cause the tobacco to heat, darken, and decay and will ultimately ruin its desirable qualities.

Cured tobacco, like many organic materials, is hygroscopic. Hygroscopic materials have a physical (as opposed to a chemical) affinity for moisture. In the case of tobacco, this moisture is usually absorbed from the water vapor in the air surrounding the leaf. The absorption of water by cured tobacco leaves is a complex process that depends on many biological and physical factors. Biological factors include leaf properties that vary with variety, cultural practices, stalk position, and weather. The important physical factors include ordering temperature and humidity, air velocity around the surface of the leaf, and quantity and arrangement of the leaves.

It is well-known that the rate of moisture absorption (usually expressed as a percentage of moisture increase per hour) increases with increasing relative humidity. At higher relative humidity, more water is in the air and available for absorption by the tobacco. It is probably less well-known that moisture absorption rates also increase with increasing temperature. For example, at 80% relative humidity, the rate of absorption at 86°F is more than double the rate at 68°F. At 140°F and 80 percent relative humidity, the rate may be as high as several percentage points per minute. In addition, stalk position and leaf quality affect the rate of water absorption. Lower-stalk or thin, poor-quality tobacco has a faster absorption rate than thicker, upper-stalk, or better-quality tobacco.

Accurate Conditioning of Tobacco at the End of the Cure

The rapid and satisfactory ordering of flue-cured tobacco after curing is essential to both efficient use of barn space and leaf quality. The ability to remove the tobacco in a matter of hours instead of a day or more after the end of curing may add an additional cure to a particular barn during the season. Additionally, purchasing companies have established upper moisture limits that, if exceeded, will result in rejection of the baled tobacco. The several methods or combinations of methods that are now used to add moisture back into the tobacco often result in wide variations in moisture content from barn to barn and even within the same barn.

Many use the existing water supply that operates at low pressure with a group of nozzles positioned in the barn. This is a slow and uneven method that often wets the tobacco in some places while increasing the moisture very little in others. Some growers rely exclusively on the moisture content in the ambient air, which can vary significantly as weather conditions change. Running the fans at the end of the cure with the vents fully open brings moist, outside air past all the tobacco in the barn at once for more rapid and consistent ordering. Depending on the weather, this process can vary significantly with time. To properly order tobacco, the addition of water at the end of the cure must follow certain guidelines.

Start while the tobacco is still warm. Research has demonstrated that the best time to start ordering is immediately after the end of curing, while the barn and tobacco are still warm. Allow the heat exchanger time to cool down before the addition of water. Some growers may refrain from this practice because they mistakenly fear that moisture will darken the tobacco. Moisture will indeed darken warm tobacco, but only if it is liquid water.

Decrease the water droplet size to increase the leaf efficiency or rate of water absorption into the leaf. The droplet size must be small enough to allow the water to evaporate before it encounters leaves of tobacco. Also, more water remains as vapor in the air circulated through the tobacco. This usually requires special nozzles and line pressure in the range of five hundred pounds per square inch (psi) or higher. Water introduced into the air in droplets too large to evaporate will stick to the first surface it encounters (usually the floor or bottom leaves in the barn) and go no farther. Some growers suppose that the moisture will migrate and even out when these tobaccos are mixed when baling. Pockets of high-moisture tobacco inside a generally lower-moisture bale will heat and decay long before the moisture has had a chance to migrate. At the end of ordering, shut off the water, close the vents, and operate the fans for at least another hour to allow the moisture in the tobacco to even out and enter the midribs.

Most experienced growers have a good estimate of how much cured tobacco they can expect from their barns. If a grower knows the cured weight target moisture content, it is simple to determine how much water to add. For example, if a grower expects to remove 2,500 pounds of tobacco from his barn at 15% moisture content, 2,500 multiplied by 0.15 equals 375 pounds of water.

Thus, 375 pounds of water must be added to the tobacco at the end of the cure. Because one gallon of water weighs approximately 8.34 pounds, 375 pounds of water equals approximately 45 gallons.

Table 10-6. Gallons of water required to bring flue-cured tobacco to a given moisture content

Cured Leaf Weight (lb)	*Moisture Content of Tobacco (% Wet Basis)*						
	12	***13***	***14***	***15***	***16***	***17***	***18***
2,000	*29*	*31*	*34*	*36*	*38*	*41*	*43*
2,200	*32*	*34*	*37*	*40*	*42*	*45*	*47*
2,400	*35*	*37*	*40*	*43*	*46*	*49*	*52*
2,600	*37*	*41*	*44*	*47*	*50*	*53*	*56*
2,800	*40*	*44*	*47*	*50*	*54*	*57*	*60*
3,000	*43*	*47*	*50*	*54*	*58*	*61*	*65*
3,200	*46*	*50*	*54*	*58*	*61*	*65*	*69*
3,400	*49*	*53*	*57*	*61*	*65*	*69*	*73*
3,600	*52*	*56*	*60*	*65*	*69*	*73*	*78*
3,800	*55*	*59*	*64*	*68*	*73*	*77*	*82*
4,000	*58*	*62*	*67*	*72*	*77*	*82*	*86*
4,200	*60*	*65*	*71*	*76*	*81*	*86*	*91*
4,400	*63*	*69*	*74*	*79*	*84*	*90*	*95*
4,600	*66*	*72*	*77*	*83*	*88*	*94*	*99*
4,800	*69*	*75*	*81*	*86*	*92*	*98*	*104*
5,000	*72*	*78*	*84*	*90*	*96*	*102*	*108*

If the pump can atomize 30 gallons of water per hour so that essentially all the water enters the tobacco, then it should take approximately 1.5 hours (45 divided by 30) to bring the barn of tobacco into order. However, actual ordering systems are much less than 100% efficient and require additional time.

Some growers have constructed homemade ordering systems out of PVC or steel pipe and a group of nozzles. A grower who knows the waterline pressure and the nozzle size can estimate the gallons per hour introduced into the barn. For example, a typical water supply pressure is 40 psi. Using four hollow-cone TX-2 nozzles at 40 psi will deliver approximately 0.132 gallons per minute or 7.92 gallons per hour (0.132 multiplied by 60). Nozzle capacity can be found in the manufacturer's catalog and is rated in gallons per minute (gpm) for a given pressure. To deliver 45 gallons of water into the airstream would thus require approximately 5.7 hours (45 divided by 7.92).

Knowing the gallons required for a desired moisture content and the ordering system output capacity can assist growers with more consistent and accurate moisture addition. Table 10-6 lists the approximate gallons of water required for varying cured weights and moisture contents.

On-Farm Ordering Data

Some commercially available portable ordering units increase the existing line pressure significantly to increase atomization of the water. Recently, a commercial unit was instrumented with a flow meter and hour meter to record on-farm performance-based information. An electromechanical 24-hour timer was also installed to operate the pump continuously or intermittently. The commercial unit increases the water supply pressure to approximately 600 psi, decreasing the water droplet size and increasing leaf absorption efficiency. An additional on-farm location used flow meters and an electromechanical timer to compare intermittent and continuous ordering using the grower's existing system, which operated at line pressure (40 psi). Although the barn fan was operated continuously, the ordering unit pump was cycled off and on. Intermittently operating the pump allows more time for the fan to move the moisture upward through the tobacco and minimizes excessive wetting of the tobacco in the bottom of the containers. A typical cycle was to operate the pump for one hour on and 30 minutes off.

The location using the commercial ordering system averaged over the season (13 cures) approximately 309 gallons of water and seven hours to order when intermittently operating the pump. At the second location (89 cures) the grower averaged 551 gallons for continuous operation and 408 gallons (26% less water) for intermittent operation. Additionally, the intermittent operation averaged approximately two hours less time to complete the process. This farm is located in eastern North Carolina, but the instrumentation was used primarily with mid- and upper-stalk tobacco until late in October, when both ambient air conditions and leaf stalk position typically increase the time and quantity of water required. At both on-farm locations, the ordering system output ranged from 0.75 gpm to 1 gpm.

Growers using the intermittent operation observed an improvement in moisture uniformity throughout the barn and consistency with the time required to complete the ordering process compared to their existing ordering method. However, some barns do not have a convenient location to insert the nozzle boom; in this case, growers might have to modify the unit boom configuration or the barn accessibility. Some growers use a high-pressure sprayer pump that will significantly increase water atomization, but the output flow rate may be significantly higher than 1 gpm, causing water to be added much faster than the leaf absorption rate.

Any ordering system output can be measured using a procedure similar to calibrating spray equipment. Simply collect each nozzle output with a volumetric measuring cup for one minute of operation. To determine the ordering unit total volume output in gallons per minute, add the measurements for each nozzle and convert from ounces to gallons (128 ounces = 1 gallon) if needed. Also, introducing water into the airstream at excessive rates will saturate the tobacco in the bottom of the containers first, which may cause quality problems. A targeted system output of approximately 1 gpm may improve any ordering system efficiency and uniformity. Increasing the system operating pressure to improve atomization will assist with increasing leaf absorption efficiency, but avoid excessive flow rates. Additionally, implementing a timer for continuous or intermittent operation will assist with improving the ordering process control and management.

11. Protecting People and the Environment When Using Pesticides

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Despite their usefulness, agricultural chemicals pose varying degrees of risk to people and the environment. We need to make choices that minimize these risks. Of particular concern are keeping nutrients and pesticides out of surface water and groundwater and reducing human and wildlife exposure to pesticides. The following sections describe some measures that tobacco producers and professional applicators can take to minimize the threat to people and water quality and reduce pesticide exposure to humans and wildlife.

The U.S. Environmental Protection Agency (EPA) Worker Protection Standard regulates actions by employers to protect agricultural workers and pesticide handlers by reducing pesticide exposure and the risk of pesticide-related illness or injury. To protect your employees, you must be aware of the Worker Protection Standard and comply with its requirements. In addition, several tobacco purchasers now require that growers comply with Good Agricultural Practices (GAPs) standards, which include worker training and protection standards.

To fulfill the requirements imposed by the Worker Protection Standard, you must protect agricultural workers (who provide hand labor in the production of agricultural plants) and pesticide handlers (who mix, load, or apply pesticides or directly come into contact with pesticides through other tasks) in three ways:

1. *Provide training on pesticide safety and information about the specific pesticides used on the farm.* Pesticide safety training should occur before workers and handlers begin working and every five years at a minimum. Information that must be posted in a central location includes a safety poster, information about the nearest emergency medical facility, and specifics on recent pesticide applications (location of application, name of the pesticide, EPA registration number, active ingredient, date and start and end times of application, restricted-entry interval, and the time when workers may reenter the field).

2. *Ensure protection against exposure.* For handlers, employers must provide personal protective equipment and be sure it is properly used and cleaned. They must also warn workers about treated areas (through oral warnings, posting of the Worker Protection Standard sign in fields, or both, depending on label requirements) and make sure that workers do not enter treated fields during restricted-entry intervals (REIs). This requires careful scheduling of pesticide application and field work so they do not conflict. Personal protective equipment requirements vary from pesticide to pesticide and may be different for applicator/handlers and mixer/loaders. REIs also vary by pesticide and are given on labels. Protective equipment requirements for fumigant labels have recently changed; as with all pesticide labels, check carefully for specific requirements, even if you have used the product in previous years.
3. *Provide ways for workers to minimize and mitigate impacts of pesticide exposure.* This includes ensuring that decontamination sites and emergency assistance in case of exposure are available. Decontamination sites must be within ¼ mile of all workers and handlers and must contain water for washing, eye-flushing, and drinking; soap; single-use towels; and clean coveralls. In case of pesticide poisoning or injury of a worker or handler, you must provide transportation to a medical facility and pesticide information to medical personnel.

The following resources can help you comply with the Worker Protection Standard:

- For more information on the Worker Protection Standard, including how to conduct training, visit **http://pesticidestewardship.org**.
- You can find detailed information on the Worker Protection Standard and a link to the entire document here: **http://www.epa.gov/agriculture/htc.html**.
- To help growers comply with Worker Protection Standard and GAP requirements, North Carolina State University provides:
  — pesticide applicator training opportunities (**http://ipm.ncsu.edu/pesticidesafety/**) and
  — a tobacco-specific Worker Protection Standard resource for training agricultural workers called the *Pesticides and Farmworker Health Toolkit* (**http://go.ncsu.edu/pesticide-toolkit**).

Table 11-1 lists products, common names, registration numbers, manufacturers, signal words, restricted-entry intervals, and posting/notification requirements for the major pesticides and growth regulators used in tobacco. This should help you to properly record and post pesticide use and to plan field operations. **However, the information in this table is presented in good faith as a reference and is not an exhaustive list. This information does not take the place of the product label; changes to label information can occur without notice. Always read and follow label directions. The label on the container you are actually using must be followed, even if there has been a change on newer labels.**

Minimize Pesticide and Fertilizer Use Where Possible

Pesticide use should be only one part of an overall pest management program for insects, diseases, suckers, and weeds. It makes good environmental and economic sense to rotate crops, destroy stalks and roots early, use thresholds where available, promote a healthy and vigorous crop with good cultural practices, and fertilize properly. Fertilizer use can also affect pest problems and water quality. Be sure to have your soil tested field by field and to apply only those nutrients recommended. This protects the environment and also saves money by reducing pesticide and fertilizer use. Refer to chapter 5, "Managing Nutrients," for guidelines. Refer to the sections on insect, disease, weed management, and sucker control for proper management of these pests.

Select Pesticides Carefully

Cultural practices are important parts of a sound pest management program, but pesticides often must still be used to prevent economically significant losses. When this is the case, take care to match the pesticide with the pest. First, identify the pest, and then select an effective pesticide, rate, and application method, carefully considering potential effects on water and safety to humans and wildlife.

A measurement called an LD_{50} is used to measure pesticide toxicity to humans and other mammals. The LD_{50} is the amount of a substance that will cause death in 50 percent of a target population (rats, mice, or rabbits are most commonly used in studies). The lower the number, the more acutely toxic the substance is. An LD_{50} can be used only to measure acute toxicity or the immediuate health effects experienced within the first few days after a brief exposure to a substance. The LD_{50} is not a measure of chronic toxicity or of the long-term consequences (including cancer) resulting from a long time period of exposure. In general, it is best to choose the least toxic pesticide that will do the job. Use extreme caution with pesticides that have low LD_{50} ratings. Note that proper handling of pesticides (including the use of appropriate personal protective equipment) minimizes the risk of acute and chronic effects of all pesticides—even those with low LD_{50} values. Information on acute toxicity can be found in Table 11-1. Information on chronic toxicity can be found on Material Safety Data Sheets (MSDS) provided by your pesticide dealer. Both the pesticide label and the MSDS should be on hand when a pesticide is being used.

Apply Pesticides Carefully

Care must be taken to make sure that pesticides are applied only to the tobacco crop and not the field borders. Field borders consist of ditches, hedgerows, and woods, which are all vital habitat for wildlife. Imprecise application can be detrimental to these areas, and contaminated water in ditches may find its way into larger bodies of water, such as ponds, lakes, and rivers, or into groundwater. Precise application is especially important with aerial pesticide applications. Virtually all pesticides used in tobacco are more effective when applied via ground equipment, and aerial applications are not recommended.

Human exposure to pesticides occurs in one of the following three ways: (1) exposure through the skin or eyes (dermal), (2) exposure through eating, drinking, and other hand-to-mouth behaviors (ingestion), or (3) exposure through breathing vapors and dusts (inhalation). The use of protective clothing by handlers and applicators is the best defense against exposure to pesticides and is specified on each pesticide label. These requirements should be followed exactly. The potential for harmful pesticide exposure is greater when handling concentrated pesticides (those not mixed with water) than with using a diluted solution (mixed with water in a sprayer). Thus, be especially careful in the mixing and loading process. For example, pesticides should not be added to a spray tank by lifting the pesticide container above one's head to pour into the tank. If pesticide poisoning is suspected, contact the Carolinas Poison Center at 1-800-222-1222 (**http://www.ncpoisoncenter.org/**) and seek immediate medical attention, bringing the pesticide label with you. The Carolinas Poison Center provides 24-hour services for diagnosing and treating human illness resulting from toxic substances.

Rotate Pesticide Modes of Action

Applying pesticides with the same mode of action (MOA) multiple times or successively can eventually result in pest resistance to these tools. To aid growers in rotating pesticide mode of action, three organizations have developed MOA categories. These codes are listed on newer pesticide labels: FRAC (Fungicide Resistance Action Committee), IRAC (Insecticide Resistance Action Committee), and HRAC (Herbicide Resistance Action Committee). When it becomes necessary to treat a tobacco pest with more than one insecticide application (for example, if multiple tobacco hornworm treatments are required per season), pesticides with different MOAs should be chosen for the applications. Note that pesticide trade names and active ingredients may share the same MOA; for example, acephate (Orthene) and carbaryl (Sevin) are both in IRAC group 1A. Therefore, following a Sevin application with an Orthene application does not represent a pesticide MOA rotation. To assist in chemical selection, FRAC, IRAC, and HRAC codes are listed in Table 11-1.

Minimize Soil Movement and Leaching

As soil particles become dislodged, they carry pesticides and nutrients that may eventually find their way into a water source. To minimize contamination of our water resources, be sure to follow sound soil conservation practices, such as avoiding unnecessary cultivation and using cover crops, waterways, and strip-cropping. Consult your local Natural Resources Conservation Service and Cooperative Extension agents for advice.

Pesticides commonly used on tobacco differ in their potential to contaminate surface water and groundwater. Predicting which pesticides may reach groundwater and where this is most likely to occur is very difficult because of differences in soil chemical and physical characteristics and in water table depth. Generally, rolling soils in the piedmont have more potential for surface water contamination through runoff, whereas the porous soils of the sandhills and coastal plain may be more susceptible to groundwater contamination through leaching. However, surface water contamination can occur even on slightly sloping soils in the coastal plain. The Natural Resources Conservation Service can help you determine the leaching and runoff potentials for your fields. There are also guidelines that help determine which pesticides may be at highest risk for runoff and leaching. Two guidelines for pesticides are *surface loss potential* and *leaching potential*. Surface loss potential is broken into two categories: the risk of a pesticide running out of a field in solution with surface water (rain, irrigation, or flooding) and the risk of a pesticide adhering (being adsorbed) to soil or organic material and washing out of the field as erosion. A high rating in either category means the pesticide has a high tendency to move off the field, while a low rating means the pesticide has a low potential to move. Leaching potential indicates the tendency of a pesticide to move in solution with water and leach below the root zone. The ratings of *very high*, *high*, *medium*, *low*, and *very low* describe the potential for leaching. These guidelines are based on knowledge of the chemical characteristics of different pesticides and are summarized in Table 11-1. (The symbol "NA" is used where information is not yet available.) These are general guidelines and should be interpreted as such. Most pesticides will move into either surface or groundwater supplies in at least one of the ways described above. For example, a material that is not very leachable will tend to be adsorbed to soil and move with erosion. Thus, your best choice will depend on the characteristics of the field and the measures you have taken to reduce the chance of runoff.

Protect Wells

Improperly constructed and protected wells offer the quickest pathway for pesticides to reach groundwater (and perhaps your drinking water). Direct flow through wells is most often the source of high levels of pesticide contamination in groundwater. Groundwater contamination is difficult and very expensive to clean up; prevention of such contamination is best.

- Ensure that wells are properly constructed and sealed.
- Do not mix or load pesticides within one hundred feet of a well.
- When filling spray tanks, be sure the hose or pipe is not at or below the surface of the water in the tank. Otherwise, it is possible to back-siphon the pesticide mixture directly into your water supply.
- Install back-flow prevention devices, and inspect them frequently.

Table 11-1. Environmental contamination potential and mammalian toxicity of commonly used tobacco pesticides

Changes to labels can occur at any time. Tthis information does not take the place of the product label. Always read and follow label directions; it is the law.

The footnoted items in Table 11-1 should be interpreted as follows:

[a] Exception to Restricted Entry Interval: If a product is soil-injected or soil-incorporated, under certain circumstances, workers may enter the treated area if there will be no contact with anything that has been treated.

[b] Worker Notification: Unless the pesticide labeling requires both types of notification, notify workers EITHER orally OR by posting warning signs at entrances to treated areas (labeled "Either"). You must inform workers which method of notification is being used. Some pesticide labels require you to notify workers BOTH orally AND with signs posted at entrances to the treated area. If both types of notification are required ("Oral and Written"), the following statement will be in the "Directions for Use" section of the pesticide labeling under the heading Agricultural Use Requirements: "Notify workers of the application by warning them orally and by posting warning signs at entrances to treated areas."

[c] Most common trade names; others may be in use as well.

[d] Surface loss may occur when pesticides go into solution in water and run off the field in surface water. Potentials by Natural Resources Conservation Service, 2004. NA = not available.

[e] Surface loss may also occur when pesticides are adsorbed to soil or organic materials and washed out of the field. Potentials by Natural Resources Conservation Service, 2004. NA = not available.

[f] Leaching occurs when pesticides are moved downward in solution. Potentials by Natural Resources Conservation Service, 2004. NA = not available.

[g] LD_{50}: The dose (quantity) of a substance that will be lethal to 50 percent of the organisms in a specific test situation. It is expressed in the weight of the chemical (mg) per unit of body weight (kg). The lower the number, the more toxic the chemical. When more than one LD_{50} for mammals was found in the literature, the lowest found is shown here. "Oral" refers to toxicity through ingestion, while "dermal" refers to toxicity by skin contact. Values are from product MSDS.

[h] Telone C-17 also contains chloropicrin.

** = Technical material. Technical material (pure active ingredient) may be more or less toxic than the formulated material.*

NA = not available.

Table 11-1. *(continued)*

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
Acephate *EPA Reg. No. 51036-236* *Micro Flo*	*Caution*	*24 hr*	*Either; all greenhouse applications must be posted*	*Acephate 75*	*Intermediate*	*Low*	*Low*	*1A*	*1,030**	*10,250**
Acetamiprid *EPA Reg. No. 8033-23-4581* *Cerexagri*	*Caution*	*12 hr*	*Either*	*Assail*	*Intermediate*	*Low*	*Intermediate*	*4A*	*1,064*	*>2,000*
Acibenzolar-S-methyl *EPA Reg. No. 100-922* *Syngenta Crop Protection*	*Caution*	*12 hr*	*Either*	*Actigard*	*Intermediate*	*Low*	*Intermediate*	*P*	*> 5,000*	*> 2,000*
Bacillus thuringiensis *EPA Reg. No. 73049-39* *Valent Agricultural Products*	*Caution*	*4 hr*	*Either*	*Dipel DF*	*NA*	*NA*	*NA*	*11*	*> 5,050*	*> 2,020*
Bifenthrin *EPA Reg. No. 279-3302* *FMC Corporation*	*Warning*	*12 hr*	*Either*	*Capture LFR*	*Low*	*Low*	*Low*	*3A*	*54.5*	*2,000*

Table 11-1. *(continued)*

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
Butralin EPA Reg. No. 33688-4-400 Chemtura	*Danger*	*12 hr*	*Either*	*Butralin*	*High*	*High*	*Low*	*K1*	*891*	*> 2,000*
Carbaryl EPA Reg. No. 264-333 Bayer CropScience	*Warning*	*12 hr*	*Either*	*Sevin XLR Plus*	*Intermediate*	*Low*	*Low*	*1A*	*500*	*> 2,000*
Chlorantraniliprole (rynaxypyr) EPA Reg. No. 352-729 DuPont Crop Protection	*NA*	*4 hr*	*Either*	*Coragen*	*Low*	*High*	*Very Low*	*28*	*>5,000*	*>5,000*
Chloropicrin EPA Reg. No. 5785-17 Great Lakes Chemical Corp.	*Danger Poison*	*48 hr*	*Both*	*Chlor-O-Pic*	*Intermediate*	*Low*	*Low*	*8B*	*NA* / *Inhalation danger*	*NA*
Chlorpyrifos EPA Reg. No. 62719-591 Dow AgroSciences	*Warning*	*24 hr*	*Either*	*Lorsban*	*Low*	*Intermediate*	*Low*	*1B*	*96*	*2,000*

Table 11-1. *(continued)*

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g] Oral	Mammalian LD_{50}[g] Dermal
Dlomazone EPA Reg. No. 279-3158 FMC Corp.	*Caution*	*12 hr*	*Either*	*Command*	*Intermediate*	*Low*	*Intermediate*	*F3*	*1,369**	*> 2,000**
Dichloropropene EPA Reg. No. 62719-32 Dow AgroSciences	*Warning*	*5 days*	*Oral and Written*	*Telone II, Telone C-17[f]*	*Intermediate*	*Low*	*High*	*8B*	*224* *Inhalation danger*	*333*
Dimethomorph EPA Reg. No. 241-410 BASF Corp.	*Caution*	*12 hr*	*Either*	*Acrobat*	*High*	*Intermedi-ate*	*Intermediate*	*40*	*3,900**	*> 2,000**
Dimethomorph & mancozeb EPA Reg. No. 241-383 BASF Corp.	*Caution*	*12 hr*	*Either*	*Acrobat MZ*	*High* *High*	*Intermedi-ate* *High*	*Intermedia-teLow*	*40* *M3*	*3,900** *> 5,000*	*> 2,000** *> 5,000*
Emamectin benzoate EPA Reg. No. 100-903 Syngenta Crop Protection	*Danger*	*48 hr*	*Either*	*Denim*	*NA*	*NA*	*NA*	*6*	*1,516*	*> 2,000*

Table 11-1. *(continued)*

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
Ethephon EPA Reg. No. 264-418 Bayer CropScience	Danger	48 hr	Oral and Written	Prep, Super Boll, Mature XL	Low	Intermedi-ate	Low		3,030	1,560
Ethoprop EPA Reg. No. 264-457 Bayer CropScience	Danger Poison	48 hr	Oral and Written	Mocap 15 G	Intermediate	Low	High	1B	16	2.4
Etridiazole EPA Reg. No. 400-422 Chemtura	Danger	12 hr	Either	Terramaster 4 EC	Intermediate	Intermediate	Low	14	1,077	> 5,000
Fenamiphos EPA Reg. No. 264-731 Bayer CropScience	Danger Poison	48 hr	Oral and Written	Nemacur	High	Intermediate	High	1B	10.6	71.5
Flubendiamide EPA Reg No. 264-1025 Bayer CropScience	Caution	12 hr	Either	Belt	High	High	Low	28	2,000	2,000
Flumetralin EPA Reg. No. 100-640 Syngenta Crop Protection	Danger	24 hr	Either	Prime+	Low	Intermediate	Low	NA	3,100	NA

Table 11-1. *(continued)*

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
Imidacloprid EPA Reg. No. 264-827 Bayer CropScience	Caution	12 hr	Either; all greenhouse applications must be posted	Admire, Provado, Nuprid, many others	High	Intermediate	High	4A	4,143	> 2,000
Lambda-cyhalothrin EPA Reg. No. 100-1112 Syngenta Crop Protection	Warning	24 hr	Either	Warrior	Low	Intermediate	Very Low	3A	351	>2,000
Maleic hydrazide EPA Reg. No. 400-84 Chemtura	Caution	12 hr	Either	Several (Royal MH-30 and many others)	Intermediate	Low	Low	NA	> 5,000	> 5,000
Mancozeb EPA Reg. No. 62719-402 Dow AgroScience	Caution	24 hr	Either	Dithane	High	High	Low	M3	> 5,000	> 5,000
Mefenoxam EPA Reg. No. 100-801 Syngenta Crop Protection	Caution	48 hr	Either	Ridomil Gold	High	Intermediate	High	4	1,172	> 2,020

Table 11-1. *(continued)*

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g] Oral	Mammalian LD_{50}[g] Dermal
Metaldehyde EPA Reg. No. 5481-507 AMVAC	Caution	12 hrs	Either	Deadline Bullets	Intermediate	Low	Low	NA	283	NA
Metam sodium EPA Reg. No. 5481-468 Amvac Chemical Corp.	Danger	48 hr	Oral and Written	Vapam	Intermediate	Low	Intermediate	Z	1,891 Inhalation danger	> 3,074
Methomyl EPA Reg. No. 352-384 DuPont	Danger Poison	48 hr	Either	Lannate LV	Intermediate	Low	High	1A	17	5,880
Napropamide EPA Reg. No. 70506-64 United Phosphorus Inc.	Danger	12 hr	Either	Devrinol 2 EC	High	Intermediate	Intermediate	K3	4,640	NA
Oxamyl EPA Reg. No. 352-372 DuPont	Danger Poison	48 hr	Either	Vydate L	Intermediate	Low	Low	1A	5.4*	2,960*

Table 11-1. *(continued)*

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
Pendimethalin EPA Reg. No. 241-337 BASF Ag Products	Caution	24 hr	Either	Prowl 3.3	Intermediate	High	Low	K1	3,956	2,200
Pymetrozine EPA Reg. No. 100-912 Syngenta Crop Protection	Caution	12 hr	Either	Fulfill	NA	NA	NA	9B	> 5,000	> 5,000
Pyrethrins EPA Reg. No. 1021-1772 MGK Company	Caution	12 hr	Either	Pyganic (multiple formulations)	NA	NA	NA	3A	> 2,000	> 2,000
Sethoxydim EPA Reg. No. 7969-58-51036 Micro Flo	Warning	12 hr	Either	Poast	Intermediate	Low	Low	A	3,200	> 5,000
Spinosad EPA Reg. No. 62719-267 Dow AgroSciences	Caution	4 hr	Either	Tracer	Low	Intermediate	Low	5	> 5,000	NA
Sulfentrazone EPA Reg. No. 279-3220 FMC Corp.	Caution	12 hr	Either	Spartan	High	Intermediate	High	E	2,855*	> 2,000*

Table 11-1. *(continued)*

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
Thiamethoxam EPA Reg. No. 100-939 Syngenta Crop Protection	*Caution*	*12 hr*	*Either; all greenhouse applications must be posted*	*Platinum, T-Moxx, Actara*	*High*	*Intermediate*	*High*	*4A*	*> 5,000*	*> 2,000*

Fred G. Bond Scholarships
for students interested in tobacco

The Fred G. Bond Scholarship Endowment provides scholarships for two- or four-year undergraduate students or for graduate students enrolled in the College of Agriculture and Life Sciences at NC State University. Recipients must be planning to pursue careers in the tobacco industry—specializing in tobacco farming, in corporate or university tobacco research, or in Extension work relating to tobacco production.

Undergraduate applicants from tobacco farms in the southeastern United States have priority in the selection of Bond Scholarship recipients. Scholarships will be awarded to in-state students ($1,500 per year) and out-of-state students ($3,000 per year) and continue as long as the student maintains a "B" average.

The Bond Scholarships are in memory of Fred G. Bond, who served the tobacco industry for 43 years, including 23 years as chief executive officer of the Flue-Cured Cooperative Stabilization Corporation. During his distinguished career, Bond represented flue-cured tobacco growers in the six flue-cured tobacco-growing states in many critical situations, and he provided leadership to numerous tobacco industry, civic, and local political boards and organizations.

Application Procedure

Students accepted or continuing in the college's two- or four-year undergraduate program or in the graduate program are sent a letter containing the following statement:

> The College's scholarship program is a part of our commitment to attract outstanding students. College scholarships are available to entering students based on academic merit as well as financial need. In order to be considered for academic merit scholarships, you need only complete and return a scholarship application, which is available from the Academic Programs Office. Call 919-515-2614. There is no special application form for the Bond Scholarship.